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Higher Education 4.0

The Digital Transformation of Classroom Lectures to Blended Learning

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Preface

This research traces its origin to the first author's (later, researcher) first few years of employment as an academic, 2002–2005, as a lecturer for the computer engineering school in a Southeast Asia university. After a brief stint in algorithms and Java programming, the teacher was appointed as the full time coordinator and lecturer of the 'Software Engineering' course.

As course coordinator, the author began to notice minor incongruities in the students' behaviours. Fleeting glimpses transformed into an acute awareness of a malaise exhibited by the students towards the established learning and teaching. The situation became increasingly evident: except for a small proportion of high achievers, students seemed very detached from and apathetic towards their learning, almost as if it were some onerous chore they were forced into. Of course, the students were much too reserved to voice such a sentiment openly, but their behaviour spoke volumes.

- Not attending lectures and tutorials—In the first few learning sessions, the attendance was high, but it quickly diminished until by mid-semester, the attendance generally stabilized to under 50%. This was in stark contrast with the near-full attendance in the lab sessions.
- Not asking questions of the teacher—Asking questions during lectures pretty well never happens. Asking after classes in a one-to-one interaction and emailing are the preferred approaches for posing questions; the highest number of students to ask questions of the teacher in a semester was 15 in a class size of over 100. In casual dialogue, students showed cognizance of the effectiveness of seeking clarification from the teacher on areas of uncertainty in the new knowledge. When pressed to explain the inconsistency of their understanding and their actions, some students claimed that they had no uncertainties. Yet, subsequent on-the-spot assessments showed that the majority of these students were nowhere near the degree of material comprehension thus professed. Other students purported shyness as their reason for not asking questions.
- Not attempting take-home formative assignments and practice questions—In the first couple of tutorials, a few students have started the assignment, with none

having completed it. (Note that these are formative, intended to build knowledge.) Thereafter, the number of students having started the assignment drops to nil.

- Not reviewing and revising new knowledge regularly or even at all, except during a few days of intense cramming before the examination—The evidence for this was situational and testimonial. There are numerous study tables for the school's student. Typically, in the teaching weeks of the semester, they are occupied by students from other schools. Only during the exam revision week do the school's students occupy the tables. In the course of casual discussions, several students candidly admitted to focusing their learning efforts solely to passing the exam, after which they would (metaphorically) 'dump' the knowledge. Other students explained it was a learned habit to cram. The corollary of this was that the students were not applying relevant knowledge from prior learning opportunities to the acquisition of new knowledge, essentially derailing the process of iterative construction of personal knowledge that is the cornerstone of the formal education system.
- Not studying the prescribed references for the new knowledge—Evidence for this was usage reports from the university's learning management software, and on-the-spot assessments and workshops. Supporting the course were approximately 50 primary references (presentations slide packages, assignment questions, lab instructions and handouts) and approximately 30 enrichment references (video lecture recordings, YouTube videos, and industry and scholarly articles). The references with standout usage statistics were lab instructions with the highest one-time-only usage (about 80% of cohort) and recorded lectures with the highest repetitive usage (about 30% of cohort). Otherwise, the overall usage was under 10% of cohort, with articles having the lowest (bordering on nil). Though possibly the students were studying reference materials from other sources like the web, the students' dismal performances on unannounced assessments and workshops clearly indicated that effort, if it existed at all, was insufficient, ineffectual or both.

Up to this point, these had been one person's observations. Regrettably, the conclusions were subjective and retrospective since the teacher had not collected data real time. (Data collection of the classroom operation had not been mentioned in the orientation.) Also possible was that these observations were a misinterpretation, a natural mistake made by a new faculty settling into the appointment and new environment. (After all, this was the Western teacher's first immersion into an Asian institution that is 99% comprised of Asian students). Yet, having formed these opinions, it was also natural to share them with colleagues. Much to the chagrin of the teacher, his observations were substantively corroborated. The agreed and consistent opinion of the majority of school's teachers was that their students also exhibited all of the observed behaviours and even more in their learning sessions. Incidental to the main theme of the information sharing, it was discovered that no one was collecting data on this situation.

Being motivated by the revelation of the veracity of the problem, the first author formulated a three-semester project and qualitative analysis in 2006-2007 to determine if authentic improvements to select artefacts and procedures in his course would generate a commensurate improvement in the student's learning behaviour, e.g. increased reference study, higher attendance and increased undertaking of assignments. The artefacts and procedures selected for improvement—lecture presentation organization, learning activeness, skill building, formative assessment and lab experiment—were recognized as being seriously divergent from the best practice of learning and teaching in higher education, according to a 150-hour course on learning and teaching that the teacher was attending at the time. Though the changes were extensive, pervasive and traceable directly to the best-practice prescriptions, an ensuing qualitative analysis showed an insubstantial increase in student behaviour (Jones and Gagnon, 2007). The report identified three possible causes for that result: language, prior conditioning, and innate learning mechanisms. That is, these causal agents were impeding the students' abilities to invest effort into the learning opportunity. This first attempt at learning and teaching research—retroactively the prelude of the teacher's research in blended learning—ended with no answers and still more questions.

It was at this time that the conventions of learning and teaching in the university were rocked by three prominent events in quick succession. First, in an unpublished experiment in the August 2007, the school dramatically reduced the class size in one computer engineering course. The cohort for that course was partitioned into three groups, and assigned three separate sets of lecturing, tutoring and supervising faculty. The results were equally dramatic. Attendance shot up, and participation in formative assignments increased significantly. However, the drain on manpower was too much for the school to sustain, and the initiative was quietly shelved after two semesters. Second, draft copies began circulating in October 2007 of a groundbreaking report on the state of the undergrad experience in the university. Officially released in March 2008, the report, Blue Ribbon Commission, called for sweeping improvements in pedagogy and learning spaces. Third, in August 2008, a new degree, computer science, was launched in the school to operate in parallel with the incumbent computer engineering programme. When the first courses began running in the first semester of 2009, students' attendance and participation in learning activities were very high.

These three events revealed a way forward in resolving the problems experienced in the school. Clearly, attendance and participation problems were not insurmountable; however, they were expensive. To achieve a substantive improvement, the evidence suggested that the change to the course and its learning and teaching had to be equally substantial. In the case of the three events, the support originated with the university; a faculty member acting alone could never enact a change of such magnitude. Moreover, the school was highly unlikely to provide such support. If it could tolerate years of the student participation problems, why would the present be perceived as the time to support amelioration? Under these conditions, the change would have to be significantly impactful to invoke the kind of change in the students' behaviours that would be worth the effort and within the teacher's purview. In other words, the change would have to be limited to the software engineering course. About this time, the second author returned to resume his academic career at the same institution after a decade in industry. Both authors remain practice-oriented researchers, having first met in 2001 as IBM consultants. The second author was also successful in securing an NRF grant with the mission of applying interactive digital media in sectors such as education, healthcare and entertainment.

Having suspected that traditional lecturing was a prominent contributing factor in the students' poor attendance and participation, the teacher straightaway prescribed an implantation into the course of a new instructional design, plus the diminishment or even elimination of lecturing. Out of several competing instructional designs, blended learning—comprising of eLearning and face-to-face learning—came out on top as the most feasible and impactful choice for these reasons.

- Blended learning was implemented neither in the university nor in any of the secondary education institutions feeding students into the university. In other words, the learning experience in the course would be calibrated to a level playing field because it would be commonly unfamiliar to all students, and measurements of the receptivity of learning preference would be as authentic and unprejudiced as possible.
- The eLearning part of the blended learning model was inherently extensible such that it could support activities and instruments more capable of enforcing the student's continuance through the sessions than other online models like flipped classroom, blog and forum.
- The face-to-face part of the blended learning model was a 'clean slate' that could be host to many options for active and participative learning activities that were not lecturing.

At about the time that the teacher was completing the final touches on the plan for his new instructional design project, the Centre for Excellence in Learning and Technology issued a call for educational projects to be submitted for Ministry of Education funding. So, with the project already in motion, the teacher wrote a proposal for the project and submitted it, unperturbed whether it would be accepted or not. Serendipitously, the submission was accepted, and the teacher was awarded a grant of SGD90K for 2 years, affording an estimated three semesters of data.

From that point onwards, the teacher adopted a dual role of researcher plus teacher. The blended learning instructional design was launched as a research platform in the first semester of 2008 to determine what effect it would have on the academic performance of the students. After weighing several alternative investigation approaches for their degree of allowable independent action and available support, the design-based research methodology (Amiel and Reeves, 2008) was adopted for the experiment. A learning model, based on Prosser and Trigwell (1999), was developed for the experiment to identify the data variables that were to be processed. Finally, a database of the learning preference of the cohorts was continued for the possibility that it might lead to a predictive mechanism.

In summary, the ideas, findings and perspectives shared in this book were preceded by years in the trenches starting from 2002, of immersion, introspection, reflection and probing into improving the learning and teaching in the university, in particular, in the software engineering course offered by the school. The authors' experience as teachers shaped the endeavour, such that the research and the learning and teaching are unified. In other words, the research cannot be envisioned as being an entity independent of the learning and teaching, and the propositions of the learning and teaching can be understood through the suppositions of the research.

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Above all, to our families.

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Synopsis of the Book

Even prior to the Covid-19 pandemic, many institutions of higher education were experiencing problems with low attendance to varying degrees in face-to-face learning sessions, with notable exceptions during examinations and labs, and dilatoriness in formative assignments. The result was lackluster and even below-potential academic performance of the students. This is not a unique problem; universities globally have been experiencing this phenomenon. Although it could be due to several things, such as fragile curriculum and ineffective teaching. From the onset of the pandemic, universities have been forced into radical, digital transformations and altered or replaced their existing instructional designs.

Taking a cue from these global efforts to turn around the diminishing performance of current students, a large, longitudinal research project was initiated to determine the effect of changing the instructional design from traditional lecturing to blended learning on the academic performance of students. This monograph reports the objectives, scope, methodology and findings of that project. The research focuses on two software engineering courses offered to students in different degree programmes by the Computer Engineering School in the university. The duration of the research was about 7 years, the first year for measuring the academic performance of students taking the course in traditional lecturing, and the next 4 years for students in blended learning. The experiment adheres to an Action Design Research (ADR) methodology, where the design of the blended learning research platform using Unified Modelling Language (UML) artefacts complies with Gagne's 'nine steps of instruction' and Chickering and Gamson's 'seven principles of good practice'.

The blended learning is a mix of eLearning and face-to-face learning. The eLearning involves motivating videos, prior knowledge assessments, digitized reading materials, learning assessments with feedback, practice exercises with feedback and surveys on the completed weeks' learning experiences. The face-to-face learning comprises problem-solving, study groups, presentations, formative assessments and formative peer evaluations; importantly, traditional lecturing is totally eliminated. Furthermore, the use of educational technology in blended learning, though more than in traditional lecturing, is kept to a reasonable level that should not be an obstacle for other teachers wishing to convert their own courses to blended learning.

A two-tier composite model relates formal learning and instruction theories with data processing. The first tier is a generalized learning model based on Prosser and Trigwell (1999), and the second tier is a data model designating the unique variables valuated in the experiment. The learning model specifies the elements in learning, primarily learning outcomes, prior experience and learning approaches. Data model elements trace 'back' to the elements in the learning model, and 'forward' to the experimental variables. The dependent variable comprises the six categories of marks, and the independent variables are instructional design, nationality, school affiliation, five categories of attendance, team leader and learning style.

The necessary rigour, repeatability and relevance for the research are handled in several ways. For the entire 11 semesters, there is only one and the same teacher for both courses, and that teacher is very experienced and steady, academic achievement strictly adheres to Bloom's taxonomy, the curricula of both courses are locked and the experiment is live in a real-life classroom setting. To the question of student variance across the eight blended learning semesters, the researcher audit of the integrity of the mark data in a 25% sample of those semesters confirmed no spurious or inconsistent variance.

Several important findings are made. The mean of academic performance achieved in blended learning is higher (statistically significant) than that in traditional lecturing; furthermore, traditional lecturing can be eliminated from higher education without diminishing the learning. Attendance has increased significantly and appears to be a very effective deep learning approach. As a tool for consistent and transparent adjudication of academic performance, Bloom's taxonomy is pre-eminent. Student critique on the teacher does decline with the operation of the new instructional design, but not enough to be detrimental to his/her employ. Students from China and India were the only members of the cohorts to experience a drop in academic performance in blended learning. A brief exploration of select global indices suggests this unexpected finding may be due to the 'digital divide' existing in those nations.

The research findings reported have now been incorporated into the work agenda of CeIDE (a collaborative intellectual venture of like-minded scholars, including both the authors). Suggestions for further research in the rollout of Higher Education 4.0 include: converting more courses to the new blended learning model, testing the learning styles and prediction mechanisms so that there is a 'goodness of fit', studying the relationship of online versus face-to-face and academic performance, and analysing prior experience of students with lowered performance in blended learning.

Contents

Acronyms

α	Alpha Significance Level
CE	Computer Engineering
CEF	Coursework, Exam, Final (marks)
CELT	Centre for Excellence in Learning and Technology
CM	Computing Minor
COTS	Commercial Off the Shelf
DLE	Digital Learning Environments
EdI	Education Index
F2F	Face-to-Face
H_0	Null Hypothesis
H_1 or H_A	Alternate Hypothesis
HDI	Human Development Index
HTML	Hypertext Markup Language
ICPC	International Collegiate Programming Competition
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
ILS	Index of Learning Styles
IOI	International Olympiad of Informatics
ISO	International Organization for Standardization
LAMS	Learning Activity Management System
LTE	Lecture, Tutorial, Exam (attendances)
MCQ	Multiple Choice Question
N7	Collective of these seven nationalities, {CN, ID, IN, MY, SG, SG PR, VN}
NRI	Network Readiness Index
OLE	Online Learning Exercise
PBL	Problem-Based Learning
PC	Personal Computer
QAP	Quiz, active learning, project (marks)
SOLO	Structure of Observed Learning Outcome
STF	Student Teaching Feedback
TEF	Teaching Excellence Fund

UML	Unified Modelling Language
WWW	World Wide Web

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Chapter 1
Introduction

This chapter introduces this document, a post graduate doctoral thesis, and outlines its contents, hereafter referred to as "the/this study". The scholarship of this study is learning and teaching in an instructional design[1] operating in an institution of higher learning. This thesis is a case study of the effect that a change of instructional design has on the academic performance of students enrolled therein. The indicated change is from the current yet antiquated 'traditional lecturing',[2] to the modern and innovative 'blended learning'.[3] This chapter is prefaced by a short dissertation on the personal motivations of the researcher, and subsequently followed by the detailed specification of the study's entire scope of literature search, planning, conduct, and analysis.

The available evidence from numerous of other case studies in several formal education settings globally suggests that blended learning has a positive/enhancing effect on the academic performance of students. This study supplements these other case studies with a unique education situation of blended learning, eliminated lecturing, higher education, Asian students, and computer engineering. This study will provide compelling evidence that the academic performance in the underpinning situation is indeed higher in blended learning than traditional lecturing.

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[1] A detailed scheme for learning and teaching in a formal education setting, that includes learning activities and outcomes, scheduling of activities, scaffolding, classroom management, and integration of educational technology. The material to be learned and the evaluation of the expected learning of that material, are imprinted into the operation of the instructional design. If the instructional design has instructionist components (Johnson, 2005), then faculty are assigned to operate it.

[2] Euphemistically known as 'sage on the stage" teaching, it is the transmission of new knowledge to multiple learners via a face-to-face (F2F) session in a classroom setting by a teacher verbally and visually communicating said knowledge. Since the learners are passive in the session, traditional lecturing relies on the transmission act itself to be sufficient to evoke learning in the recipients.

[3] It is a mix of different but reinforcing kinds of instructional designs that enhances learning through variance of packaging and delivery of the material to be learned. Blended learning is more of a template than a distinct design; the constituents of the "blend" are unlimited. In this study's blended learning, the mix comprises eLearning and F2F that is not traditional lecturing.

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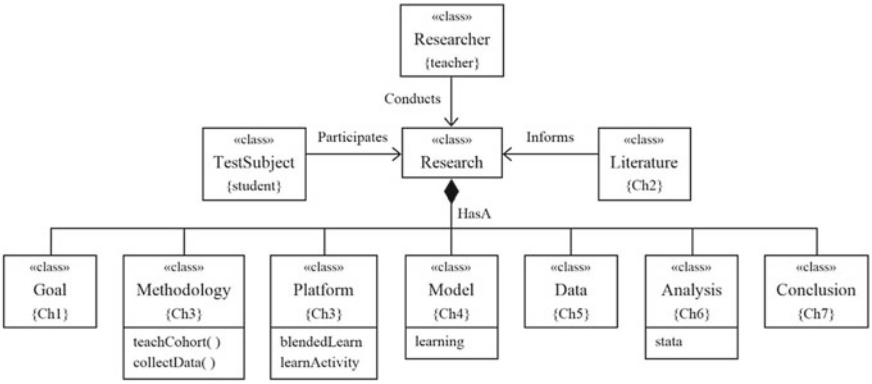

Fig. 1.1 Organization of research functions for this study (UML Class diagram)

The research in this study does not investigate the science of learning. Instead, it interrogates the theory and praxis of existing instruments in formal education, definitively categorizing it as educational research. While some researchers in other disciplines consider educational research to be methodologically unqualified (Shavelson, Phillips, Towne, & Feuer, 2003), more warrant that it exhibits all the requisite core qualities—representativeness, repeatability, and rigour—for it to be accepted as substantive research (Barab, 2006). So, this study will also take appropriate opportunities to reinforce this warrant of educational research quality.

Formal education has been practiced for at least three millennia. Consequently, there is an abundance of learning models upon which to base any educational research. It is a deliberate and necessary approach (for rigour, as explained later) in this study to employ an existing and widely accepted formal learning model instead of devising a new and unproven one. The model in point is from Prosser and Trigwell (1999), and it is applied in its rudimental form except for three minor modifications purposed to enhance its rigour and usability.

Figure 1.1 shows the ten major functional Classes that comprise most other research generally, and this research in particular, plus their relations to this chapter through Seven of this study.

Regarding all diagrams enclosed as figures, most are compliant with Unified Modeling Language (UML) (UML, 2004; Rumbaugh, Jacobson, & Booch, 2004), and will be identified as such with the appropriate UML diagram name, for example "UML Class diagram" appended to the figure's caption. UML is a world-class modeling language, globally accepted by much of the engineering community, and eminently appropriate for specifying any conceptions in this study.

As a walkthrough of the ten functional Classes in Fig. 1.1, this chapter is organized into the following sections.

1. Research setting;
2. Research question;
3. Survey of existing knowledge;

4. Research and experiment design;
5. Operation of the research platform;
6. Transformation and analysis of data; and
7. Reconciling the findings.

Research Setting

This section situates the research according to venue and roles. The applicable Classes from Fig. 1.1 are Researcher and TestSubject.

For most research, it is unlikely that its venue and participants would be a primary cause for rejecting it. However, situation of the educational research is a significant factor in the acceptance of its findings by practitioners in the community. In fact, much educational research is dismissed by fellow educators by virtue of their own students being in a different country or a different course. A case in point: though traditional lecturing has been discredited starting in the 1950s as a largely ineffective instructional design (see "Research Question" section), it is still the dominant instructional design in the majority of formal education institutions. The research on lecturing has been ignored by education practitioners and management alike for over 60 years because of mismatches in country and course. Consider the state that other disciplines would be in if research in those fields was similarly disregarded.

The venue of this study is a relatively young institution of higher education in science and technology hereafter referred to as "the University"; it is located in a prestigious Southeast Asia nation. The University has, on average, a population of 22,700 students. The majority of the student intake, approximately 62%, is drawn from its country of residence. The remainder are mostly from South Central, East, and Southeast Asia; less than one percent of the international students are from outside Asia.

The University's student intake registers into established degree programs offered by its 13 semi-autonomous schools. Each school employs a compliment of faculty who teach/supervise/tutor the courses in its degree programs. The research in this study is situated in the University's computer engineering school, hereafter referred to as "the School". The researcher is a member of the School's faculty, and all but three percent of the test subjects are students from the School. The course whose students are the research's test subjects is "Software engineering".[4]

This study involves operating an old instructional design for the course, then replacing it and restarting operations with the new one. The Preface explains that the roles of researcher and teacher are combined into one person. In other words, the researcher in this study is also the teacher of the students in the course. This circumstance turns out to be a serendipitous condition and 'key success factor' in

[4]This course teaches the effective and efficient development of modern software, and general awareness of theory, knowledge, and practice in all phases of the software development life cycle, with an emphasis on design. It is a centrepiece course for the software domain of computer engineering, and mandatory for all students in the School.

this study. There are no misunderstandings between researcher and teacher in the development of the new instructional design. Even more important is that the teacher is highly knowledgeable and confident in operating it. Both instructional designs are associated with instructionism[5]—traditional lecturing is entirely instructionist, while blended learning is selectively so—consequentially, the capability and steadfastness of the teacher are inextricable factors in the experiment's conduct and generated results. Though somewhat messy and subjective, the real-worldliness of this circumstance is an integral even essential element of education research. (This is explained in the "Research and Experiment Design" section.) Fortunately, the subjectivity is greatly reduced by having one and the same teacher effecting the entire learning and teaching for the entire period of the experiment. This, plus the fact that the teacher has accrued three decades of teaching acumen, means that whatever peculiarities or personal imperfections are intrinsic to the teacher will be the same for all students for the entire duration of the experiment. In summary, the Researcher Class is a singleton,[6] and the operation of the instructional designs both before and after the changeover, are normalized and will not differentially bias some parts of the experiment over others.

There are 856 student test subjects participating in the research. All but three percent are registered in the computer engineering (CE) degree program, and taking the Software Engineering course. These three percent are registered in a reduced version of the CE degree, known as the computing minor (CM) degree, and the course these students are taking, "Reasoning with Objects", covers exactly the same material in "Software Engineering", except in less breadth and depth. Though it may be another messy and subjective effort to relate the two courses, the common teacher plus ingrained compensation (by virtue of the lessened difficulty) for the CM student's lesser background knowledge in computing, serve to induce a degree of normalization into the situation. Hence, it is reasonable to expect that the potential of academic performance of each of the 856 instances in the TestSubject Class will fit into a normal distribution.

In summary, the Researcher Class is CE faculty in a young technology and science university in Asia. The TestSubject Class is Asian higher education students in the CE and CM degree programs, all taking courses in computer engineering.

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[5] Theory of learning and teaching that is teacher-focused, skill-based, product-oriented, non-interactive, and highly prescribed. Instruction is directed toward efficient movement of skills and knowledge from the teacher to the student, often in the form of drill, practice, and rote memorization. The application of instruction technique by the teacher, and the nature of the new knowledge are assumed to be isomorphic (Johnson, 2005).

[6] In software and design vernacular, this defines the existence of a single instance for the subject Class. In the case of this research, the Researcher Class is a singleton because there is only one researcher for the entire experiment.

Research Question

This section describes the learning and teaching problem that prompted the research, and states the solution chosen to address that problem. The applicable Class from Fig. 1.1 is Goal.

The research question is "what effect will a change of instructional design have on the academic performance of students enrolled therein, the change being from traditional lecturing to blended learning". It unpacks into two fundamental aspects, effect and problem–solution. Firstly, the aspect of "effect on academic performance" is naturally quite expansive. Assuming an "effect" is even observable, it would range from positive/enhancing, to nil/negligible, to negative/detracting, and anywhere in-between. "Academic performance" is bound to the 'attainment of learning outcomes' that are bound to the institutions' authorized modes of evaluation and the nature of the material to be learned. The measure of "attainment" is 'marks' with values drawn from the scale 0–100 allocated to the student, where the higher the mark duly indicates the more and better attainment of learning outcomes. The allocation of marks is adjudicated by the teacher; this is another reason why there being one and the same teacher for the entire period of the experiment is such a success factor in the study. So, the effect being sought in the experiment is, the students achieving higher marks in blended learning than in traditional lecturing.

Secondly, the research question implies the existence of a problem with respect to traditional lecturing and posits that blended learning will act to counter the problem in a positive manner. Chapter 2 provides substantive evidence for these two suppositions of problem and solution, but just a few are elucidated now. Publications tell an uncompromising story of traditional lecturing and blended learning. Against the extensive publications proclaiming traditional lecturing to be ineffective for formal learning, there is a pittance that declares otherwise. Contrastingly, one finds almost no publications revealing issues with blended learning; instead, nearly all publications in that it is discussed praise its effectiveness in formal learning.

A common sense and ostensibly crucial difference between the two instructional designs emerges. Traditional lecturing is designed and practiced pursuant to the supposition that a student can activate their learning capability as a function of personal will. That is, the student can enter a dictated space at a dictated time of day, listen passively to a dictated 'knowledge expert' transmitting "information chunks" in closely-timed intervals, and within a few short moments acquire, process, and commit to memory, all that information and its nuances before the next chunk is fully sent. From the Preface, traditional lecturing is evidently neither an effective nor preferable model of learning for most of the School's students. For one thing, these students opt to not even attend lectures, and instead view the recordings of said lectures from an outside learning space. For another, the majority of students engage in the practice of 'cram learning'.[7] Both of these are clear pronouncements

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[7]This is rote memorization of the entire complement of course material in preparation for a mass regurgitation during the final examination. However, for many of those students doing the cramming, it is their first time viewing the course material, or opening their textbook, or putting pen to paper

by the students that anywhere–anytime learning is far more favoured than dictated place-time learning.

Some may point to traditional lecturing being a mainstay of formal education for millennia, and acclaim this as evidentiary of its effectiveness. However, the truth is that for all that time traditional lecturing was never conducted on a mass (hundreds of students in a single place) scale across the entire society. Instead, most formal learning in the ancient world to middle ages was always conducted with small and select[8] groups of students, in programs such as trade apprenticeships, theology and other indoctrinations, and ruling-class perpetuations. Traditional lecturing, as it is now practiced in classrooms loaded with hundreds of students, is an imperative of the industrial age. Its longevity is expediency in the absence of mass communication technology, not a testament of effectiveness. (In one of his early publications, Dewey (1915) perceived the establishment of mass education as the industrial age's by-product, and derided it as a failure of equally massive proportions.)

Blended learning promotes a mantra of the student being in control of his/her learning insofar as the place, time, and topic for that place-time. Though this seems to be merely a personalization of learning, it also and importantly inserts activeness and resource optimization into the learning process. Choosing the time-place for undertaking a learning activity, opening a desired document to find a page containing a topic for reading, and the combination of positioning a cursor then pressing a mouse button, are all examples of individual activeness. In point of fact, though the student is sitting in front of his/her computer, he/she is actively participating in the material being displayed, by virtue of mental deliberations as well as physical movements. It is a universally accepted fact that "an active student is a learning student". The other benefit of choosing the place and time of learning is the coincidental access to an expanded supplement of information resources. In an accommodating learning space, surrounded by books, notes, images, videos, and computer files, a learner can turn to owned and trusted sources of background and foundational information in an unhurried and deeply deliberative manner not possible in a classroom where the learning period is immutable and limited.

In summary, the Goal Class specifies the evidentiary conceptions of the research that blended learning results in higher marks than traditional lecturing for Asian, higher education students accepted into the University and assigned to the School. The Goal is rooted in the knowledge that, not only is traditional lecturing found in numerous publications to be ineffective at generating learning in today's mass classrooms, it is also rejected by the students themselves. Blended learning, on the other hand, has shown repeatedly to generate learning effectively in the information age classrooms.

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in undertaking any kind of interrogation of the material in a problem–solution exercise. In other words, cramming is their form of instructional design.

[8]The selection process of 'double-acceptance' essentially guarantees that whatever instructional design is employed in the learning and teaching will result in effective learning. The first acceptance is the candidate apprentice must strongly desire the training, and explicitly signal that desire plus rationale for worthiness to receive the master's learning. The second stage is for the master to accept the candidate apprentice as being worthy of the secrets of his/her knowledge.

Survey of Existing Knowledge

This section describes the survey of existing knowledge in learning and teaching in higher education, the domain pertinent to this study. The applicable Class from Fig. 1.1 is Literature.

In learning and teaching, as in other mainstream scholarly pursuits, there exists a plethora of literature assembled from centuries of study by a large and diverse community of scholars and practitioners, that is at times overlapping and at other times rehashing duplicate ideas, circumstances, processes, and phenomena. The challenge for the researcher is to sift through this material and discover the most useful and reasonable inter-relations to his/her research.

The experiment is that changing instructional design from traditional lecturing to blended learning instigates some effect upon the test subjects. However, an instructional design is a plan for applying instruction theory towards formal education. In this 'plan form', analysis is meaningless. It must be transformed into an instance of tangible parts and procedures that is applied to tangible learners, for a meaningful experiment to transpire. To this end, instructional design is a deliberation of praxis that must be manifested into a phenomenographic[9] (Marton, 1981) practice that generates real data in a real-world occurrence. Therefore, the most relevant and educative literature concerns the praxis of learning and teaching, the instructional theory that informs it, and the foundational theories of formal learning that correspond to it.

The Literature Class for this study starts with the essential formal learning theories, such as behaviourism and cognitive. Then, it explores the instructionism and constructivism (Papert, 1990; Johnson, 2005), and cognitive development theory (Huitt and Hummel, 2003) and fixes the study at the 'formal operational stage' conforming to higher education. The Class proceeds with discussing instructional theories proposed by several eminent theorists and practitioners, followed by the desired learning strategy crafted from those theories.

Next is an examination of as much as possible of the literature on blended learning. As inferred earlier, blended learning infers a mix of different instructional designs; the version employed in this study, which is the most common, is the mixing of eLearning and face-to-face (F2F) instructional designs. Varying definitions for eLearning and F2F instructional designs are also explored. In conjunction with the eLearning, the Class unpacks relevant topics in educational technology, such as its challenges for the teacher, and 'digital native'[10] stereotyping of the modern higher education students.

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[9]A collective intellect of common, stable, and generalizable conceptions and understandings of reality borne from peoples' interpretations. Phenomenography posits two perspectives: first-order descriptions of various aspects of the world, and second-order descriptions of people's experience with the first order. A phenomenographic practice is an evolutionary tool that facilitates expanded understanding of aspects of the real-world, such as education and learning.

[10]A term coining a theory by Prensky in 2001 that modern students think and process information fundamentally differently as a result of the volume, pervasiveness, and ubiquity of digital devices in the human condition. While the depth of adroitness and generational situating of the theory are contested, there is a great deal of observational evidence that keeps this theory in view. Prensky's

The Literature Class ends with a walkthrough of the learning style for engineers developed by Felder and Silverman in 1988.

All conceptions in the Class have models to explain their structure and behaviour. Most of these models are textual in nature. There are also a few diagrammatic models, some conforming to the UML specification, and some not.

In summary, the Literature Class walks through the relation of learning theory to instructional theory to instructional designs most appropriate to the situation of this study, being Asian higher education students studying computer engineering in blended learning with no lecturing.

Research and Experiment Design

This section describes the research methodology followed in the experiment, and the manifestation of the solution proposed in the "Research question" section. The applicable Classes from Fig. 1.1 are "Methodology" and "Platform".

As mentioned earlier, the conduct of educational research is saddled with certain messy and subjective exigencies by virtue of its real-worldliness. In this study, the real-worldliness facing the researcher includes:

- dependence on the teacher's ability to effect learning and teaching consistently regardless of instructional design;
- longitudinality of the experiment in order to reconcile with a principle of induction[11] proof; and
- sampling test subjects with individualized prior experience (Kozulin, 2003), and varying degrees of situational awareness (Chaiklin, 2003) over a period of several years.

Design-based methodology is the most widely applied in educational research for retaining the real-worldliness while diminishing the messiness and subjectivity.

Design-Based Methodology

Design-based research methodology is the development and measurement of performance of an instance of design and its iterations. Findings are derived from an analysis of its performance in the context of the environment. Crucially, the design must conform verifiably to accepted principles and best practice; in other words, the

original article has 15,306 citations by Google Scholar's count, and has been reprinted in 270 versions.

[11]This is a philosophy of scientific proof taking the direction from the single occurrence to the classification of taxonomically-related occurrences. The opposite of induction is deduction, which is from the classification to the single. Induction is particularly applicable for design-based research.

design must be 'right'. The instance of the new instructional design plus its iterations is hereafter referred to as "the research platform". (Its specification is in next section.) A diagram (not UML compliant) in Chap. 3 describes the basic differences between design-based and hypothesis-based research methodologies.

Educational research has many confounding variables, thus challenging the veracity of variable dependencies on posited triggers. However, the innate real-worldliness in the design formulation and implementation is exactly the condition that must be followed to make the research relevant. Since mass education has not yet graduated to direct-to-brain stimulus of its students (see Fig. 1.2 for a satirical portrayal of such a mechanism), research is relevant to today's students only if it is implementable in today's classrooms. Finally, if sufficient rigour is applied in normalizing as many confounding variables as possible, and in ensuring the repeatability of the design and experiment, then the methodology is recognized as sound and congruent for educational research.

The high-level plan for the research in this study is to record one year of traditional learning data, followed by a run of the experiment for at least one year. The high-level milestones for the experiment are:

- brainstorm and finalize development plans for the research platform from August 2007 to April 2008;
- obtain School's acceptance of the experiment by end-May 2008; and
- deploy the research platform in August 2008.

Traditional learning, as its name suggests, is a well-established instructional design and is known to produce stable academic performance results semester-on-semester for years. So, the year of performance data may be gleaned from any period prior to the launch of the experiment, without concern for its integrity. For simplicity, the year period decided upon is 07S1 to 07S2, just prior to the experiment's start.

However, blended learning is entirely without precedent in the School and University; its newness engenders a significant deployment risk. A new instructional design

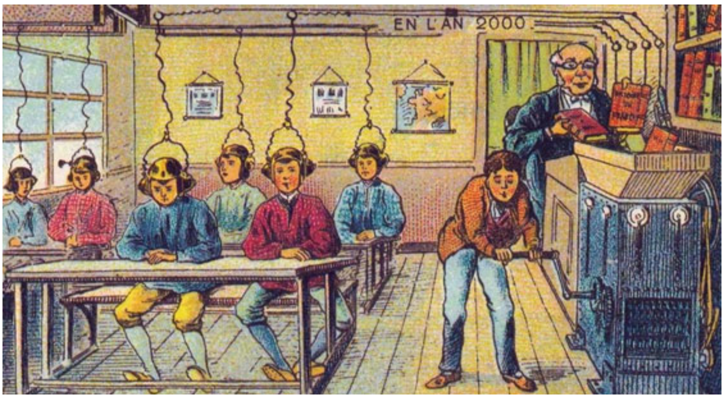

Fig. 1.2 At school; 1900 World Exhibition in Paris (Asimov & Côté, 1986)

is similar to a new course in that it requires several iterations of edits and enhancements before it is reasonably free of design and deployment incongruities and inadequacies. Finally, with such difference to the other courses that the students take in the year, there is no knowing what their reaction to blended learning will be. Yet, the eventual duration of the experiment is forced by a circumstance and unpredicted, that of fatigue of the researcher-teacher in carrying out the workload of two roles. The final duration of the experiment ends up being four years.

It is understood that the University recruits its students according to well-established processes and standards. During the period of the research, 2007–2012, these were not changed significantly, rather tweaked in select and very focused circumstances, such as special foreign recruitment of Kazakhstani students in 09S2 (second semester of academic year 2009–2010). Therefore, it is presumed upon good account that the potential of desired academic performance of the University's students is normalized, and that this normalization extends to the students assigned to the School. Given this, it is a viable exercise to compare overall results against that semester-by-semester, and thus reveal any significant deviance. Typical root causes of such deviances are students who are repeaters, not exposed to innovative instructional design in their prior experience, resolutely anchored to traditional lecturing, or nonproficient in digital learning environments. If a deviance is unexplainable, only then may the semester-on-semester integrity of the test subjects be suspect.

Specification of the Research Platform

The research platform comprises 13 customized learning activities, two learning journeys/sequences, and 11 educational technologies. In conformance with the agreed "blend" for this study, some activities are eLearning and others are F2F; however, no activity is both. With the advice of the Centre for Excellence in Learning and Technology (CELT), a six-step method for constructing and deploying the research platform is devised in early 2008 by the researcher, and then put to the test in the summer leading up to its launch. It is only after the experiment's termination, with the method fully tried and proven sound, that it is published for advisement of the University faculty (Jones, 2012).

The six-step method identifies up to three dimensions of learning activities and journeys in any blended learning instance: daily, weekly, and one-time-only by semester. In this study, only the weekly and semester dimensions pertain. There are eight weekly learning activities, {Conspectus parts 1&2, Online learning exercise (OLE), Project, ReflectionIndividual, Review, Seminar parts 1&2}, and five semester activities, {ExamFinal, ExamMidterm, Orientation, ProjectAssessment, ReflectionTeam}. The weekly learning journey is based on a three stage cycle, initialize take possession assure quality. In that cycle, first the student learns the scope and content of the week's new material via the OLE. Second, the student reinforces and expands his/her initial learning by reflection, formative assignments and presentation in the Project and Seminar. Third, the student undergoes a summative assessment of his/her learning (Review), and wraps up his/her learning by sharing an application of that learning towards a unique problem with the remainder of the cohort (Conspectus and ReflectionIndividual).

The semester learning journey supplements the weekly learning journey with specialty activities, mostly assessments, occurring before, in the middle, and at the end of the semester. However, Orientation and ReflectionTeam are noteworthy. Perhaps a 'key success factor' for the experiment and its assigned cohort is a solid introduction and familiarization with blended learning. Quelling the anxiety of students with respect to the unfamiliar and quite alien blended learning is considered by the teacher to be a necessity for encouraging them to cooperate and even flourish in the new learning situation. For a positive message about the new instructional design to promulgate to the next-in-line cohort, a debrief with each team is held by the teacher at the end of the semester as an outlet for the students to share their thoughts on innovative learning and how the blended learning experience affected their learning success.

Any practitioner can attest to the initial use of new educational technology being highly stressful. So, the technology is selected with a mind to downplaying the extent of its scope and reducing its inherent potential obstacles (Ertmer, 1999). The intended payoff is to not discourage other faculty from setting up blended learning in their own courses. In other words, the emphasis in the research platform is for the technology to support the learning activities and not supercede them in importance and effort. This is effected in two ways. First, approximately 60% of the eleven educational technologies are commercial of the shelf (COTS) that are supplied along with training and maintenance by the University. Second, the other 40% are customized using HTML and java script programming languages that are intuitive and easy for any engineer to learn and apply.

The behaviours of the {Conspectus, OLE, Seminar} learning activities, and {weekly, semester} learning journeys are modeled with the UML Activity diagram. The educational technology models are screen-snip figures of telling displays.

In summary, the Methodology Class is design-based, with a high-level plan of gathering test subject data for one year traditional lecturing and four years blended learning. The Platform Class is an instance of blended learning with eight weekly and five semester custom learning activities, and eleven educational technologies.

Operation of the Research Platform

This section describes the learning model, and the first bisection of the computer methods for data processing, that is the data requirements, collection, cleaning, and combination. (The second bisection is described in "Transformation and analysis of data" section.) The applicable Classes from Fig. 1.1 are Model and Data.

With all the emphasis in design-based research on the design being 'right', it is likely that at best the design would be concomitant but not inter-dependent with the phenomena under investigation. At worst, a data processing scheme would have to be supplanted into the design. In this study, the potential gap between the learning and teaching theories in Chapter 2, and the research platform of Chapter 3 is bridged by a 'two-tier composite model'. The first tier model specifies the elements of learning and teaching pertaining to the instructional designs, as understood from the Literature Class; hereafter, this is referred to as "the learning model". The second tier model specifies the data items in the research platform to be processed, hereafter referred to as "the data model". The learning model constitutes the requirements for the data model, as it connotes those elements intrinsic to learning and teaching, for which synonymous data must be collected. Thus, the two-tier model ensures that the data processing compatible with the research platform, is also conformant to the conceptions of learning and teaching theories promoted in the Literature Class.

Educational research dictates that the research platform must operate as an authentic, real-world learning endeavour. So, it is expected to generate data in excess of the learning model. Hence, the mapping of the learning model's elements to those in the data model is expected to be, in most cases, one to many. (With this first ever instance of innovative learning and teaching in the School, the researcher has maximized the data collection, to the point where far more data has been accrued than is needed in this study. The intention is to analyse this excess data in future studies.)

Learning Model/Data Requirements

The learning model is a synthesis of all the relevant conceptions of learning and instruction theories and designs into one cohesive specification of this study's learning and teaching for higher education students. In this study, it is the first tier of a two-tier composite model.

A new model could have been developed from scratch interpreting the conceptions in Chapter Two. Recall this from earlier sections; it is in the interests of any educational research to exercise the highest degree possible of representativeness, repeatability, and rigour. Therefore, the well-endorsed Prosser and Trigwell (1999) model of learning and teaching of higher education students is adopted as the learning model for this study. Its rudimentary form is retained, except for three minor modifications to enhance the rigour and usability of a few of its more esoteric aspects:

- two diagrams espousing the substance of their model are redrawn to be compliant with UML specifications;
- the term and concept of 'constitutionalism' is completely dropped from the model, as it is deemed incongruent; and
- "disintegrated" learning approach is replaced with the "strategic" approach, since the School's students are observed practicing the latter but not the former.

The learning model comprises two UML diagrams, a Class diagram for the structural aspects of learning and teaching, and an Activity diagram for the behavioural aspects. Having these two dimensions in the learning model is a testament to the completeness and competency of Prosser and Trigwell's handiwork. In no way diminishing that, only the structure diagram is needed for the derivation of the data items as they are entirely structural in nature. (The data model is a UML Class diagram.)

The structure model specifies that the major building blocks in a higher education student's learning are his/her: prior experience (per Vygotsky theory), situation perception (per theories of Piaget and Dewey), and adopted learning approach (per foundation theories of Gagné, Chickering and Gamson, plus many countless other approach proponents). All these are conjoined with the learning outcomes (per theories of Biggs and Bloom), and decreed by the learning context (including course and instructional design). The behaviour model shows that prior experience and learning context form a perception of learning that leads to execution of learning approaches, that in turn lead to fulfilling the learning outcomes.

The Classes of the learning model are individually verified for feasibility of measuring and evaluating their conceptions as data items possibly collectable by the research platform. Fortunately, the learning model is well-conceived and very authentic in its design, so most of its Classes are successfully verified. Those Classes deemed evaluate-able as data items are {Context, Outcome, PriorExperience, Relational, Style}.

Derivation of Data Model

The data model specifies the data items to be processed in the research platform. In this study, the data model is the second tier of a two-tier composite model. The data items in the model are traceable to elements of learning and teaching theory through the first tier, learning model.

Five Classes from the learning model are evaluate-able as data items; the research platform is designed to generate many more data items than that. So, the mapping of the element in the learning model to those in the data model is definitely 'one to many'. Additionally, the nascent mapping must be validated against the already ongoing data collection scheme, in order to eliminate any data items from consideration that contravene the processing standards of the University as actualized in traditional lecturing. The set of mapped and validated data items are then assembled as design constituents of the data model.

The only mapping that is essentially one-to-one, and therefore the easiest to establish, is the Style Class. Only the 1988 Felder and Silverman learning style is studied with respect to the student's learning approaches. Using this scheme, there are just four bands of values provided in a reading of a person's learning style. Validation is waived. The mapping is, Style {Act&Ref, Sen&Int, Vis&Vrb, Seq&Gbl}.

Probably the most straightforward mapping pertains to the Outcome Class. Learning outcomes are manifested in the University only by marks. Two principal marks, coursework and final examination, are required to be submitted to the University through its mark entry system. The mark system generates a final mark that is a weighted average of the two submissions. Additionally, the teacher captures many more kinds of marks, such as participation, peer assessment, post in forum/wiki, project, quiz, workshop, etc. Validation highlights that several kinds of marks were collected by the teacher in traditional learning that do not exist blended learning, and vice versa. This leads to a cap of six marks in the mapping, thus making it Outcome {Final, Exam, Coursework, Active, Quiz, Project}.

The next straightforward mapping applies to the Context Class. The learning context is analogous to the situation of the educational research, which is Asian higher education students studying computer engineering in blended learning with no lecturing. Validation is waived. The mapping is, Context {BlendedLrn, Student, Teacher, Traditional}.

Unfortunately, the two last Classes are difficult to map to evaluate-able data items. For the PriorExperience Class, the data items have to trace to indelible aspects of the students' perceptions of learning in formal education, originating prior to taking the course. The main issue is validation; there is little call for such data under traditional lecturing. The best to be done is to use the few biodata items available from the University. For the Relational Class, data items are needed that represent students' choices of how to learn that are not forced by the teacher or School, for example, volunteering for the competitive programming club to acquire deep learning of software coding. The challenge is again validation, as the set of choices that can be made by the students in each instructional design are unique; it is really a guesstimate as to their equivalence. The finalized mappings are PriorExperience {Nationality, SchoolAffiliation}, and Relational Class {Attendance {F2F, Exam, Lab, Lecture, Tutorial}, TeamLeader}.

In summary, the data model, a UML Class diagram, has in total 27 Classes, including six for marks, six for attendance, five for learning style, and three for instructional design. The remainder of the Classes are Course, Nationality, SchoolAffiliation, Semester, Student, Teacher, and TeamLeader. The marks and attendance data is quantitative (ratio), and the remainder of the data is qualitative (nominal, ordinal, and binary).

Collection of Data

Data for the 856 test subjects is collected in almost all of the 27 Classes of the data model. The exception is those Classes belonging to the learning style, for which there are 826 observations. The total quantity of data collected for the five years of research is 17,079 items. The next stages in the first bisection of data processing following the application of the data requirements into the data model are collection, cleansing, and combination.

The data items in the data model are generated from three sources: teacher, University, and online questionnaire for index of learning styles (ILS) (Felder & Soloman, 1999). The teacher generates all the marks, attendance, and team leader data. The University records the student biodata for regulatory reasons, and provides the teacher on request with a subset of that data for classroom management purposes. Lastly, upon submission by the student of his/her responses to the questionnaire, an ILS report is returned online. The student emails a copy of it to the teacher.

The teacher collects all the data—every item in digital format—and permanently stores it in Excel workbooks. One workbook holds all the ILS data for every student, with each semester's survey in its own worksheet. In addition, there are two other workbooks per semester, for a total of 22. The first workbook holds the student biodata, and attendance and participation data for tutorials and seminars in five worksheets. The second workbook holds the all marks and project data in 15 worksheets. The contents of the 23 workbooks corresponding to the data items in the data model are copied into one new workbook, the content of each workbook condensed into one worksheet therein. The contents of this new workbook are hereafter referred to as "the data set".

The cleansing stage involves identifying students who dropped out of and repeated the course. Students who dropped out of the course are easily recognized by having biodata, but partial or no marks and attendance ILS data; these are summarily purged from the data set. Those that repeat the course are harder to deal with, as some repeat several times, some repeat only the exam, and others repeat the coursework and the exam. Some are purged, others are left in and given a zero mark for coursework and/or exam. Fortunately, these students amounted to only two percent of the total test subjects.

The combination stage involves masking the student names and aggregating the data set—each semester's data is thus far in its own worksheet—into one worksheet. The masking schema is a randomized set of two to five letters, based loosely on letters found in the students real names. A masked name column is added into each semester's data, thus relating each student's row of data with the masked name. Note that students repeating the course have their masked name repeating in the semesters. Next, columns for biodata and ILS are added to the 11 marks-project worksheets, and the corresponding biodata and ILS scores are copied into those columns, matching row-by-row to each student in the semester. Finally, these expanded worksheets with the masked name in place of the student's real name, are copied into a new worksheet starting with the 07S1 semester. The copy of each successive semester's data is appended immediately below the last row of the previous semester's data copy, until all 11 semesters are combined into the one worksheet. This worksheet is ready for inserting into the statistics software's proprietary data table format.

Three aspects of the data set are noteworthy. Shortly after the experiment commenced, the School launched a new degree program, which reduced the students taking Software Engineering per year, from 233 to 129. Eighteen nationalities are represented in the 856 test subjects, although only seven of them have a frequency of 30 or greater. The set of these seven nationalities is referred to as "N7".Lastly, marks are adjudicated according to the seminal taxonomy of cognitive outcomes first published in 1956 by Benjamin Bloom,[12] and then revised by in 2001 by Anderson, Krathwohl, and Bloom.

Access by outsiders to the collected data set for audit and verification is controlled. Though the marks are generated by the teacher, he does not own them; they are the IP of the University. Furthermore, access to the data with the students' identities unmasked is prohibited per the informed consent. The data set with students' identities masked—in other words, the combined worksheet described earlier—is provided for public access.

Transformation and Analysis of Data

This section describes the second bisection of the computer methods for data processing, that is the transformation and analysis of the data set subsequent to its cleansing and combination. The applicable Class from Fig. 1.1 is "Analysis".

If transformation of data is conducted, it is to only select data and typically for the purpose of simplifying the written expression of frequently repeated analysis commands. In this study, two sets of derived data items are transformed from existing data. First, InstructionalDesign data is derived from semesters, whereby {07S1, 07S2, 07ST} are transformed into "trad" for traditional lecturing, and {08S1 to 11S2} are transformed into "blend" for blended learning. Second, all 12 code values in the four bands of the ILS report are transformed into 48 separate columns of binary values in the data set. Those code values originally assigned in the ILS report are evaluated as "1", while the unassigned values are evaluated as "0". (See Fig. 5.3 for a pictorial explanation.)

The data processing analysis in this study is primarily descriptive and exploratory statistics. The descriptive statistics are necessary for understanding all that the data set is and contains. The data set comprises over 17,000 data items belonging to 27 data classifications. Familiarization with the data set involves checking out the ranges of values in each classification, and establishing baseline connections between evaluations in ranges belonging to different classifications. For example, are the proportions of the mix of nationalities similar in each semester? Given the large size of the data set, determining such baselines is a time-consuming and tedious effort.

In the design-based research methodology, the researcher has not established a priori a set of hypotheses pertaining to the theoretical model. Instead, a trial design is operated/tested with the purpose of recording observations of some effect; hence, the analysis is more an exploration and less an explanation. Crucially, the researcher must be familiar with all of the data set in order to focus the exploratory statistics to those relations with the highest possibility of yielding significant findings. The other guiding factor in the conduct of the exploratory statistics is the research question. The

[12] 15,219 citations by Google Scholar's count, solely for the 1st edition. There are thousands more citations for the hundreds of supplemental publications co-authored with him, and spin-offs by other authors.

researcher honed the original question, “what effect will a change of instructional design have on the academic performance of students enrolled therein, the change being from traditional lecturing to blended learning”, into these more precise aspects of the effect:

1. Exhibit higher academic performance in blended learning than in traditional lecturing (for a majority of students);
2. Exhibit lower academic performance in blended learning than in traditional lecturing (for a coherent group); and
3. Can predilection for higher academic performance in blended learning be predicted (for any student)?

The analysis explores what phenomena are the three effects dependent upon for either occurrence or the degree of effect realized. The sole indicator of academic performance—the LearningOutcome Class in the learning model—accepted by the University are marks. This makes the six kinds of marks collectively the dependent variable. The candidates for phenomena upon which, the learning model suggests, marks are dependent are the Classes PriorExperience, and Relational and Style LearningApproaches. Summarizing from the data model perspective, the:

- dependent variable is the collection of {Final, Exam, Coursework, Active, Quiz, Project} data items; and
- independent variables are {Nationality, SchoolAffiliation}, {Attendance {F2F, Exam, Lab, Lecture, Tutorial}, TeamLeader}, and {Act&Ref, Sen&Int, Vis&Vrb, Seq&Gbl}.

The statistical analysis is conducted using the Stata software by StataCorp, a top-ranked package operating in numerous universities such as UCLA and Stanford. Stata is used in the descriptive and exploratory statistics to conduct almost 1900 tests such as {describe, summarize, tabulate, tab-with-sum, t-test two-tailed, Wilcoxon (Mann Whitney), correlation, regression}. The t-tests are for marks, since their distributions are determined to be normal. However, attendance is discovered to be non-parametric, so the Wilcoxon test is used instead.

The descriptive statistics cover all five major groups of items in the data set, that is context, marks, prior experience, relational learning approach, and style learning approach. Of the 25 charts and plots illustrating the findings of the descriptive statistics, two findings standout. First, the marks that the University’s students achieve seem to be independent of all their prior experiences. In other words, there is virtually no difference in the mean marks achieved by all nationalities and all schools in the University. This greatly contradicts existing perceptions! As stated in the Preface, it is the concerted opinion of the teachers in the School that its students are not as academically proficient—recall this is in traditional lecturing—as those in other schools. It is not known what gives rise to this opinion, but the reason why prior experienced has no discernible impact on the marks achievement is posited to be the University’s recruitment process. It is reasonable to believe that said process is purposed to exclude candidates that will not perform from entering the University. It is feasible that the process is very effective in recognizing those prior experiences that are efficacious so that the owning students may be accepted, and those prior experiences that are deleterious so that the owning students may be rejected. The overall effect would be as if the University population were academically homogenous despite their different and unique prior experiences.

Second, attendance and team leader have a significant direct relationship to higher academic performance. While this finding does not purport causation, it is unquestionable that students that regularly attended the F2F sessions exhibited higher marks. This aligns directly with the School faculty, of whom the majority equate the low attendance in classrooms with low-achieving students. The ramification of team leadership does not have a similar majority opinion because team leadership is not a prevalent characteristic of the School's courses. There is an extensive amount of work on the importance of attendance, and not so much on leadership in academics per se. Although there is not an accepted explanation on why attendance and academic performance are correlated, it is posited that making the choice to attend evokes a cognitive inducement to prioritize learning, whereas making the choice to not attend evokes a cognitive depreciation/diminishment of learning.

The exploration of the three effect questions revealed several interesting findings. First, blended learning does increase the academic performance of the majority of students. While the increase in performance is only a few marks, it is significant, and also, it is most significantly manifested in the examination performance. This means that the increase was in the individual's personal learning, not in team work. Attendance in F2F sessions also increases in blended learning.

Second, students with specific prior experience are disadvantaged in blended learning. Students from China and India achieve lower marks than students from the other nationalities in N7. Students from other schools, that is are 'not-School', achieve lower marks than those in the School. Concerning the differences in nationality, it is posited that the students may be the impacted by something of a digital divide. Possibly, the eLearning component being most prominent in technology acceptance, evokes some rebuff/dismissal with some students in those nationalities, thus reducing the overall marks. This finding is considered to have merit. However, the contrast in schools marks is considered inconclusive due to low frequencies of data.

Third, a prediction pattern is gleaned from the ILS report, though there is disconcertion with the exclusion of 'visual' responses. It is posited that since every coherent student group scored moderate to strong in 'visual' response, then academic performance is inert to the 'visual' response. It means that the visual scoring in ILS report is to be ignored, and only the three remaining bands are useful in the prediction of academic performance.

Finally, a continuity check of the final marks data across the 11 semesters validated the semester-on-semester integrity of the students. Two semesters exhibit marks observably outside the mean, {09S2, 10S1}. Once they are removed, the variance decreases significantly, and the semester-on-semester data settles into a state of uniformity. The outlier semesters are analysed in detail for student incongruities associated with the following standard detriments to student performance:

1. Repeating the examination, coursework, or both;
2. Nil prior exposure to innovative instructional design;
3. Resolute anchorage to traditional lecturing; and
4. Nonproficiency in digital learning environments.

Item 2 of the preceding items is inconclusive as qualitative data concerning this is not available for this study. However, the remaining three items exhibit remarkable clarity and consistency in explaining their positions above and below the mean. Therefore, the continuity check of the students is successful.

In summary, the Analysis Class is the descriptive and exploratory statistics applied to analyse the data set, and the findings gleaned from those statistics. The preeminent findings for blended learning are that it does result in higher marks, students from China and India do not perform as well in it, a prediction pattern in the ILS report has been found, and a continuity check validates the semester-on-semester data of the students.

Reconciling the Findings

This section describes the conclusions drawn from the findings, and the additions to the body of knowledge in learning and teaching. The applicable Class from Fig. 1.1 is “Conclusion”.

There are three important facts to keep in view in the pursuit of conclusions and additions to the body of knowledge. First, this study is a textbook educational researcher endeavour. It is an exploration of the effect on the academic performance of students in blended learning; a ‘right’ design is operated with test subjects, and the performance of the test subjects is measured and analysed. However, design-based research—the recognized methodology for education research—does not provide the researcher with the tools and process to explain the causality of the effect. Second, this is not an ethnographic effort, but the test subjects are over 99% Asian, so it is valid to situate the study’s findings as insights concerning Asian students. Third, the prominence and isolation of the research could have induced all manner of integrity issues, including the Hawthorne and inauthenticity effects. However, the significance of having the same person as the only teacher for the entire five years of the research cannot be emphasized enough. It is by far the greatest contributor to the study’s integrity and veracity, because it serves to normalize most of the confounding variables that could have otherwise plagued a research endeavour of this magnitude.

This study advances 11 conclusions from the research, all correlating the findings in Chap. 6 to create broader statements about learning and teaching.

1. Higher academic performance in blended learning is authentic;
2. Traditional lecturing is nonessential for higher education;
3. Undertaking a team leader role in a course project is an effective learning approach that transcends instructional design;
4. Attendance is deep learning approach in blended learning;

5. ‘Visual’ is not a predictor of higher achievement in blended learning because it is an innate trait of the University students;
6. Bloom’s taxonomy is an eminently capable tool for managing learning outcomes in blended learning;
7. The teacher must promote effective learning approaches for a new instructional design;
8. The roles of teacher and researcher should be separately realized;
9. Student candidacy into the School must take into account ‘digital divide’ and international programming competition experience if it is going to offer courses with a high digital constitution;
10. School affiliation is not reliable predictor of achievement in blended learning; and
11. STF does decrease with a new and innovative instructional design being used in the classroom.

This study makes the following contributions to the body of knowledge with respect to learning and teaching.

- Blended learning in Asia;
- Higher education teaching without lecturing;
- Linking learning achievement with nationality and ‘digital divide’;
- New design for ILS report;
- Design of inceptive ILS-based prediction mechanism of academic performance; and
- Inceptive report on attendance and normalized marks of different schools in the University.

This study was confounded with the deleterious effects of these limitations.

- Undesired reduction of test subjects;
- Incongruent scheduling of learning sessions;
- No provision of teaching assistant;
- No moratorium on STF during the experiment; and
- No promotion to the cohort of the research being mainstream.

This study makes the following suggestions for areas of further research in the operation of blended learning in the classroom.

- Test and verify the ILS-based prediction mechanism;
- Study the relationship of attendance and academic performance;
- Convert more School courses to blended learning;
- Study the impact of prior experience; and
- Analyse the dependency of the ILS report’s bands.

In summary, the Conclusion Class is the set of conclusions, contributions to the body of knowledge, list of limitations, and recommendation of future research resulting from this study.

Chapter 2
Existing Knowledge

This chapter is a survey of existing knowledge in learning and teaching pertinent to this study. In reiteration, the situation of this study is Asian higher education students studying software engineering in blended learning with no lecturing, and the research question is what effect will blended learning have on the student's academic performance. Concordantly, the focus of this survey is on learning and teaching informed by instruction theory and realized by an instance of instructional design. The survey also sets the groundwork with theories of formal learning. Lastly, this study is not ethnographical, so the literature concerning Asian students will be limited to general observations in educational settings.

Figure 2.1 specifies how the existing knowledge culminates with the instance of the blended learning that is the research platform for the experiment. The starting point of the knowledge association is the LearningTheory Class. It lays the foundation of formal learning, including the primary "isms" of learning, including cognitivism, constructionism, constructivism, and instructionism. Yet, it does not extend to the domain of 'learning science'; it focuses on the mechanisms that engage a learning process in an educational setting. Also, this Class does not include the larger conversation of educational philosophy and its societal and ontological perspectives.

TheInstructionTheory Class explores the conceptions of delivering effective and efficient learning sessions.[1] It mandates the conditions, events, and principles that must be present in a learning session for student's learning to occur. The InstructionalDesign Class represents knowledge on traditional lecturing and three other instructional designs that constitute the blended learning instance. However, due to its extensiveness, the knowledge on blended learning is detailed in the BlendedLearning Class.

[1] A period devoted to learning a "chunk" of knowledge or skill, such as a topic or threshold concept. The period is fixed, and subsequently scheduled as one of a series of periods belonging to a 'course'. Essentially, a learning session is an approach to manage the segmentation of the knowledge chunk, and choreograph its delivery and sequence. It may be identified in a course timetable according to the configuration of the room it is allocated to, such as lecture, seminar, tutorial, or laboratory.

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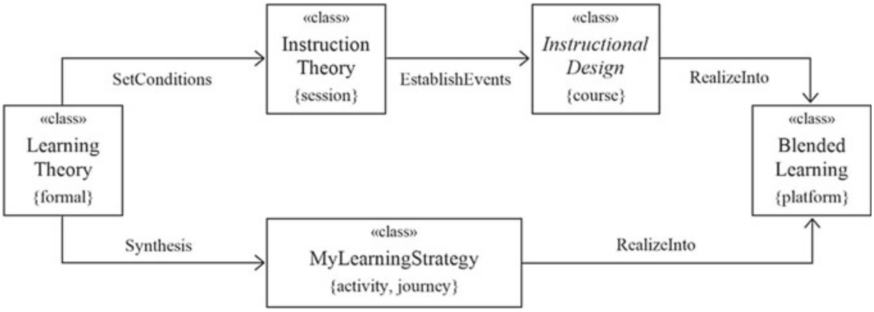


Fig. 2.1 Relation of existing knowledge for this study (UML Class diagram)

The LearningStrategy Class explains the set of invariant conditions or rules of learning that that are applied consistently across the course, and that integrate separate learning activities into coherent learning journeys. It may be considered as the "glue" that coheres the learning for the whole course. This differs from the InstructionTheory Class that formulates the learning in a session, but not for the whole course. Lastly, the LearningStrategy Class takes into account the: higher education landscape, digital native and immigrant, higher education engineering learning styles, and learning profile of Asian students.

The BlendedLearning Class explains the history and current world-wide practice of blended learning. Also, it clarifies the taxonomy of learning outcomes, and the benefits and problems of education technology, both of which have notable purpose in this study.

Missing from this chapter is the existing knowledge concerning design-based research. This is surveyed in Chapter Three in conjunction with the details of the planning and deployment of the methodology.

This chapter is organized into the following sections according to the five functional Classes in Fig. 2.1:

1. Essential formal learning theories;
2. Theory of instruction;
3. Choices of instructional designs;
4. Learning strategy for this study; and
5. Blended learning.

Essential Formal Learning Theories

This section surveys the existing knowledge with respect to formal learning theories. The model for formal learning is explained, followed by the theories of development, and formal learning strategies. The applicable Class from Fig. 2.1 is LearningTheory.

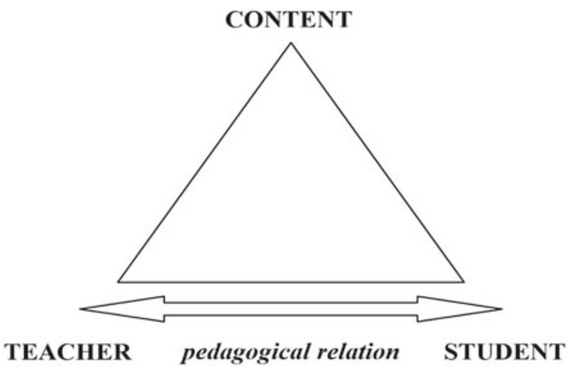
Learning is the processing and inculcation by a person of hitherto unrealized and possibly unknown knowledge, such that the person has gained the new-found ability to function in his/her environment either thinking- or behaviour-wise (Ormrod, 2011). Learning is widely considered a dominant trait in people relating with the environment to utilize select knowledge about it while rejecting others is the most basic tenet of learning. It is the way that people profit from their environment (Marler, 2004). In principle, people can learn anywhere and anytime that is conducive to learning (Bourne, Harris, and Mayadas, 2005). If the environment is uncontrolled and unplanned, the learning is known as ‘informal’. The opposite of this is ‘formal’ learning, where the environment is controlled and planned.

Didactic Model of Formal Learning

Didactics is the science or perhaps art of teaching. Figure 2.2, the didactics triangle, is the basic model for formal learning. (Fig. 2.2 is not a UML diagram.) It shows the relation of the three primary elements in formal learning, the Content, Student, and Teacher. The sides of the triangle indicate interactions between the corners; generally, these interactions are discussed singly. Content represents the knowledge to be learned, and Student represents the recipient learner of that knowledge. The Teacher represents the purveyor of the learning process. The Content does not exhibit behaviour in the model, whereas both the Student and Teacher do. Owing to that behaviour, whatever it is, the Student–Teacher relation is especially significant to the functioning of formal learning.

> … this relation is necessary from the point of view of a young person and it aims to draw out his/her best. The content of this relation has to be thought through in each situation; it must be interactive in nature, a student cannot be compelled/forced into it. It is not a permanent relation, but one which the young person gradually grows out of, developing into independence. (Kansanen and Meri, 1999, p. 112)

Fig. 2.2 Didactic triangle with student–teacher relation (Kansanen and Meri)



Theories of Development

The Student–Teacher relation is underpinned by the philosophy that development towards a capacity for thinking and situational intelligence is an innate part of a person's make-up, at least initially in his/her life (Prosser and Trigwell, 1999). In other words, both the Teacher and Student are developmentalists to an extent. The raison d'être of formal learning is to further such development in the Students. To that end, theories are devised to explain how development occurs, and what strategies can be employed to leverage the unique strengths of the theories.

There are two dominant theories of development: Piaget's "cognitive development" also known as "developmental stage theory" (Piaget, 1952; Piaget and Inhelder, 1969), and Vygotsky's "zone of proximal development" (Vygotsky, 1980; Wertsch, 1988). Piaget posits that people undergo a progressive building, transformation, and re-organization of internal mental structures manifesting acquired intelligence. This process is contingent upon biological maturation and environmental interaction. The development of a person from child to adulthood goes through four primary stages: sensorimotor, preoperational, concrete operational, and formal operational. At each stage, the person constructs a representation of reality that is added to or built over that from a previous stage. This is consistent with observations that people exhibit different capacities, interests, and motivations at different stages. Furthermore, as they mature biologically, people outgrow their current worldviews and construct deeper understandings about themselves and the world. As to an underlying cause beyond biology for the seemingly unarrestable drive to develop, 'natural selection' is often cited as the ultimate arbiter. There is no role for the teacher in the theory, inferring that the motivation to learn and develop is entirely intrinsic to the person. Presumably, the teacher may play a supporting role in the process.

Vygotsky posited that people develop their thinking and knowledge by emulating an expert's practices such that, they progressively inculcate that ability, and subsequently master analogous practices without guidance. The term zone is a pictorial metaphor, intended to illustrate the distinctions between being able to do something unaided, being able to do with expert guidance, and not being able to do at all. The zone of proximal development is doing something with expert guidance, and thus is an inducement of development in the person so aided. The development with respect to that endeavour is considered fully achieved when the person can do any kind of that endeavour without guidance. Expert guidance may come in non-human form, for example cultural accoutrements and tools, and be equally effective in spurring development. Finally, observations bear out the fact that gaps in knowledge do not fill solely with the passage of time. People, who already know they cannot do something, and are subsequently left alone to try it and do it anyway, will most often lose entirely their motivation to complete the undertaking. In this theory, the role of the teacher as the provider of expert guidance is paramount.

Clearly, the development theories have polarized positions on the Student–Teacher relation. "Zone of proximal development" requires the Teacher role, while "cognitive development" does not, plus the Student is the active generator of the learning.

However, is there any circumstance where people's development through learning falls in between these two poles? Yes, because formal learning brings with it certain issues that may not conform to either theory (Matthews, 2003).

Firstly, not all knowledge handled in formal learning can be part of natural selection, for example, writing and computing are far too recent in history; the time scales don't match. Secondly, ranking each student in relation to his/her peers in a competitive environment, as grading systems do, may work counter to learning motivation. Thirdly, formal learning sessions are doled out according to frameworks and plans that are extrinsic to the student. Being receptive to learning is a personal state that is hardly controllable or unplannable. Although gain, self-improvement, and curiosity are considered viable as influences of Student receptivity, only the promise of material gain, such as attractive employment with higher salary, seems to be effective. Of course, the imperativeness of education for the well-being of society is of no influence. So, in the face of this incapability to influence receptivity, it falls to the Teacher to evoke receptivity in the Student, and thus carry out the true purpose of formal education: to induce the Student "to learn how to learn" when the plan of the formal education institution dictates (Hofstede, Hofstede, and Minkov, 1991).

Instructionism and Constructivism

There are two viable but contrasting strategies a Teacher can follow in realizing his/her responsibility to induce the development of the Student. The first is 'instructionism', a managed and supervised conduction of knowledge, and the second is 'constructivism', a spontaneous and autonomous exchange of knowledge (Johnson, 2005; Diaz and Bontenbal, 2000). Constructivism is not to be confused with the constructionism discussed in the next section.

Instructionism is a prescribed and non-interactive knowledge transference practice that has the Teacher at the centre of the enterprise and instates a fixed, a priori outcome as the goal (Johnson, 2005). The practice is closely managed with prepared lessons and established modes of communication. The Teacher is accepted by the Student as the actioner of the knowledge transference, and the Student is consigned to the passive role of being a receptacle for the knowledge. In this situation, the Teacher's application of instructionist technique, and the nature of the new knowledge must be isomorphic. So, it follows that if the Student fails to learn, then it is the instructionist technique that must be flawed and not the Student. An effective application of instructionism is to analyze the Student's entry capability, establish optimal knowledge delivery methods, and correct any problems of delivery as they are identified. Instructionism associates with Vygotsky's "zone of proximal development".

Constructivism is an uncontrolled and interactive knowledge exchange practice that has the Student at the centre of the enterprise and a dynamic outcome as the result (Phillips, 1995; Tobias and Duffy, 2009). Despite the lessons and communication modes being prepared, the Student does not acquire the knowledge as an immutable object. Instead, the Student constructs it as a perception of reality based on his/her

Table 2.1 Models (textual) of instructionism and constructivism

Strategy	Modeling metaphor
Instructionism	A biologist brings a child onto an unpopulated island, and begins explaining all the animals and fauna thereon. The biologist shows the child a sea creature in a tidal pool, states it is poisonous, and instructs the child not to touch it. The child believes the knowledge is correct and heeds the instruction
Constructivism	A child arrives on an unpopulated island with a topographical map and other accoutrements of learning. The child studies the island from a hilltop, and builds his own maps, markers, and other useful devices all around the island, that allow him to master and control the island in his own way

prior knowledge and extrapolation of meaning; in other words, his/her worldview. Under normal circumstances, the construct is not subversion or substitution of reality, but a conditionalized and contextualized interpretation. The constructed knowledge is 'assimilated' into the Student's pre-existing, coherent, and robust mental structures, reaching a plateau or equilibrium of worldview and knowledge. In this situation, the emphasis is on the learning process as opposed to the learning object. So, it follows that if the Student fails to learn, then it is a flaw in the Student's assimilation process and not with the Teacher. An effective application of constructivism is to determine prior knowledge, conduct open-ended conditionalized learning, and provide feedback on the feasibility and realism of the multiple constructions of knowledge (Steffe and Gale (Eds.), 1995). Constructivism associates with Piaget's "cognitive development".

A technique often used in modeling learning theory is the 'child metaphor' where the child always represents the student in formal learning, and an unpopulated island rich in animal and plant life represents waiting knowledge to be acquired. Table 2.1 provides child metaphors to model the two formal learning strategies.

Big Three—Behaviourism, Cognitivism, and Constructionism

The two learning strategies in formal education are general arrangements of the learning situation, being either transference or a translation. There are several theories for how people learn when the two strategies are followed. This study addresses the three most prevailed upon in higher education (Ertmer and Newby, 1993).

Behaviourism, pioneered by Edward Thorndike, John B. Watson, and B.F. Skinner, is the manifestation of observable behaviour due to environmental stimuli, either alone or in conjunction with the history of internal states and current motivation. Some behaviour is a reflex or involuntary action triggered by an external stimulus; this is 'methodological behaviourism'. Other behaviour is voluntary enacted by a memory of the consequences of the external stimuli when it is repeated; this is 'radical behaviourism'. A learning session conducted according to behaviourism theory applies reinforcement and repetition to evoke the desired observable behaviour. The Teacher, accepted by the Students as dominant, evaluates learning according to fixed and possibly non-transparent rubric. This learning, also known as ‘rote learning’, is superficial but quickly induced and relatively reliable for a short term after acquisition (Brown, 2004).

Cognitivism postulates that learning is an internal process of the mind and the end-result of mental processing (Atkins, Brown, and Brown, 2002). The significance of this seemingly obvious statement is clearer when juxtapositioned to behaviourism. Behaviourism asserts that learning is behaviour modification brought about by conditioning using reinforcement, but is unable to explain complex learning, including the permeation of knowledge from precept to concept, and the formulation of ideas that are not directly reinforced. Cognitivism explains these by envisioning learning as a pervasive network of memory units containing various sorts of information. The learner is provided with facts and concepts pertaining to a new “increment” of knowledge, and continuously relates that with previous memorized increments through the employment of innate mental functions. With time, enough knowledge is accrued that the appropriate extent of knowledge is reached. The criticism of cognitivism is that it does not cater for creativity, learner differences, and cross-disciplinary thinking (Mechlova and Malcik, 2012).

A progressive learning theory that does support creativity, learner differences, and cross-disciplinary thinking is constructionism (Papert and Harel, 1991). Constructivism accepts assimilation, but goes beyond to ‘accommodation’ (Ackermann, 2001). If the assimilated knowledge contradicts a Student’s worldview, then he/she resituates with the environment, “becomes one with the phenomenon” (Papert, 1980; 1990; 1993), and allows alternate models of thinking to expand or alter his/her current worldview; this is accommodating the knowledge. Constructionism acknowledges that the mental structures suffer fragility during accommodation. It also posits that learners build fluency (optimization and normalization of knowledge connections in context), and therefore have a capacity to share their knowledge constructions because they have context and situation. Constructionism is underpinned by metacognition, where the learner conducts a reasoned exploration of the thinking and learning involved, as well as accepts external critique, with the objective of improving his/her learning. Finally, constructionism is adaptive to solitary as well as social learning, involving peers, teacher, and the macrocosm of the learning environment (Du and Wagner, 2007). Table 2.2 provides child metaphors to model the three formal learning theories.

To be clear, there is no suggestion that neither the two learning strategies nor the three learning theories, are competing. (Such thinking belongs to a novice in this field.) Instead, the learning strategies and the learning theories that are associated with them co-exist. They are like a buffet of different schemes for developing and operating a learning and teaching endeavour in formal education. The teacher’s intent has, is, and always will be, to appropriately incorporate the learning strategies and theories into any instructional design deployed for a course. In this study, this quality promise is applied to both traditional lecturing and blended learning.

Table 2.2 Models (textual) of behaviourism, cognitivism, and constructionism

Theory	Modeling metaphor
Behaviourism	A child touches a brightly coloured sea creature in a tidal pool, and is subsequently given a painful sting. In ensuing encounters, the child does not touch brightly coloured creatures. (This could be either or both strategies. In a large part, it depends on the establishment of the situation, for example, was the child instructed to touch the creature so that he could be stung and thereby learns?)
Cognitivism	With a biologist on an unpopulated island, a child observes that land animals drink from inland pools but not from the surrounding sea. The biologist explains the idea of salinization. The child observes dew in the morning, and is told about condensation. The child digs a well, and is told about water table, and so on. Eventually, the child has developed a comprehensive knowledge about the water system for the island. (Typically, the applied strategy is instructionism)
Constructionism	A child arrives on an unpopulated island and starts exploring it. Soon, the child and comes across an interesting grove of trees, in which he beds down and listens to the night sounds. He stays for days on end, studying intently everything living there. The child cares not for mastering or controlling the whole island, but exploring its secrets as he happens upon them. (This is an application of constructivism)

Theory of Instruction

This section surveys the existing knowledge with respect to two pre-eminent theories of instruction used in the design of the learning sessions in blended learning. The applicable Class from Fig. 2.1 is InstructionTheory.

Nine Events of Instruction

There are two theories of instruction considered eminently appropriate for the instructional designs in this study: Robert Gagné's "nine events of instruction" (Gagné, 1985), and Chickering and Gamson's "seven principles of good practice" (NIE-US, 1984; Chickering and Gamson, 1987). Although one may intuit otherwise, theories of instruction are not exclusive to the instructionism strategy. Instead, they are concerned with low-level learning, stopping short of purporting to be learning science. A foundational article on instruction theory expresses as much: a theory of instruction is a theory of learning with a model, permissible actions, objectives, and criteria for measure of achievement (Atkinson, 1972). Also this time, Gagné championed behaviourism, constructionism, and cognitivism theories (though they were not directed designated by those names), and also posited conditions, events, and media as key aspects of good instruction (Gagné, 1970). Another foundational paper, in addition to tracing behaviourism, cognitivism, and constructionism directly into the theory of instruction, also listed prior experience, inferring underlying knowledge from the observed performances, novice-compatible representations, and practice for invention, as criteria to include into instruction theory (Resnick, 1984).

In his 1985 magnum opus, Gagné decomposes his theory into three components: learning outcomes, conditions of learning, and nine events of instruction. The learning outcomes are specified according to Benjamin Bloom's taxonomy (Bloom, 1956; Bloom, Englehart, Furst, Hill, and Krathwohl, 1956). The following is a subset of the conditions that critically influence learning in the classroom. The learning theory or theories in which the condition exists is appended in parentheses.

- receptiveness and suitable motivation (cognitivism);
- knowledge meaningfully contextualized and situated (cognitivism);
- prior knowledge recalled and retrieved (behaviourism, cognitivism);
- knowledge explained and perceived (cognitivism);
- knowledge chunked to not exceed working memory (cognitivism);
- knowledge assimilated and consolidated (constructionism);
- knowledge accommodated and reconciled (constructionism);
- knowledge practiced and reviewed periodically (cognitivism, constructionism);
- metacognition and external critique performed (constructionism);
- new knowledge assessed and evaluated (cognitivism); and
- new knowledge generalization promoted and rewarded (behaviourism).

Finally, the following are Gagné's nine events of instruction, also known as "nine steps of learning". These are considered to be the universal scheme for developing any instructional design. In his theory, Gagné aligns the events with Bloom's learning outcomes. (Probably because Gagné and Bloom are contemporaries.) In general, an instruction theory should contain learning outcomes, because any learning process must orient to desired outcomes.

1. Gain and maintain attention;
2. Delineate objective;
3. Recall prior learning;
4. Present the new knowledge;
5. Aid learning with hints, cues, and media;
6. Elicit performance;
7. Provide timely and meaningful feedback;
8. Assess performance in achieving outcomes; and
9. Energize retention and reward generalization.

Figure 2.3 associates the events of instruction on the right side with the conditions of learning on the left side, thus showcasing the intellectual bridge between the learning theories and instructional designs.

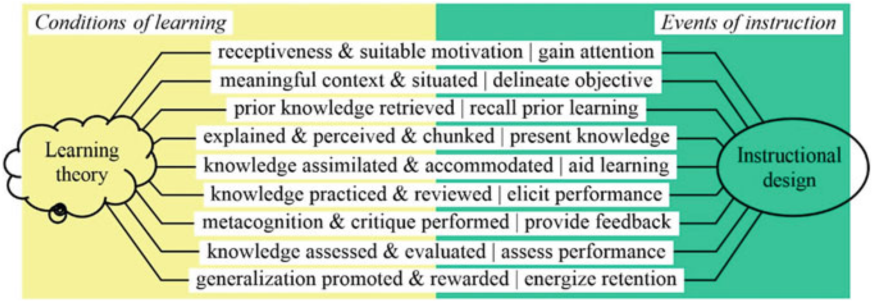


Fig. 2.3 Mapping of conditions of learning to events of instruction

Seven Principles of Good Practice

In their pre-eminent work, Chickering and Gamson return the focus of learning and teaching in higher education to the two most important players, the Student and Teacher. They also added new variables to the equation, that of the institution management, government officials, and accrediting associations, without whose support and influence the proposed improvements can never go far.[2] Here then are the seven principles of good practice in higher education.

1. Encourages contacts between students and faculty;
2. Develops reciprocity and cooperation among students;
3. Uses active learning techniques;
4. Gives prompt feedback;
5. Emphasizes time on task;
6. Communicates high expectations; and
7. Respects diverse talents and ways of learning.

In deference to Chickering and Gamson's principles, the formal learning didactic triangle in Fig. 2.2 is revised with the addition of a fourth variable called "Institution" to represent the extrinsic influence that the institution exerts on the Student–Teacher relation. Similarly, Prosser and Trigwell (1999) situate the teacher-student relationship in a shared context that is the instructional design, the degree program, and the institution. Figure 2.4 is the revised model of formal learning with the Institution variable added.

Unlike Gagné's events, Chickering and Gamson's principles are not a hierarchy, meaning that every principle stands alone, devoid of dependency to any other. So, it is incongruous to attempt to map the elements of one list to the other. Instead, the decision is taken to incorporate the elements in both lists, predominantly Gagné's

[2] An example of this is the University's "Blue Ribbon Commission" (Shah, 2008), setting in motion a massive reset of its students experience academically and recreationally that is still ongoing a decade later. Besides providing motivational support for this study, the report provided the impetus for the construction of new learning rooms, and procurement of educational technology such as campus videography studios for crafting online lessons, and audience response systems in all classrooms.

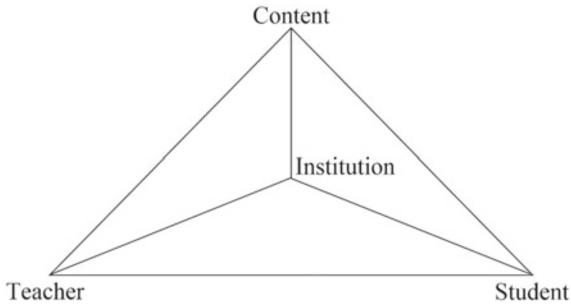


Fig. 2.4 Revised didactic triangle with Chickering & Gamson "Institution"

events for the weekly dimension, and Chickering and Gamson's principles for the semester dimension.

Choices of Instructional Designs

This section surveys the existing knowledge concerning instructional designs utilized in this study, except blended learning; the survey of blended learning literature is detailed in the final section. The applicable Class from Fig. 2.1 is Instructional Design.

Traditional Lecturing

Traditional lecturing seems to be a natural and likely instinctive way of perpetuating knowledge; people are comfortable with and accepting of it (Charlton, 2006). Probably for these reasons, lecturing is the pre-dominant instructional design in higher education (Gibbs, 1981). The professors therein are recognized by the institutional hierarchy as authoritative creators of new knowledge, and that their raison d'etre is to pass on that new knowledge to the learners. So, lecturing and university seems to be a perfect combination: the professors have the knowledge that their students want, and lecturing has a distinguished history of being the most universal instructional design for passing on that knowledge.

Since the Second World War, there has been a proliferation of publications on instructional design and associated educational technology (Reiser, 2001). Given the dominance of traditional lecturing, one would anticipate that a high proportion of those publications should affirm its continued use. To the contrary, the proportion of publications proposing replacing lecturing with new instructional designs is much higher than that affirming its continued usage. Just how significant is the imbalance in favour of new instructional designs may be illustrated in the following example. The first author conducted a metadata analysis in August 2013 of IEEE journals and magazines from 1945 to present in IEEEXplore Digital Library. These were filtered offline by content comparing traditional lecturing against other instructional designs in the context of learning and teaching experiments; this produced 303 relevant articles. Of these, only 14% affirm traditional lecturing. Of the articles remaining, 10% advocate retaining lecturing but with necessary enhancements, and the rest endorse entirely new instructional designs. On top of all of that, there are the superlative articles that make a lasting impression, such as Gibbs (1981). He makes what is perhaps the most forthright and compelling case against traditional lecturing, in a most senior statesman-like manner.

This clear pronouncement from the learning and teaching research community has spurred the emergence of new and innovative instructional designs, divided between secondary education (Horn and Staker, 2011) and higher education (Applebee, McShane, Sheely, and Ellis, 2005). Yet, their deployment in the classroom is often to compliment or enhance traditional lecturing. It is as if lecturing is the central ingredient of any and all learning and teaching (Barr and Tagg, 1995). Is this really true, or can education be successfully implemented using instructional designs other than lecturing; in other words, eliminate lecturing altogether (Jones, 2011)? If such an instructional design could be accepted by students while maintaining the same degree of academic rigour as with lecturing, then it would be a giant leap forward to realizing the national formal learning mantra of "teach less, learn more" (Tan, Tan, and Chua, 2008; Tan, 2011).

Instructional Designs Aggregated into Blended Learning

Blended learning is not just an instructional design. It is a template of instructional design, meaning that it cannot be realized into a deployable instance. Instead, an instance of blended learning is created as an aggregation of instances of other instructional designs that are not templates. Figure 2.5 models this condition; the instance of blended learning is on the right side, being realized by many non-template instructional designs from the left side.

Additionally, Fig. 2.5 shows that blended learning is comprised of eLearning and F2F that are themselves template instructional designs. It means that the eLearning and F2F are separately instantiated by non-template designs from the left side of Fig. 2.5, and then combined to form the blended learning instance.

How does the researcher choose which instructional designs would constitute the separate eLearning and F2F instances for this study? There are numerous instructional designs (Reigeluth (Ed.), 1999), and most have detractors as well as supporters. So, the following criteria are used to determine which instructional designs are suitable to instantiate eLearning and F2F:

- Are realizable;
- Have a solid history of exemplary performance in learning and teaching;
- Have the continued backing by its founder;
- Are workable in eLearning and F2F interventions; and

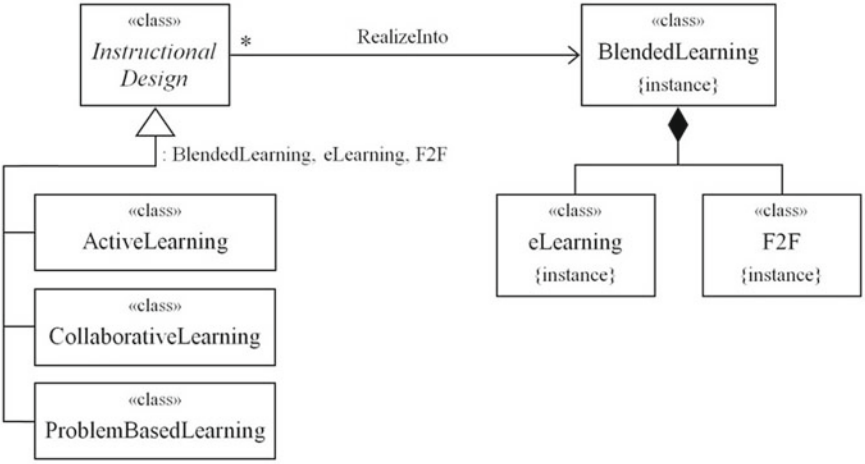


Fig. 2.5 Blended learning instructional design is a template (UML Class diagram)

- Apply to as many of this study's learning strategies as possible.

Accordingly, the instructional designs chosen for the blended learning instance in this study are active learning, collaborative learning, and problem-based learning (PBL). They are realizable, well-published with exemplary performance, still supported by their founders, workable in eLearning and F2F, and are consistent with this study's learning strategies.

Active Learning

Active learning is where the learner performs any activity that is formulated to facilitate and further the learning process (Bonwell and Eison, 1991). It can be as simple as pausing during a lecture for the learners to conduct a review and clarification of notes with a partner, or as complicated as playing out a heavily scripted role-scenario. In fact, active learning encompasses such a wide variety of activities, such as short writes, discussion, presentations, peer correction, timed research, and serious games (Jones, 2008; Prakash, Brindle, Jones, Zhou, Chaudhari, and Wong, 2009; Jones, 2016), that it is more informative to define it by exclusion, that is, what it is not. That said, it is not a traditional lecture. Finally, the students are guided and evaluated individually for achievement of the learning outcomes.

Active learning is often affiliated with F2F, but there is no stipulation that it cannot be affiliated with eLearning. Also, the mere existence of activity does not mean active learning; the activity must relate to the learning intended by the teacher. For example, homework is clearly active, and should promote learning, but will not if the actions are not consistent with the curriculum. In the classroom, actions are harmonized with the desired learning via direct intervention of the teacher. For this outside the classroom, the teacher relies on scaffolding. Active learning can be conducted with the learners as individuals or in small teams. The computer-based classroom is an ideal environment for the use of active learning, for which several experiments have been conducted (Holbert and Karady, 2009).

Collaborative Learning

Collaborative learning is where the learners are assigned into groups and together work towards a common objective (Johnson, Johnson, Holubec, and Roy, 1984). If multiple groups are assigned, the objectives for each group may or may not be the same. Collaborative learning is usually demonstrated via a deliverable that all members contribute to, such as a presentation or a written report. By definition, collaborative learning is active, and active learning can be collaborative, so how are the two differentiated? By target! Active learning targets the individual learner; even when in small groups, the learning is directed at and confirmed for individuals. On the other hand, collaborative learning explicitly targets the group, and the learners are not considered as existing separately from the group. The group is evaluated for achievement of the learning outcomes as a singular entity; in other words, every member of the group is awarded the same mark.

This leads to the contention of accountability of the group members. If the learners in a group are accountable only to themselves, that is, they share their knowledge but are assessed individually, this is cooperative learning. If the group members are accountable to each other because they are obliged to participate equally and as equals, this is collaborative learning. Nonetheless, how to mark a collaborative group is still being debated. The most recent research suggests that formative not summative assessment be used, and that the learners in the group focus on their objective and not their reward, which is typically a mark (Strijbos, 2011). Being common practice in engineering education, collaborative learning is applied to the University of Rijeka blended learning experiment (Hoic-Bozic, Mornar, and Boticki, 2009), and it is also applied extensively in the use of online and multimedia learning resources for undergrad courses, for example a course wiki (Tsai, Li, Elston, and Chen, 2011).

PBL

PBL is analogous to collaborative learning, where the learners are assigned into groups that work towards a common objective, and whose members earn the same assessment. However, there are three important differences. First, the common objective is to solve a specific real-world problem that must be open-ended to engender several possible solutions. Second, the conduct of a PBL session is centred on the classroom with the teacher present. Third, it is conducted in accordance with the following prescribed and immutable process (Hung, Jonassen, and Liu, 2008):

1. The group is assembled with five to eight members;
2. The group is assigned a real-world problem to solve. If multiple groups populate the one session, all are assigned the same problem. Typically, the time accorded the entire session is between one day and one week;
3. The group defines and bounds the problem in terms of the prior knowledge of its members;
4. The group establishes a proposition on how best to solve the problem, and self-organizes accordingly. This step includes, determining what is needed to be learned in order to solve the problem, establishing the accordant tasks and deliverables, and assigning them to the members;
5. The group members go their separate ways to effect self-directed learning associated with their tasks, and collect their specified deliverables;
6. The group re-assembles, and one-by-one, each member passes on what he/she has learned to the other members;
7. With this new and more comprehensive knowledge, the group re-evaluates the problem, rejects now-perceived incongruous suppositions, and finalizes two or more suitable alternative solutions. The group discusses the merits of each solution, and subsequently reaches a consensus on one; and
8. The group presents their solution and explains the thinking of the group in reaching that solution to the teacher. If there are multiple groups in the session, each receives the other groups' presentations, and integrates the other groups' learning with their own.

In PBL, the teacher is a facilitator and metacognitive coach. He/she explains the PBL process, offers hints and cues for the problem, clarifies the self-directed learning, facilitates the groups dynamics and reasoning, probes the groups' knowledge and findings, and provides deep feedback on the thinking process and presented solution. However, the teacher is not the knowledge disseminator, so he/she never interjects content nor provides model solutions (Stepien and Gallagher, 1993). The solution derived by the groups in a PBL session equivocates to the outcome of a 'think-tank'; in other words, a group's solution is itself a model solution.

PBL is "apprenticeship for real-life problem solving" (Ward and Lee, 2002). In other words, the learning value emerges from the group's approach to inter-disciplinary exploration, so the success of PBL depends greatly on the quality of the problem and the coaching acumen of the teacher. Originally applied to graduate medical education, PBL is now used extensively in engineering education for network design, embedded systems, mobile applications, and communication systems (Mitchell, Canavan, and Smith, 2010). PBL is also applied in the University of Rijeka blended learning experiment (Hoic-Bozic, Mornar, and Boticki, 2009).

Learning Strategy for This Study

This section surveys the existing knowledge underpinning the strategy for the course-wise learning and teaching. The key factors considered in deriving the strategy are: changing landscape of higher education, observed learning habits of current students, higher education engineering learning styles, and Asian student learning habituation. The applicable Class from Fig. 2.1 is My Learning Strategy.

Present Landscape of Higher Education

Education, the epitome of formal learning, is the transference of epistemological attainments of society to its children. The system supporting education is arranged into multiple tiers that enact development of the child in an iterative fashion. As a tier is completed, the child is promoted into the next tier, where the complexity of activities and conceptions is increased. The number of tiers differs by nationality, but generally, higher education is the last tier in education systems. Higher education also corresponds to the final stage in Piaget's cognitive development, formal operational. During this stage, students are expected to transition from:

- inductive to deductive reasoning;
- concrete to abstract thought;
- trial and error to problem-solving methodologies including analysis;
- cognition to meta-cognition (thinking about thinking); and
- actual to hypothetical or counterfactual thinking.

There is a widespread consensus among academics that the learning partnership between the Institution (as in Fig. 2.4) and its Students is deteriorating. Attendance rates are falling significantly in lecture halls. Leufer and Cleary-Holdforth (2010) discuss the impact on students and teachers of mandating lecture attendance in response to that fall. Friedman, Rodriguez, and McComb (2001) argue that the university teaching techniques do not align with the students' learning needs, and serious reform is warranted. In a seminal article introducing engineering learning styles, the reduction in the effectiveness of higher education is described as follows.

> Mismatches exist between common learning styles of engineering students and traditional teaching styles of engineering professors. In consequence, students become bored and inattentive in class, do poorly on tests, get discouraged about the courses, the curriculum, and themselves, and in some cases change to other curricula or drop out of school. (Felder and Silverman, 1988, p. 1)

A considerable body of journal and textbook publications has accumulated regarding the ineffectiveness of lecturing, in particular with respect to the excessive reliance on PowerPoint (Jones and Gagnon, 2007). An above average treatment of the issue is by Amare (2006). A concomitant body of research asserts the effectiveness of non-lecturing techniques, like active learning (a superior recent example is

Deslauriers, Schelew, and Wieman, 2011) and eLearning (Tutunea, Rus, and Toader, 2009). Finally, there is the growing gap of realism and applicability, also known as "fragility", of the knowledge that students are receiving from higher education.

> Education needs to undergo changes both because of its general state of affairs, and because of the changes that take place around it. It just does not prepare its graduates for intelligent functioning in today's information society. Schools as we know them are becoming more and more out of sync with the rest of the world, and thus have to change. (Salomon, 2002, p. 1)

This relatively sudden confluence of decreasing attendance, discredited lecturing, mismatch of learning styles, and fragility of knowledge must be rooted in at least one of the four elements in formal learning, Content, Institution, Student, and Teacher. Two explanations are offered. The first is that Students have naturally changed in line with the digital era. The second is that the Institution and Teacher have not changed enough to keep pace with the progress of modernity in education.

Digital Native and Immigrant

The first explanation comes from education and learning visionary, Marc Prensky (2001a, b). He introduces the concept of 'digital native', young persons and students from kindergarten to university who have been exposed to ubiquitous digital technology since they were born, and are now "no longer the people our educational system was designed to teach" (Prensky, 2001a, p. 1). Other researchers have come to similar conclusions about young people growing in an age of ubiquitous computing, most notably a technology-in-society thought-leader, Don Tapscott (2008), who refers to them as the "net generation".

Digital natives are attuned to exceptionally fast rates of information acquisition and processing, are avid multi-taskers, are deeply involved in social networking, and have a strong predisposition for instantaneity. Though these traits in education might promote prodigies, digital natives are instead marginalized because the teacher gets in the way of them realizing their exceptional potential. Why? Because the teacher is a 'digital immigrant', exposed to but not adroit at the new intellections. (Analogous to a landed immigrant getting used to new social customs.) Prensky argues that digital immigrants speak the outdated language of the pre-digital age, and since language is everything in instruction, they are unable to meet the new learning needs of the digital natives who speak an entirely different language. Arguably, the Teacher must reform. (Per Chickering and Gamson's treatise, the same goes for the Institution.) There is no regressing to a pre-digital mode for the digital natives, especially not with the digital technology that catalysed their emergence becoming ever more ubiquitous. Digital nativeness is expected to be a continuing condition of future generations.

Engineering Learning Styles

The second explanation of the problem confluence in education is an incompatibility of the student's learning style—the preferred ways a learner receives information and processes it into knowledge—with the established modalities of instruction. The incompatibility leads to lower academic achievement, frustration, and apathy. Learning style is based on the learner's psychological disposition and shaped or supplemented by experiential reinforcement. Though it is a personal attribute, students from similar backgrounds may share similar learning styles. A learner's learning style may evolve over time as the learner encounters new situations and acquires new reinforcing experiences.

Platsidou and Metallidou (2009) compare and contrast several competing learning styles. The one founded by Felder and Silverman in 1988 for their engineering higher education classes is an excellent fit for the software engineering situation of this study, and hence the one employed herein. It focuses on the cognitive domain, unlike other learning styles that include motor functions, and aligns well with the cognition domain of Bloom's Taxonomy. This engineering learning style has been used repeatedly in higher education science and engineering (Montgomery and Groat, 1998; Kolmos and Holgaard, 2005; Kapadia, 2008; O'Dwyer, 2009). Additionally, Montgomery et al. and Kapadia, add in the extra dimension of comparing different learning styles for the same sampling of students.

There are eight elements in the engineering learning style, listed in alphabetic order, in which the learner is identified as …, preferring to …:

- Active—gain understanding through engagement, discussion, and experimentation, often in groups;
- Global—process info in random, non-linear/unordered, divergent, and creative ways, with a view to the big-picture or holistic;
- Intuitive—make sense of the world indirectly via the unconscious, imagination, and guesswork, leaning towards abstract thinking;
- Reflective—gain understanding via introspection, thought exercises, and theorization, often alone or in pairs;
- Sensing—make sense of the world directly through the senses, facts, and truth/provability, leaning towards concrete thinking;
- Sequential—process info in stepwise, linear/ordered, convergent, and established ways, with a view to the individual step or minutia;
- Verbal—receive external info in form of sounds, words, and language, with an affinity for explanation; and
- Visual—receive external info in form of sights, images, and cinematography, with an affinity for demonstration.

Elements that are polar opposites are coupled into dimensions or bands of learning style. Sensing and intuitive are opposite approaches to constructing a worldview. Visual and verbal are converse channels for receiving external information. Sequential and global are opposite schemes of assimilating large quantities of information.

Active and reflective are opposite strategies of building an understanding leading to knowledge. Every element is denoted by its own scale {11, 9, 7, 5, 3, 1}. Each band is arranged so that the scales of its two elements combine into a descending-then-ascending range {11, 9, 7, 5, 3, 1, 1, 3, 5, 7, 9, 11}. A person's learning style in a band is a value within that range.

How does one obtain an evaluation of his/her learning style? Felder teamed with Barbara Soloman to construct an online questionnaire (1991) for determining the taker's learning style, designated as the Index of Learning Styles© (ILS©). Soon after its launch on the world wide web in 1996, the ILS registered "about 100,000 hits a year and has been translated into half a dozen languages that I know about and probably more that I don't, even though it has not yet been validated" (para. 1 in Author's Preface June 2002 to Felder and Silverman, 1988). Subsequently, the ILS has been validated several times, including by Zywno (2003), and Litzinger, Lee, Wise, and Felder (2005). The popularity of the ILS site has grown to a present level of half a million hits annually. A telling indicator of this popularity can be seen in the initiative by several universities to embed ILS scaffolding for new users into their world-wide web (WWW) sites (Teaching and Learning with Technology, 2004).

As to applying learning styles in an educational setting, a comprehensive analysis of Felder's learning styles and how in theory to best apply them is provided by Graf, Viola, Leo, and Kinshuk (2007). One of many articles reporting on a case study where Felder's learning styles were applied is Franzoni and Assar (2009). Finally, learning styles are not just restricted to engineering students, but can be applied to students in any field of study, for example, Al-Tamimi and Shuib (2009) highlighted the use of learning styles for English language students).

Asian Learners

The conceptions of learning and teaching research discussed thus far embody the conventional wisdom about effective learning established by educational research conducted in Western countries. However, this study has predominantly Asian students as its test subjects. What should we understand about the way that Asian students learn that would be prudent to apply in this circumstance?

Underpinning this part of the survey is the fact that "Asian" is not presumed to encapsulate a homogeneous grouping of people inhabiting continental Asia.

> … Asia is more of a cultural concept incorporating a number of regions than a homogeneous physical entity. It has little in the way of common history and it comprises many cultures, physical environments, historical ties and governmental systems. While there may be said to be attributes common to many, if not all, Asian societies such as valuing education, personal relationships, mutual obligation and authority, there are also many differences in the socio-economic circumstances, traditions, religious beliefs, philosophies and practices. Added to which there is now a fusion of Western and Asian thinking and practices. (Latchem and Jung, 2009, preface)

The two primary takeaways in this quotation are that, formal education and the educational technology afforded to that system can be expected to be different depending on nationality, and that there exists enclaves of learning approach that are a confluence of Western and Asian people. That is, nationality and learning approaches are uniqueness quotients decisive in the discussion of Asian students.

Digital divide. In this study, the distinctness of Asian people through their nationality is perhaps a function of 'digital divide' as explained in Sharma and Mokhtar (2005). This is the condition of access to modern computing facilities being unevenly established across nations; in this case Asian. Nationalities such as Singapore and Malaysia rank high in such access, while others such as China, India, and Indonesia though showing impressive gains in achieving widespread access, still have far to go. The presence of educational technology though not overbearing is still substantial in blended learning, especially considering its eLearning element. Relation of the digital divide on academic performance is the subject of numerous studies (Solomon, Allen, and Resta (Eds.), 2003; Warschauer, Knobel, and Stone, 2004; Wei and Hindman, 2011), and there is evidence that for both Western and Asian students, there is a correlation between access to digital facilities, including home computers, and academic performance. Given this, it is plausible that Asian students that have undergone all pre-tertiary education in a nation with a large digital divide, will exhibit lower academic performance in blended learning at the University than those coming from nationalities with significantly less of a divide.

Learning approaches of Asian students have been intensely explored in the areas of creativity and depth of learning. These studies typically adopt one of three perspectives concerning the higher education setting in which the Asian students are learning, namely Asian, Western, and taking a Western university's distance learning degree program while enrolled in an Asian university. It is universally accepted that societal norms permeate the policy and practice of its educational institutions, and these will shape the learning approaches of the students therein. However, for students not from the society in which the institution belongs and entering it as a stranger to those norms, their learning differences would standout and perhaps be misinterpreted as substandard learning approaches. The reason why researchers keep revisiting this topic is that the academic performance of Asian students seems to transcend the apparent substandard nature of their learning approaches. And perspective is important for reasons of authenticity and relevance.

Asians in Asian institution. Some of the best research concerning Asian students in Asian higher education institutions comes from Kember and Gow (1991), Biggs (1994), Cooper (2004), Kwok (2004), and Chee Mok (2006). Foremost is that Asians may be associated with Confusion-heritage cultures (CHC)—China, Hong Kong, Japan, Korea, Singapore, and Taiwan—and others not. Faculty in a CHC higher education institution generally accept a teacher-centric mode of learning; guidance is the means to the students achieving better outcomes. Class-size is typically large. F2F learning sessions are rigid, topic-oriented, and delimited to a "one right way" of performance. Examinations play a major role in the assessments of their students' learning due to the large class. Students adapt to these conditions via a complex strategy of repetitive learning of select topics to develop accurate recall under examination. In adaption to the large class size, Asian students engage in one-to-one interactions with the teacher after lessons. Finally, students a substantial amount of time in collective activities, including academic discussions and study groups. The distribution of resultant marks is normal.

Asian in Western institution. A contrasting perspective is the Asian student studying and living as an international learner in a Western institution (Ogbu, 1992; Chalmers and Volet, 1997; Ramburuth and McCormick, 2001; Peng, 2006). Their Western counterparts do not perceive the finer granularity of CHC within their community, and also don't understand the cognitive and emotional stress of their situation.

> Based on the background variable that almost all of the Asian international students have no previous learning experience abroad, it is reasonable to assume that their present learning carried the hope or responsibility from their family, friends or even employer. Their present academic success would be vital for their future back home, since failure is not acceptable. Therefore, the value of fear of failure maybe results directly or indirectly into their high test anxiety. (Peng, 2006, p. 18)

Nevertheless, the Asian students seem to regard learning as an enjoyable challenge, and make their learning choices based on practicality and interest. The Western classroom operates a student-centric mode of learning where encouragement replaces guidance. Class sizes are small, so the low participation in class dialogue and question-asking by Asian students is easily noticed. They engage in rote learning, and yet, exhibit more critical thinking and elaboration. So, it is more likely that rote learning is a misinterpretation of repetitive learning, which does set a strong foundation for critical thinking when evidence is available. Asian students continue to engage in study groups after class, which is thought to be an adaptation to the sharp decrease of one-on-one interactions with the teacher after-class. But concluding that Asian students undertake shallow learning approaches contrasts with the reality that Asian students perform well above the average Western student. The likely reasons for this include the aforementioned fear of failure, collaborative learning, and repetitive learning.

Western online to Asian institution. The final perception of Asian students comes from their engagement in Western university's distance learning degree program while enrolled in an Asian university (Ziguras, 2001; Mills, Eyre, and Harvey, 2005).

> The use of online learning in transnational education brings together, in an unfamiliar environment, students and educators whose experience of teaching and learning stems from very different cultural traditions. Educators who have taught international students in classrooms come to understand that students from different countries bring with them different experiences and expectations of teaching and learning. (Ziguras, 2001, p. 2)

The discussion about the use of educational technology extends beyond the conceptions of purely learning and teaching, in three offerings. First, there is the distance learning that imposes the cultural values of the provider onto the receiver, although there may be an underlying aversion on the part of sincere educators in the provider to do this. Second, there is the compelling position that the offering strictly adhere to the norms of good learning that are held as universal is the most effective and neutral approach, knowing that such best practice is largely promulgated from the West. Finally, there is the wisdom of the middle ground with online pedagogy that is supplemented by local instruction provided in F2F sessions, bringing the course to blended learning with the one distinction that the online element was from a different higher education institution than the F2F.

As of now, the online offerings available for Asian students are in their infancy, and those with minds made up to take an online course also have to accede to the conditions under which the offering is configured. However, it will be a very different story in five years, and then Asian students will (metaphorically) vote with their feet as to which offering they deem the most suitable to them.

The paradox for the Asian student is that what works learning-wise is conflated with a perceived universal cultural approach, when in actual fact, it is just good pedagogical practice that adapts to the cultural conditions imposed upon them (Biggs, 1994). In other words, Asians learn the best way they know how, given a solid start with their heritage of cooperation, a resilient and continuously refreshed prior experience, and a keen and adaptive situational awareness. The clear message from all the documentation is that if that the Asian student can be engaged in a learning endeavour that he/she is convinced is truly relevant and meaningful delivered via any reasonable instructional design, he/she can and does find the learning approach to make it work well.

Overview of the Learning Strategy

The learning strategy is primarily based on Bransford, Brown, and Cocking (1999), Prosser and Trigwell (1999), Dick, Carey, and Carey (2001), Atkins, Brown, and Brown (2002), Ramsden (2003), and Brown (2004). From these, seven learning strategies are generated that are to be followed in blended learning. These strategies are published in Jones (2012b), and discussed in detail in Chapter Four; here now is a brief overview:

1. competent foundation;
2. knowledge fluency;
3. group learning;
4. learning transfer;
5. metacognition;
6. engaging contrasts; and
7. enhanced marking.

Blended Learning

This section surveys the existing knowledge on blended learning. The amount of publications is staggering, so this survey of existing knowledge focuses on publications with substantial citations. Also included in this section survey are measuring learning outcomes, and incorporating educational technology. The applicable Class from Fig. 2.1 is Blended Learning.

Overview of Blended Learning

Blended learning is a mix of instruction modalities, instructional designs, and delivery media (Graham, 2006). It blends traditional and innovative thus synergizing the learning endeavour (Chen and Jones, 2007). Instruction modalities include classroom, distance, and self-paced learning (Martyn, 2004; Picciano, 2006; Rossett, Douglis, and Frazee, 2003). The concept is decades old, with several designations all applied to similar educational settings, but each having some subtle variation in semantics; see Harvey (2004) for a compilation of thirteen meaning variations. The term "blended learning" is a recent designation; unfortunately, the plurality of names and liberal variations of semantics is a source for confusion and even misinformation.

ELearning and F2F

The most prominent definition of blended learning is a mix of eLearning and F2F instructional designs (Bonk and Graham, 2005). Being a mix means that the combined elements retain their individual characteristics, and that in any contiguous period of time, only one of the two or more elements can be operating. So, across any demarked and substantive interval of time, like several months, the ratio of the blend can be determined from the time-wise and relative proportions of each of the elements. Of the varying definitions for eLearning and F2F, the following are the most accepted (Dziuban, Hartman, and Moskal, 2005).

- eLearning is a virtualistic, scaffolded, asynchronous, and solitary learning intervention, where the student directly—not through the teacher—explores the content. The teacher plays a supporting role by arranging and populating the online site. Without detracting from the asynchronicity of eLearning, the teacher may be available at prescribed times for online coaching; and
- F2F is a humanistic, managed, synchronous, and collective learning intervention, where the student is explained the content in a choreographed presentation by the teacher. To an extent, the student plays a supporting role in the content dissemination. However, the students are expected to engage in self-directed preparation activities.

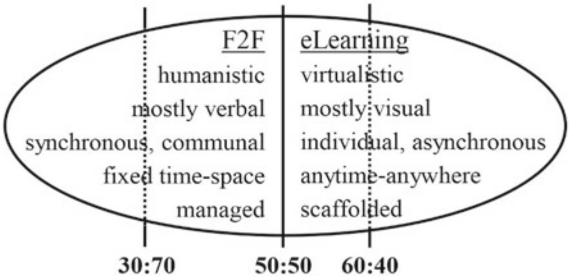


Fig. 2.6 ELearning and F2F mix proportions in blended learning

Figure 2.6 illustrates the concepts of blended learning being a mix of eLearning and F2F, and the proportionality of the mix, against a backdrop of the definitive characteristics of each. Importantly, the skew of the proportion in favour of any one of the elements in the blend is not in itself an enhancer or disruptor with respect to the achievement in and of learning outcomes (Bernard, Abrami, Lou, Borokhovski, Wade, Wozney, Wallet, Fixet, and Huang, 2004). Blended learning is not the mere sum of its separate and distinct parts, but a seamless integration of reinforcing elements.

In one of its many incarnations, blended learning can be a mix of media delivery schemes, such as paper and electronic, text and image, web-based and PC based, book and Internet, PowerPoint and OHP, handout and CD-ROM, simulation and physical reality (Bersin, 2003). Notwithstanding, the technology is only a supplement of or infusion into the pedagogy. Thus, blended learning avoids being associated with the dualism of "traditional versus twenty-first century", and espouses an approach whereby both online and physical learning are made better by the presence of the other (Garrison and Vaughan, 2008).

Bibliography on Blended Learning

The following is a short bibliography of blended learning literature, arranged into four areas of interest: expository, case studies, tool kits, and bibliographies.

Expository. The literature in this area focuses on what and why of blended learning. Osguthorpe and Graham (2003) provide a balanced explanation of the background, semantics, and goals of blended learning, while Chew, Jones, and Turner (2008) critically review blended learning in comparison to well-established learning theories, and provide a robust substantiation for the theory of blending. One of the most comprehensive and rigourously-researched online publications is the "blended learning in K-12" series (Horn and Staker, 2011; Staker and Horn, 2012). It is well organized and consistent, and offers an extensive reference list. A book cited earlier, "The Handbook of Blended Learning: Global Perspectives, Local Designs" (Bonk and Graham, 2005) is "…invaluable for any educator seeking to understand the design, implementation, and study of next-generation learning experiences" (Dede, Whitehouse, and Brown-L'Bahy, 2002, from the Harvard Graduate School of Education) and has a published review (Ates Book review: The handbook of blended learning: Global perspectives, local designs, 2009) that also commends it. Finally, there are several good publications on the theory and practice of blended learning interventions in higher education settings, including Garrison and Kanuka (2004), Vaughan (2007), and Garrison and Vaughan (2007).

Case studies. The literature in this interest area focuses on research or experience of establishing and conducting a blended learning intervention. One of the better books on this interest area is "The blended learning book: Best practices, proven methodologies, and lessons learned", authored by long-time technologist Josh Bersin (2004). Chapter One, the history of blended learning from a technology perspective, is very thorough and insightful with interesting artifacts drawn from the author's personal memorabilia. Its twenty case studies are all from industry, and the lessons learned are general enough to be applied to education. Torrao and Tiirmaa-Oras (2007) is a comprehensive report generated by a university project to identify and analyse key blended learning case studies in European academic research, university classrooms, and commercial practice. Also, there are numerous articles like Boyle, Bradley, Chalk, Jones, and Pickard (2003) that report on successful realizations of blended learning in some isolated educational setting, in this case, an introductory computer programming subject in a higher education institution. Lastly, Watson (2008) authored a moderately detailed non-government organization report on blended learning interventions in nine prestigious K-12 institutions in the USA. The nine case studies are contrasted in a blending continuum and the report ends with a set of lessons learned.

Tool kits. The literature in this interest area focuses on methodologies, checklists, and hints and tips for instantiating your own blended learning intervention. The best book on the market for this interest area is Barbara Allan's "Tools for Teaching and Training" (2007). It was reviewed by Esyin Chew (2008) who stated it is "…a remarkable "start-up kit" … for those who wish to practise blended e-learning" (p. 346); Chew also authored an earlier recommended expository article. "How to Integrate Online & Traditional Learning" by Kaye Thorne (2003) is another substantial toolkit, plus it is published online and well-cited. An interesting toolkit has been produced by University of Iowa (Center for Teaching, 2008): it is an extract of Garrison and Vaughan, and comes in eBook and iPhone download versions. Stacey and Gerbic (2008) is a concise and very readable article for starting up a blended learning intervention that gives the perspectives of the institution, teacher, student, and instructional designer. Singh (2003) provides a more verbose and equally effective model for designing a blended learning intervention. Lastly, there are two excellent online toolkits for helping faculty and educational institutions planning to implement blended learning interventions:

- Penn State (2004) site—an in-campus guide for the transformation of their "large enrolment undergraduate courses to online or blended environments" (para. 2); and

- UCF-AASCU (2010)—a joint project to provide resources and an ideas forum to educational institutions.

Bibliographies. The literature in this interest area focuses on listing other blended learning literature. The bibliography by Vignare, Dziuban, Moskal, Luby, Serra-Roldan, and Wood (2005) is very comprehensive with over 60 entries, and a listing of appropriate journals for sourcing blended learning literature. Woodruff (2007) is more recent, but has a very small selection of only 20 entries.

Why Blended Learning?

There are several reasons to choose blended learning as the replacement instructional design. First is that it is a prevalent of the innovative instructional design in education with substantial practice-based evidence of it being a successful instructional design (Watson, 2008; Means, Toyama, Murphy, Bakia, and Jones, 2010; Horn and Staker, 2011).

Second, it exudes a synergy from its multiple instruction modalities and design components that is absent in other instructional designs. To date, that synergy has only been superficially researched. A formal learning theory of variationism (Oliver and Trigwell, 2005)—learning by discernment or contrast—is proposed, but it is still largely without recognition and supporters. Perhaps the synergy is a by-product of our human nature. In a short whitepaper authored by the President of Agilent Learning (an offshoot of Hewlett Packard) and reasonably well cited because of its clarity and ease of understanding, it is stated that "people are not single-method learners … we are, as a species, blended learners" (Carman, 2005, p. 1). In other words, blended learning aligns with our natural tendency to multi-faceted learning. Regardless of its source, this synergy is counted on to put a degree of enjoyment back into the learning and teaching for the course.

The only negative point for blended learning is its varying definitions probably due to its newness, commonplace vernacular, and the rapid expansion of its install base.

Importantly, while this experiment is antecedent in the University, similar studies of blended learning and no lecturing have been conducted in other universities. While these are not copied in this experiment, they provide a reality check and an expectation baseline. The closest in overall context and conduct is in the University of Rijeka for an information science course, although lectures are retained but in lesser quantity (Hoic-Bozic, Mornar, and Boticki, 2009). There is also a similar experiment on blended learning for computer science undergrads in the Technical University of Madrid, but with its focus on contrasting its performance against a distance learning model (Alonso, Manrique, Martinez, and Vines, 2011). The closest experiment in terms of eliminating lectures is in the University of Utah for electrical engineering students (Furse, 2011); the replacement is a structured sequence of five-minute videos, F2F review, small group work, and application, essentially blended learning, though the term is not used in the paper. Finally, there is experiment of eLearning totally replacing lecturing for a foundational psychology course in North Dakota State University (Maki and Maki, 1997).

Taxonomy of Learning Outcomes

In a formal learning setting, measuring the degree of achievement of learning gives the endeavour its meaning. However, until learning science is sufficiently advanced to detect changes in the brain associated with the occurrence of learning, measurement must be made of characteristics that infer learning has happened. The two most common choices for this are correctness and capability. In the end, both measurements still generate a mark as per the grading systems standardized globally. However, the choices entail very different designs of instruments and techniques.

Correctness is measured using a 'rubric', which is a set of criteria that specify for some work product of the student, what can be accepted as being 'correct', where correct is established in some agreed oracle, such as a textbook or a lecture. By definition, correctness is binary, {yes, no}, so complicated work products require a rubric with many disjoint criteria. To determine correctness, an evaluator partitions the work product structurally according to the criteria in the rubric, and compares/contrasts the content of those partitions to the oracle. If the criteria in the rubric are broad, then the partitions will be broad and more likely to reveal co-existing correct and not correct elements. Thus emerges the incongruity of "partially correct".

Capability is measured using a 'learning outcome', which is an aspect of content (see Fig. 2.4) that the student is able to do or demonstrate in terms of knowledge, skills, and values upon completion of a learning period (Trigwell and Prosser, 1991; Biggs and Tang, 2007). Instead of an oracle, capability has context, that is "capability in < something > ". In context associated with cognitive behaviour, capability is ordinal, not binary, meaning that "partially capable" is congruous. Furthermore, capability is progressive in nature—a person starts as incapable, and grows in capability until he/she is as capable as humanly possible—and therefore may be mapped into a hierarchy. To determine capability, an evaluator inspects and interrogates the aspect of content according to the statement of the learning outcome, and identifies the position in a hierarchy reflecting the student's achievement (Kennedy, Hyland, and Ryan, 2006). For this study, learning outcome is the chosen technique for the measurement of learning.

In order to accomplish the mapping from aspect of content to assessment hierarchy, the evaluator needs a framework of textual descriptors associating with the various states that the aspect of content would be in, as a function of the capability of the doing student. In other words, the evaluator needs a 'taxonomy of capability'. Hence, a technique for measuring learning outcomes is designated as a "taxonomy".

Two taxonomies of learning outcome schemas received consideration during this study: Bloom's "Taxonomy of educational objectives", and Biggs and Collis' "Structure of the Observed Learning Outcome" (SOLO). Bloom's taxonomy is the senior of the two, having its first version published in 1956 (Bloom; Bloom, et al.), rewritten in 1984 (Bloom, Krathwohl, and Masia), revised in 2001 (Anderson, Krathwohl, and Bloom; Bloom's contributions are before his death in 1999), and republished as a complete edition in 2005 (Conklin, Anderson, Krathwohl, Airasian, Cruikshank, Mayer, Pintrich, Raths, and Wittrock). SOLO taxonomy is much younger, having been developed by Biggs and Collis in 1982 and updated in 2014. Also, it is favoured by Prosser and Trigwell in their 1999 book, one of the key references for the learning and teaching conceptions in this study. Nevertheless, after using Bloom's taxonomy in the years before the experiment, the decision is taken to continue with it to the end of the research.

Bloom's taxonomy is organized into three domains—cognitive (thinking), affective (emotional), and psychomotor (tactility and coordination)—each comprising a set of categories corresponding to step-wise progression of learning from 'knowing-of' to 'knowing-how'. The following are the six categories in the cognitive domain, in order of capability from least to greatest:

1. Knowledge—remembers individual facts, concepts, and/or main idea;
2. Comprehension—interprets #1 into "own words" and discusses it fluently;
3. Application—applies and maps #2 into new situations to resolve issues, explain rationales, and formulates guides/rules of usage;
4. Analysis—decomposes #2&3 to determine intrinsic interrelationships, formulates inferences, derives principles, and composes generalizations;
5. Synthesis—creates authentic and unprecedented forms/patterns of relationships of multiple facets of the knowledge (#3&4); and
6. Evaluation—rates/ranks/contrasts/compares #5 with external/internal evidence for quality, such as soundness and correctness.

Each category lists a dozen or more verbs that designate the kind of behaviour in the prosecution of a learning outcome that is commensurate to it. For example, the verb "rewrite" is commensurate with a capability in the category "comprehension". Each category lists also six or more artifacts that can be generated in said prosecution. For example, a "hypothesis" is commensurate with a capability in the category "synthesis". Ergo, to determine capability with Bloom's taxonomy, an evaluator formulates—from his/her inspection and/or interrogation—verbs and artifacts that reflect the student's achievement for the aspect of content, and then maps them to the category where they are listed of most appropriate. An outstanding toolkit can be retrieved online from (UNC Charlotte, 2005) for doing such a mapping.

Overview of Educational Technology

Blended learning is not just a proposition of educational technology, and the technology is not the blended learning. Instead, the imperative purpose of the technology is to enhance even multiply the student's knowledge inculcation (Singh, 2003). However, not until computers and smart phones is this requirement actually achievable.

As early as the 1940s, audio-visual technology was incepted into the classroom. The three major classifications of audio-visual technology were: moving pictures (films and TV), still pictures (slides and photographs), and sound (LP records and tape) (DeVaney and Butler, 1996). But these technologies had to be operated in the classroom, hence they could not move away from only extending traditional lecturing.

The twentieth century hosted a rapid expansion in the use of educational technology for the classroom. The earliest blended learning in education—although at the time it was called "hybrid learning" not blended learning—was in the 1970′s, with the mix of computer-based training (CBT) on mainframe platforms and instructor-led training. In the 1980–90s, blended learning came in the form of "distance learning" interventions, mostly for adult education, with live video feeds of instructor lead training mixed with locally-available CBT. eLearning systems on PC platforms replaced mainframe CBT in the 1990s. By the middle of the first decade of the third millennia A.D., web-based training systems and virtual classrooms were the norm, and blended learning became the recognized term for the mix of computer- and person-delivered education (Bersin, 2004, Chap. 1).

As costs and device footprint reduce, the numbers of computers deploying in education, especially higher education, increase. This is very welcoming to the digital natives, who up to this point do not have adequate opportunity to use their skills to full advantage (Dziuban, Moskal, and Hartman, 2005).

Recent research on educational technology suggests it has great potential for enhancing the student's learning in education. There are many case studies where emerging technology has been utilized successfully in an educational setting, such as Muirhead (2007), Amiel and Reeves (2008), and Saeed, Yang, and Sinnappan (2009). Yet, it has also met with failure (Wang and Reeves, 2003). For the student, some technology obscures and overwhelms what is being learned with excessive levels of detail. For the teacher, the cumbersomeness of some technology far outweighs the limited and uneven gains in the student's learning. Finally, for the institution, underutilization in the face of high expenses to procure, maintain, and upgrade, is the problem. If the first two problems can be solved, the third will resolve itself.

Ertmer (1999) published an important paper, aimed at the teacher, concerning the obstacles accompanying new educational technology deployment, and how to overcome them. Ertmer posits two obstacles, unfamiliarity and instruction redesign. Unfamiliarity originates with being a digital immigrant, someone who has adapted to, but never really assimilated, the new technology. With a lack of mastery and confidence that goes with it, the unfamiliarity leads to mistakes, and then to the breakdown of classroom governance. This, Ertmer states, can be resolved with scaffolding and technical support.

Instruction redesign—which is exactly what this study is engaging in—is hard work for the teacher, and twice the problem to resolve. Funding is not so much the problem as the teacher's time and institution support. To prepare and deliver a new course with the same instructional design takes upwards of a year. To redesign the instruction takes at least as long. Add to this the necessity of institution support. "Lack of institutional support, from encouragement by administration to try new technologies, to provide funding specifically for technical support and technology purchases, becomes a major barrier to the infusion of new technologies" (Rogers, 2000, p. 461). Interestingly, there is as yet no learning theory that explains why educational technology enhances learning. "The problem does not reside in electronic technology itself, but rather with its uneasy and traumatized entry into the classroom" (Albirini, 2007, p. 231). Essentially, a project to bring technology into an education intervention may be more a leap of faith than a prudently assessed and risk-manage venture.

Two well-known traps that can easily be avoided in an instruction redesign are trivialization and omnipotence (Salomon, 2002). The technology is "trivialized" by utilizing it in learning situations that it was never meant to work, or it is made "omnipotent" by relying entirely on the technology to do the teaching without any objectives, pedagogical checkpoints, or verification of learning outcomes. The obvious avoidance measures are to use it only as a supplement to the pedagogy, and use it sparingly. In other words, best practice is to overuse a little technology than underuse a lot of technology.

Two Interesting Case Studies in Educational Technology

Two very informative and intriguing case studies have emerged, illustrating how much there is still to understand about education technology and its possibilities for enhancing formal learning.

The first started with an experiment known as the "hole-in-the-wall", where a computer with a high-speed internet connection was installed in a wall in a neighbourhood slum in New Delhi, India (Mitra, 2006; he is the principle investigator in the experiment). Children began to interact with the computer. Without access to formal education and despite their illiterateness, these children were able to acquire extensive knowledge on operating the computer, and navigate the WWW without the guidance of teachers or adults. In fact, the children quickly established their own system of mentorship to help them all get the most out of the computer and WWW. This experiment was duplicated in other cities, all with the same outcomes of self-guided and self-organized learning. At first glance, this transgresses the findings of Salomon (2002) and Albirini (2007) that emerging technology is not effective without "expert" support and guidance. However, as the children never were exposed to the concept of formal education and teachers, then perhaps the tenets of support and guidance are not applicable in this situation. Mitra's conclusion is that education is a self-organizing system where learning is an emergent phenomenon.

The second is the Khan Academy, where the premise is that stylized videos can render effective learning outcomes without the guidance of a teacher (Khan Academy, 2009). Since its inception, the academy has delivered over 84 million lessons, and accolades form tens of thousands of users claiming its effectiveness in promoting learning. The thought-provoking aspect of the Khan Academy is that there is no curriculum or course structure. The videos are standalone and provide knowledge on a confined topic. The learner is responsible to imbue context and assimilation scheme to the choice and sequence of video viewing. This is the academy founder's learning philosophy:

> A lot of my own educational experience was spent frustrated with how information was conveyed in textbooks and lectures. There would be connections in the subject matter that standard curricula would ignore despite the fact that they make the content easier to understand, enjoy, and RETAIN. I felt like fascinating and INTUITIVE concepts were almost intentionally being butchered into pages and pages of sleep-inducing text and monotonic, scripted lectures. A direct observation was otherwise intelligent peers memorizing steps and formulas for the next exam without any sense of the intuition or big picture, only to forget everything within a matter of weeks. These videos are my expression of how the concepts should have been expressed in the first place, all while not compromising rigor or comprehensiveness. (FAQ, para. 1)

Though the two case studies have entirely different settings with entirely different technology emphases, their conclusions appear strikingly analogous: people can learn by employing technological interventions without any extrinsic assistance or guidance. To all appearances, if the student is in a high-receptivity mode, some technology can be an effective facilitator of learning while rendering scaffolds and other instructionist aids obsolete. Another thought to consider is that the persons in the case studies are actually exhibiting digital nativeness, giving more credence to the proposition that the digital native or net generation is a real phenomenon. As the world becomes increasingly stocked with ubiquitous computing devices, one can only wonder at what this will mean for the propitiousness of instructionism and the zone of proximal development theories in formal education?

In summary, there is a plethora of existing knowledge for learning and teaching. However, the amount is not as much of a problem as the overlapping of the conceptions. A telling example is contructivism and constructionism, two very similar theories concerning learning from different people in different timelines that have never been normalized. Another very interesting example of possible overlap is the learning style and digital native conceptions. Though on the surface they are very different, they may be far more similar. Both involve the uber-important Teacher-Student interaction, and both suggest that a neo-physiological condition in the Student is the cause for the well-documented growing problem in the conduct of formal learning. All-in-all, for an engineering teacher to move into the learning and teaching domain for the love of the craft is certainly faced with the spectacular task of coming up to speed with the mountain of publications.

Chapter 3
Empirical Methodology

This chapter outlines the methodology followed in the design, construction, and deployment of the research platform, and the conduct of the experiment. The methodology is informed by the instructional design literature examined in the preceding chapter, and also is consistent with the Asia-centricity of the learning environment and the educational norms of the University. The research platform is the new instructional design, blended learning, sequenced with learning activities, educational technology, course content, and assessment instruments. It is the mechanism for generating the data being walked through in Chap. 5 and then analysed in Chap. 6. The experiment dictates all aspects of how, when, and where the platform is employed.

The actions now categorized as those of the research methodology trace their origins to the teacher's individual initiative in his capacity as course coordinator: to provide a more modern and concordantly more effective learning and teaching experience in his Software Engineering course. (The course belongs to the CE degree program offered at the School.) The Preface is a personal reflection of the teacher's initiative. Before the advent of blended learning, and even after the experiment's closure,[1] the only instructional design that students in the School experienced in the entire four years of their CE degree and higher education learning experience is traditional lecturing. Evidence is provided in Chap. 2 that out-datedness and learning ineffectiveness are deep-seated features of traditional lecturing. Accordingly, the teacher's focus was initially on improving the learning experience in his course by replacing traditional lecturing.

This endeavour is not easy. Replacement of an instructional design in a continuously running biannual course is an enterprise operation at level of complexity, detail,

[1]After the end of the research project, and the secondment of the teacher to the newly established medical school to assist in its realization of an innovative instruction design, the Software Engineering course's research platform was discarded by the new faculty and its instructional design reverted to traditional lecturing. Yet three years after that, traditional lecturing has finally been supplanted from its position of pre-eminence in the University's learning and teaching with the launch of the Technology Enabled Learning program, by all accounts a clone of blended learning pioneered in the Software Engineering course.

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and risk similar to creating a new course from scratch. Consequently, there was no thought initially of piling on additional duties and responsibilities commensurate with a research project, overtop of the standing effort to plan, construct, critique, and remedy the new instructional design. However, shortly after its commencement, the endeavour did switch from a teacher's individual initiative to educational research. This turnaround occurred with the award to the teacher of a grant of $90 K from the Teaching Excellence Fund (TEF) (Koh, 2008) for developing a scalable and extensible blended learning model for engineering students.

By choice, this chapter focusses on the research methodology in its full formulation after receipt of the grant. It does not discuss the correlation of the old endeavour (teacher initiative) to the new one (educational research), the path taken for the formulation of the research, nor the rationale of decisions shaping the formulation process. In other words, the research methodology is advanced as existing from the start of the research endeavour and that there was no personal initiative preceding the research.

This chapter comprises the following sections:

1. Explanation of the experimental strategy;
2. Substantiation of design-based research methodology for this study;
3. Method for instructional design replacement; and
4. Specification of the particular blended learning instance for the experiment.

Explanation of the Experimental Strategy

Prior to the proposal for the educational research project, data useful for analysing the academic performance of his students in traditional lecturing was being collected by the teacher of the Software Engineering course. The primary constituents of that data are marks for examination and a variety of coursework components, attendance for F2F activities including examination, project leadership, and nationality. Collection of this data is a standard activity carried out by all faculty in the University. What distinguishes the teacher's collection effort is his inclusion into the regular data of learning styles data in the form of the ILS report[2] (Felder & Soloman, 1991).

With several years of traditional lecturing data being collected, the teacher proposes an educational research project to determine if an instructional design different than the incumbent would have a positive effect upon the academic performance of Asian higher education students. The high-level plan is to record a year of student performance in traditional lecturing prior to the experiment, and then conduct the experiment—replace incumbent instructional design with the research platform—for at least one year. The research platform for this study is blended

[2]A few years after joining the University, the teacher volunteered for a professional development program regarding innovative teaching. In the program, the teacher was introduced to the Felder and Silverman learning styles (1988), and subsequently began administering the ILS survey in his course. In the short term, the teacher intended to use the ILS data to justify and spur the development of more effective learning activities in his course.

learning, an instructional design that is regarded as more effective than traditional lecturing (see Chap. 2). The data collected in the experiment is of similar classes to that already collected in the traditional lecturing term (see Chaps. 4 and 5). Subsequently, the two sets of data are compared to determine what if any are the significant differences.

Research Methodology is Design-Based

In reiteration of Chap. 2, blended learning is an instructional design describing a framework of distinct and independent components whose conjunctive conduct is designed to promote learning; this definition is suggested figuratively by its designation of "blended". The specification of blended learning adopted in this study is the archetypal 'eLearning plus F2F'.

However, to say that this affords a precise specification of blended learning is an overstatement. eLearning and F2F are themselves abstractions that require manifestation with concrete schemes of online and classroom learning activities before a true understanding of their structure and behaviour can be appreciated. Importantly, both components are engineered, in much the same way that a course curriculum is engineered, with sets of learning activities bound into a coherent sequence covering the length of time allotted to each component. Also like a course curriculum, any observed inadequacies in the learning activities are corrected in an iterative rather than all-out disruptive manner. This is to say, planned changes are minimized and imprinted subtly into the needy activities without adulterating their cores, their conjunction with other activities, or their conformity within their owning sequence. These conditions correspond to the accepted definition of 'design experiment' or as it is better known and so utilized in this study, 'design-based research'. Consider this definition by thought leaders in the field.

> Prototypically, design experiments entail both "engineering" particular forms of learning and systematically studying those forms of learning with the context defined by the means of supporting them. This designed context is subjective to test and revision, and the successive iterations that result play a role similar to that of systematic variation in experiment. (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003, p. 9)

The learning activities comprising blended learning are itemized and detailed in this chapter's final section.

High-Level Plan for Deploying Experiment

As inferred in the Preface, the experiment is a personal initiative, requiring School approval contingent on the premise that it would not engender any overt support or auxiliary timetabling of the F2F sessions for the target course, Software Engineering.

Accordingly, the teacher of that course brainstormed a high-level plan for deploying the experiment within the constraints of his teaching schedule.

The first step in the plan is choosing when the deployment of blended learning will happen; this is the critical milestone about which is developed the high-level plan for the experiment. Prior to the milestone, collection of a year's worth of student performance data in traditional lecturing musty have already occurred. The proposal, School approval, and construction of the research platform would be complete prior to the deployment milestone. The course would run with blended learning for at least two semesters.

In late year 2006, the deployment milestone is set as the start of semester 08S1, which is August 2008. Discussions concerning an implementation of blended learning in the School commence with CELT in mid-2007. Over the next half-year period, this generates a preliminary proposal of the design of an instance of blended learning, plus the method for constructing and deploying this instance. On the strength of CELT's participation and their technical "go-ahead" for the researcher's preliminary proposal, in April 2008 the School tentatively approves the instructional design experiment in its core Software Engineering course. The preliminary proposal is finalized by end May 2007. Construction of the research platform begins in earnest June 2008, and finishes in early August 2008 in time for the attachment of the first cohort, 08S1.

Duration of Experiment

Initially, the duration of the experiment is unspecified. Though the minimum duration is decided—the experiment must be conducted for at least two semesters for any meaningful results to be obtained—its maximum duration is flexible. From an investigative perspective, the duration must allow sufficient time for the new instructional design to take hold within the student community, and be accepted as at least authentic and possibly even mainstream for the Software Engineering course. It is particularly important that this sentiment makes its way to the freshmen who are poised to undertake the course as sophomores. Additionally, the newly constructed instructional design needs time—in parallel to its pursuit of acceptance as authentic—to settle into a groove of polished and confident delivery. Given that there is no precedent of blended learning in the University, there is a better than average risk of there being initial misjudgements in the learning activities that need remedying. These would subsequently increase the length of time needed for the new instructional design to "settle in".

From the teacher's perspective, if the majority of students are experiencing better learning with blended learning, then he is compelled professionally to operate the more effective instructional design as long as possible. Doing so would benefit as many of the learner throughput as possible, and enlighten as many—later in their lives, either as parents or industrial leaders—potential instructors about the capacity of innovative learning and teaching.

Finally, the political perspective involves the teacher, his colleagues, and the School, and is more speculative in nature. An en-masse adverse response to the blended learning by the students at the outset of the experiment cannot be discounted, again because there is no precedent for such research in the School or for the operation of blended learning in the University. Such a response would undoubtedly be manifested in the student teaching feedback (STF),[3] which would be outright disastrous for the teacher if experienced for more than two years. On the other hand, a longer duration may benefit the research by providing more time for the news of the research to circulate amongst the School faculty. If this encourages just one to deploy a small innovation in his/her course, it might trigger a domino effect of decreasing the isolation of the blended learning research, contributing to its acceptance into the teaching mainstream of the School, and reducing the influence of spurious agitators who use the STF to vent their frustrations. Independently of these, there may be opposition to a longitudinal experiment from the University's risk-adverse management, who may reason that it would expose the University to students' complaints about such educational research being taken to a public forum.

Upon reaching the two-semester minimum, the teacher notes that the first cohort of students are coping well with blended learning. Though it is not yet recognized as authentic, there is no virulent dissatisfaction with the learning experience, and the teacher's STF scores remain reasonably high. Hence, the teacher decides to continue the experiment and operate the research platform for another two semesters, and then again revisit the decision to continue. This extending the experiment by two semesters continues until the fourth year, when the teacher abruptly stops the experiment due to diminishing returns, lack of recognition within the School, and researcher fatigue. The factor leading to the cessation of the experiment is discussed in one of the research limitations documented in Chap. 7.

Congruity of Research Platform Data

Primarily, the findings of the research will come from a comparison of two sets of data, one set associated with traditional lecturing and the other with the research platform. Since the research platform is unprecedented, it is important to consider the possibility that congruity of the data, especially that collected in a longitudinal experiment, is compromised. Such incongruity in the data may arise from either/both

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[3]Every student in the University is surveyed in every semester of his/her degree program concerning the instruction received in every core course, with the 'student teaching feedback' (STF) survey instrument. The name belies its unstated purpose, which is to derive an empirical specification of the performance of the faculty. The rating given by the student is also not feedback; instead, it is a statement of the student's personal satisfaction. The survey results are never vetted for outliers and obvious ad hominem attacks, and are nearly always self-contradictory. Anxiety of the STF's impact on one's contract renewal leads a number of faculty to maintain a status quo teaching praxis at best, and teach to the examination at worst.

a change of teaching praxis, or difference between the student cohorts, and thus actualized as some non-uniformity in the data, semester-on-semester.

The teacher conducting the experiment is experienced, steadfast, and competent. He has 30 years of experience in teaching young adults, with the last five of those in the University. The teacher has been the course coordinator and sole teacher for lectures, tutorials, and laboratory projects conducted in the Software Engineering course for the last three years. In his capacity of course coordinator, the teacher rewrote the course curriculum, and so is completely familiar with every aspect of the course's content and conduct. Moreover, he is in a privileged position of possessing an acute awareness of the many different ways in which the students create their perceptions of the course material. The highly respected authors Prosser and Trigwell assert in their 1998 book on "Understanding learning and teaching", that "high-quality learning is more likely to be achieved if the teacher has an awareness of the variation in the ways students understand the phenomenon being learned" (p. 129). Evidencing his proficiency in high-quality teaching, the teacher consistently scores above the School average in the STF. Therefore, a deviation in teaching praxis, whether accidental or unconscious, is rejected.

On the other hand, a difference between the student cohorts semester-on-semester is a possibility, and may be significant. The sole exception in terms of significance is the class sizes; this difference is the most predictable—the number of students in the S1 semester is always smaller by about half than that for the S2 semester—and also the least consequential. Instead, the differences semester-on-semester that are impactful to the point of being significant are the proportions of students:

- Repeating the examination, coursework, or both;
- Not exposed to innovative instructional design in their prior experience;
- Resolutely anchored to traditional lecturing; and
- Nonproficient in digital learning environments.

Given the degrees of variance within these four circumstances, it is reasonable to anticipate that there will be semester-on-semester differences in the students participating in the experiment.

A side note is that innovative instructional designs and digital learning environments are not synonymous. While it is true that some innovative instructional designs incorporate digital learning environments, the difference between the two is one of emphasis. An innovative instructional design is construed as predominantly a protocol of a student's learning process, whereas a digital learning environment is predominantly a modality of facilitation that has to be mastered in order to support the student's learning process.

Returning to the four semester-on-semester circumstances, just because these exist does not render the data incongruent. In actuality, some non-uniformity of data in the semesters is a necessary condition of the experiment. Consider that the students are all inductees of the University, subject to a strict and immutable protocol of acceptance criteria. Essentially, the University limits its recruitment of students to only those that it expects have the capability to do well academically. This recruitment strategy serves to normalize the academic achievement potential of the University's students given the prevailing instructional design, traditional lecturing. Of course, normalized does not construe homogenized; it is unreasonable to expect that the University's students are identical, but only that they have the same potential. In fact, this absence of homogenization is precisely what the research is expecting will invoke observable and different responses to blended learning in the students. The key to accepting the congruity of the data collected semester-on-semester, is that the same differences invoke the same kinds of responses regardless of semester. Such a determination will be rendered by statistical analysis conducted in Chap. 6. Once all the factors are analysed for the kind of responses that they invoke in the students, select semesters will be analysed to validate the congruity of the data semester-on-semester.

On a final note, it is accepted that the data pertaining to traditional lecturing suffers from none of the incongruity concerns that beleaguer the research platform. When the data was being collected, traditional lecturing was the mainstream already, most faculty exuded a quiet confidence in their delivery to the students, there was no uncertainty for its learning effectiveness, and no conflict policy-wise or political raised by its practice. Hence, it is appropriate for the teacher to choose any data collected during the entire period preceding the research, for representing the learning achieved with traditional lecturing because of its stability and equilibrium. For simplicity, the year period of traditional lecturing student performance data chosen for this study is academic year 2007–2008 semesters one and two, {07S1, 07S2}.

Substantiation of Design-Based Research Methodology

In the previous section, it is asserted that the research methodology used in the experiment is design-based. This section explains the conduct, theory-data concordance, and educational relevance, interspersed with substantiations from eminent researchers and philosophers to justify in no uncertain terms the validity and veracity of this approach.

At its simplest, design-based research is devoid of the 'a priori' hypothesis, a fixture of the scientific method.[4] Figure 3.1 compares in more detail hypothesis-based research (shown in the upper sequence) with design-based research (shown in the lower sequence). Note that Fig. 3.1 in in non UML compliant form.

A few clarifications to the design-based research sequence in Fig. 3.1 are pertinent to the application of design-based research sequence in this study. The "researcher and practitioner" roles designated in the first step are actually realised by a by a single person, contrary to Amiel and Reeves's recommendation that they be separate persons. The "design principles" in the second step equivocate to the learning strategy and implementation of the instructional design decided by the teacher. The

[4]The scientific method is a corpus of techniques for investigating the world and generating knowledge. It starts with falsifiable hypotheses, followed by predictions of their probable consequences, then experimentation to test the predictions. Depending on the results, the hypotheses may be altered or even rejected.

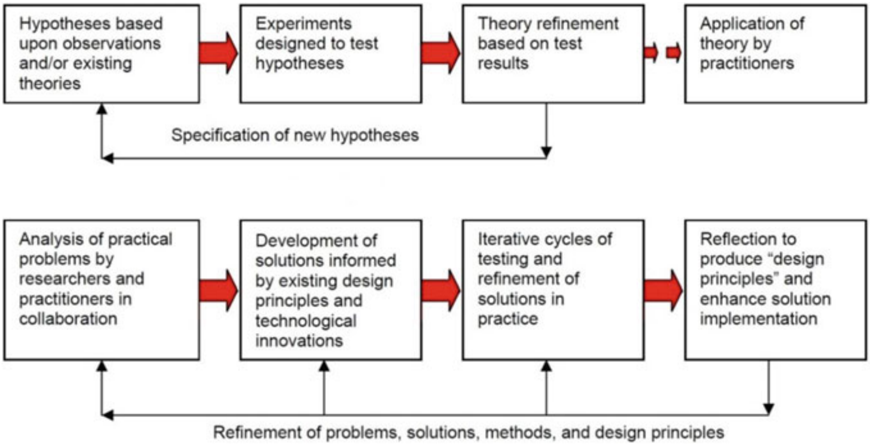


Fig. 3.1 Hypothesis-based versus design-based research (Amiel & Reeves, 2008, p. 34)

"solution" in the second and third steps is the research platform, defined blended learning sequenced with activities, technology, content, and assessment instruments. The "design principles" and "solution" are detailed in the final sections of this chapter. The third step "iterate cycles" spans across the eight semesters {08S1-11S2} that eventually comprise the experiment's duration. Lastly, the fourth step's "reflection" occurs after every two semesters in the summer break when there is sufficient time to develop the technical or procedural enhancement. Additionally, two formal reports are generated for the experiment. The first is the final report (Jones, 2012a) on the first three semesters written in accordance with the terms of the TEF grant, and the second is this thesis.

An understanding of the context of the praxis is essential for designing research experiments in any field, including educational research, which must form-fit to the fundamental didactic model of formal education, comprising the student, teacher, and content (Kansanen & Meri, 1999). In contrast, learning science research is not synonymous with educational research because the teacher and content are suppressed, leaving only the student with his/her biological and psychological nature. The standard functional space in a higher education institution where the three formal education elements, student, teacher, and content, come together is the classroom. In other words, educational research must be conducted in the classroom for it to be relevant and meaningful. Thus obliged, the subsequent research must acquiesce to the two tenets that underpin all learning and teaching therein, authenticity and ethics.

Authenticity

The learning and teaching in a higher education classroom is real-world—real persons engaging in real interactions with real-life impacting outcomes—operating in real-time. Numerous variables are present in the classroom, some of which openly or otherwise are inter-dependent. All this serves to inhibit or preclude the researcher from developing models of causality and deriving companion hypotheses for the learning and teaching.

> According to many educational researchers and contrary to the arguments of those pushing for experimental designs as the gold standard, the messiness of real-world practice must be recognized, understood, and integrated as part of theoretical claims if the claims are to have real-world explanatory value. From this perspective, examining teaching and learning as isolated variables within laboratory or other artificial contexts will necessarily lead to understandings and theories that are incomplete. Experimental studies that simply indicate a variable is significant may be less useful than rich examples and case narratives are for informing how to implement a particular variable or theory within the context of real-world practice. Within learning environments, so-called confounding variables necessarily occur and must be taken into account (not controlled) if the findings are to be relevant to practitioners. Context is not simply a container within which the disembodied "regularities" under study occur, but is an integral part of the complex causal mechanisms that give rise to the phenomenon under study. (Maxwell, 2004, p. 154)

Though all the inter-acting and confounding variables make the application of any coherent model nearly impossible, nevertheless there are some paradigms of commonality—ethnography, Piaget's theory of cognitive development (Huitt & Hummel, 2003), prior experience and proximity learning (Kozulin, 2003; Chaiklin, 2003), instructional design theory, subject content, degree program framework, and ubiquitous computing and generational reception—in the classroom that serve to narrow the degree of variance (Marton, 1981) and facilitate analysis. These paradigms do not decrease variables, but they normalize many of those existing and consequently decrease the variance within the set of variables associated with the paradigm.

This idea is exemplified in Biggs (1994) where he singles out two coherent learner groups, Asian and Western (obviously based on the ethnography paradigm), distinguishable by select in-classroom behaviours shared within each group. He identifies some of the variables having common values in their group, and then compares them to produce findings on the causes and mechanisms of learning for each group. Other paradigms' groupings will yield other distinguishable in-classroom learning behaviours. These may then merge with the design-based methodology to facilitate educational research as follows.

> First, design studies are more akin to case studies and ethnographies, in that they seek to provide levels of detail and specificity about complex interactions over extended periods of time, rather than establishing broad and representative patterns. Second, design studies are not typically scaled up to widespread practice; instead, they often provide information that teachers find compelling as a means to make sense of their already rich experiences in practice. They are often the basis for a staged series of investigations which can be followed by curricular development and evaluation, or broader forms of instructional efficacy studies. (Confrey, 2005, p. 146)

In summary, if an education research experiment is design-based and confined to groups with these commonalities, the findings will be more representative of the nature of relation or effect, the experiment more replicable, and overall conclusions possibly more generalizable.

Ethics

The notion by Confrey (2005) that design-based research is used by teachers to make sense of their practice infers a moral pursuance on the part of the teacher, and hence puts it squarely in the domain of ethical considerations. To paraphrase Sammons (2005), employment of design-based research to gain a new understanding of how to teach better has "moral overtones". The situation worsens if the teacher and researcher are the same person. This promotes a personal stake in the outcome, giving rise to a potentially biased research situation. (Recall Amiel and Reeves recommend the researcher and practitioner be separate persons.) All this necessitates the inclusion of ethics precepts into the research.

The standard ethics precepts for research, such as access, confidentiality, disclosure, diminished harm, and informed consent (Burgess, 2005, p. 5), are compatible with both design-based and hypothesis-based research. However, employment of control groups, common in hypothesis-based research experimentation, are not consistent with design-based ethical considerations. It is not that these considerations are more stringent for design-based; but rather that using control groups transgress the ethics precepts of disclosure and harm.

Control group creation may be either inside or outside the research platform; in this study, that platform is a blended learning conversion of the Software Engineering course. First consider group creation inside that platform; for argument sake, half of the cohort is assigned to the research platform and the other half to the control, traditional lecturing. Such an arrangement could be realised if the cohort is divided into two separate classrooms, the same teacher scheduled to be in both at different times, and each half of the cohort remained unaware of the other. This secrecy would be vital because once the students discover that their course mates are in a different instructional design, they would question the value and fairness of their own learning situation. Each half would believe their instructional design is either obsolete and inadequate, or too new and unauthentic. At this point, some explanation or form of disclosure would be necessary. Regardless of the disclosure being partial or full, it is unlikely to quell the discontent, only worsen it, thus harming the cohort's overall academic performance. The effect on the dependant variables would be completely outside of the commonality paradigms discussed in the previous section, thus confounding the findings of the subsequent analysis. Not to mention, the researcher/teacher would find it exceptionally challenging, perhaps impossible, to develop the research platform's iterations that are a key aspect of the methodology, due to the encumbrance of concurrent monitoring and analysis of the two opposing groups.

Now consider creation (of the control group) outside of that platform. The learning situation in the control group has to be similar to that of the test subject group, plus, the members of both groups have to belong to the same population. In the case of education research, particularly for this study where the population is the University's student body, the major factors affecting the learning situation are students, teacher, and course. The closest match of the learning situations of the control and test subject groups, is attained by running the same course with the same teacher, but in a different semester with different students. If every run of the control group were to be prior to the start of research platform, then this is the approach actually employed for this study's experiment. However, if the control group is interleaved with the research platform, in other words in a sequence such as platform then control then second platform then second control, and so on, this harms the experiment in every aspect discussed in the "duration of experiment" section. The other variations of students, teacher, and course—for example same students and teacher, but different course, and different students and course, but same teacher—become increasingly less relevant as a control for the experiment.

In summary, education research must be conducted in the classroom because of the issues of authenticity and ethics that are at the core of formal learning. To paraphrase Sawyer (2005), design-based research methodology is the universally accepted choice for educational research, meeting all standards of scientific research, including a substantive formal model (Fig. 3.1), necessary rigour (conduct of experiment is exacting), and explicit and feasible relevance of its claims to education practices (transcending control group). The definitive judgment of the validity of design-based research is best expressed as follows.

> We have argued that design-based research methods can compose a coherent methodology that bridges theoretical research and educational practice. Viewing both the design of an intervention and its specific enactments as objects of research can produce robust explanations of innovative practice and provide principles that can be localized for others to apply to new settings. Design-based research, by grounding itself in the needs, constraints, and interactions of local practice, can provide a lens for understanding how theoretical claims about teaching and learning can be transformed into effective learning in educational settings. (The Design-Based Research Collective, 2003, p. 8)

Method for Constructing Research Platform

It is stated earlier that replacing the instructional design of an existing course entails a workload of a similar magnitude to creating a new course from scratch. This is because the learning resources of one model of instructional design are likely not suitable for use in another model. For example, learning resources in an eLearning model are not mere digitizations of the resources used in the lecturing model; instead, they are virtualizations and very expensive time-wise to build (Díaz & Entonado, 2009). The other key consideration is that the entire development and evaluation effort for the experiment rests with a single individual, namely the course coordinator.

In a similar experiment where lectures were also replaced in their entirety, a team of minimum four persons was assigned to the project (Maki & Maki, 1997).

In the first-half of year 2007, the researcher posited a six-step method of constructing and deploying the blended learning instructional design and published it after the experiment (Jones, 2012b). It comprises the following six steps.

1. Establish the eLearning and F2F ratio—This underpins the work breakdown for the conversion, and also provides the School management, fixated on the primacy of traditional lecturing, with a concise benchmark for assessing the bureaucratic risk of the experiment;
2. Rethink the new pedagogy—This rationalizes the essential principles and strategies for setting the right conditions for the right learning. It is both an opportunity and a necessity. An opportunity because there are a continuum of new discoveries and developments in learning science and instructional theory that should be taken into consideration in any new course. A necessity because a new instructional design demands understanding for its correct conditionalization, especially with respect to its conditions of learning;
3. Develop the learning activities—These are the purposeful sessions that realise the instructional theory and design discussed in the previous step. These learning activities classify pedagogically and in-practice to either eLearning or F2F, and duly account for the class size, learning space, timetabling, and available educational technology. Liberated from the confines of the lecture format, countless innovative renditions of new learning activities are imagined;
4. Map the learning journey—This assembles the basic structure of the entire course using the learning activities from the previous step. The learning journey has three dimensions: semester, weekly, and daily. Semester contains one-time-only learning activities such as the welcome briefing, midterm assessment, and final assessment. Weekly contains eLearning and F2F learning activities such as 'online learning exercise' and 'review'. In this research platform, no consecutive activities are scheduled in any single day, so daily dimension is not applicable;
5. Run pilot and review performance—This is the test run of the new instructional design. Changing the instructional design is not a routine endeavour in any educational institution, especially for the case of the design being the first of its kind. It is not advisable to downplay the exactitude of a new instructional design for a course. In the University, it is a mandatory code of ethical behaviour to advise the students of their participation in an educational experiment; and
6. Incorporate enhancements and launch—This is the inauguration of the course with its new instructional design being fully operational. This should be considered only after conducting at least one year of a test run review and enhancement. Even after the course is fully operational, the process of enhancing individual learning activities and incorporating new pedagogy should be on-going.

The six-step replacement method is purposefully generic, yet flexible, allowing the teacher and University to regulate the details of each step to suit their norms. The following sections expand upon the first three steps.

Establish eLearning and F2F Ratio

There is no known optimal ratio of eLearning to F2F; the teacher may choose any ratio for his/her instance of blended learning. The ratio adopted for this study is 40% eLearning and 60% F2F, derived from an appraisal of three factors: course timetable, study culture, and workload. From the School management's viewpoint, the new course is a temporary and localized incidence, so the aggregate of the F2F activities cannot exceed the university norm of six hours scheduled in the learner's weekly timetable. The unofficial and accepted study culture for the undergraduates is, one hour preparation for every one hour of lecturing. This preparation traces to eLearning, necessitating that eLearning follow suit in the given timings. Finally, there has been a dictum of the Ministry of Education standing since 1997 for its schools to "teach less" (Tan, Tan, & Chua, 2008), which was unofficially followed in the University until officially adopted in 2011 (Tan, 2011). Given this and the abundance of references proclaiming eLearning to facilitate as good, if not better, learning as lecturing (see Chap. 2), it is reasonable to substitute eLearning for some of the class work. So, the final tally of the course's assigned time per week is 3.6 h of eLearning and a reduced 5 h of F2F (Table 3.1).

The 40:60 ratio speaks to a moderate emphasis of F2F instructional design that brings a degree of easiness to a university that has the lecturing model entrenched in its teaching praxis. A dialog in the first semester of the blended learning course with NTU's Dean of Engineering illustrates the point that F2F is integral to the University's education.[5] While not being specific in the nature of the F2F encounter—particularly there being no lectures—the larger emphasis on F2F (60%) convinced the Dean that the experiment was sanctionable.

Rethink the Pedagogy

The extent to which the teacher unpacks and rethinks the course pedagogy is at his/her discretion. In this study, all the learning activities (with the exception of the laboratory project), assessment instruments, and most of the technology in the course, are re-envisioned for blended learning. A new learning cycle incorporates the new activities, assessments, and technology, but at the higher level they remain constrained to the weekly session scheme—timing (one hour) and student loading (lectures are cohort, tutorials are subsets of cohort)—established for all courses in the School. The laboratory project, "Public Bus Service Simulator", is unchanged

[5]During the Dean's tea/coffee mixer on 28 November 2008, an informal event for the College of Engineering faculty in different schools to share ideas and socialize, the teacher discussed the blended learning experiment with him. Although supportive in principle, the Dean emphasized that the delivery could not be all eLearning. He stated that a key aspect of the university experience was the traditional F2F discourse between the professor and the student, and in the management's opinion, it is essential for NTU to retain that for some part of the four years of the degree process.

Table 3.1 Comparison of weekly learning sessions and durations by instructional design

Instructional	Timetable periods				
Design	1st lecture	2nd lecture	3rd lecture	Tutorial	Laboratory
Old: lecture	Class work—1 h; Homework—1 h	Class work—1 h; Homework—1 h	Class work—1 h; Homework—1 h	Class work—1 h; Homework—1 h	Class work—2 h; Homework—1 h
New: blended learning	F2F—1 h; eLearning—1 h	F2F—1 h; eLearning—1 h	eLearning—1.1 h	F2F—1 h; eLearning—0.5 h	F2F—2 h

because it is a revolutionary teaching concept launched several semesters before this study. It transcends traditional lecturing, thus is appropriate to operate alongside the other new activities in blended learning.

Recall in Chap. 2 the description of prominent learning theories presently in vogue with educational researchers. Also recall Gagné's 1985 "nine steps of instruction" in his preeminent theory of instructional design and its summarization in Fig. 2.3. The teacher has the opportunity now to develop his own learning strategy that incorporates the desired learning theory and as many as possible of the condition-events into the research platform's instance of blended learning. The subsequent strategy draws heavily from the leading—with over 10,600 citations—handbook on learning for this generation, "How people learn: Brain, mind, experience, and school" by Bransford, Brown, and Cocking (2004). The learning strategy has seven parts that amalgamate learning theory with the "nine steps of instruction" for optimal learning.

1. Build a competency-based foundation—This involves prior learning and new understanding. Early in the course, the learner's preconceptions about the subject are activated and if necessary corrected; it is essential for the learner to be aware of and subsequently abandon incompatible prior knowledge. Following this, the learner creates an integral knowledge baseline comprising new facts and foundational concepts.
2. Facilitate knowledge fluency—This means that the learner's prior knowledge is easily and effectively retrieved and correlated to all immediate learning. This does not imply that the learner is an expert. It does mean that the learner organizes his/her knowledge with some intuitive associations of relative meanings, patterns, and situational metadata.
3. Emphasize learning in teams—This requires the formation of teams of learners early in the course to facilitate their organic growth in effectiveness and productivity. The team size is optimized to ensure individual members have a reasonable amount of workload, while having sufficient available time to sustain a healthy degree of discourse with the other members. In other words, the team arrangement leverages the unique strengths of its members via interaction, thus encouraging them to apply their fair-share in the undertaking of the work products.
4. Sponsor learner metacognition—This entails the learner setting his/her learning goals and monitoring his/her progress in achieving them. The intention is for the learner to learn how to learn using the new instructional design; this includes learning teamwork. It also involves the active guidance of and monitoring by the teacher to incentivise the learner.
5. Encourage learning transfer—This calls for an ingrained culture of thinking out of the box, and there being no single right answer. In addition to espousing quantity, productivity of the learners also embodies creativity and risk. The intention is to provide less standard examples and solicit more application by the learners of foundational knowledge in unexplored scenarios to create new knowledge. Such new culture requires continuous reinforcement as the

imperatives of conformity and right-wrong have been drilled into the learners throughout their entire schooling (Derwent, 1990).

6. Engage with contrasts—This occasions the employment of informative contrasts for developing concepts and stimulating interest. In this experiment, these contrasts explore a longitudinal rather than a true–false perspective of the subject material, and are both theoretical and real-life. The learner is not required to make a relative value judgment; however, he/she is required to understand the relative situated utilizations. This supplements the 'foundation' and 'fluency' parts.
7. Enhance the marking paradigm—The proportion of summative assessment is decreased, while formative is increased; more feedback encourages better learning. Also, the weightage in the final mark of the examination is decreased, and the coursework increased; realism in assessment and emphasis on hands-on as opposed to memorization also encourages learning. This is cogent with metacognition and team parts.

The relation of learning theory and most pertinent events of the instructional theory for each part of the learning strategy is shown in Table 3.2.

The final phase of rethinking the pedagogy is to select suitable instructional designs for the learning activities in blended learning. If this is confusing, recall from Chap. 2 that instructional design is a 'powertype', meaning its instances may also

Table 3.2 Relation of learning and instructional theories in learning strategy

Learning strategy part	Learning theory	Steps of instruction
Build foundation	Cognitivism	Objective, prior learning, stimulus
Facilitate fluency	Constructionism	Prior learning, feedback, retention
Emphasize team learning	Constructionism	Guidance, performance, feedback
Emphasize learning transfer	Constructionism	Performance, feedback, retention
Enhance marking paradigm	Constructionism	Objective, performance, assessment
Engage with contrasts	Cognitivism	Attention, stimulus, retention
Sponsor metacognition	Constructionism	Attention, objective, prior learning

be sub-classifications of other super-classifications of instructional design. Blended learning is the archetypical super-classification instructional design, with eLearning and F2F sub-classifications. Within each of these are further sub-classifications of instructional design instances such as active learning. There are numerous instructional designs—Reigeluth (1999) has compiled 80 design models—to choose from, most having both detractors as well as supporters. For this study, the instructional designs are chosen according to: well established with a long history of use (which usually means that the supporters outweigh the detractors), continued backing by the model's founder, workable in eLearning and F2F encounters, and apply to as many of the seven learning strategy parts as possible. In the end, the instructional designs chosen in this study are active learning, collaborative learning, and PBL.

All these instructional designs are in use today, and have supporting communities that believe them to be appropriate in their own right for learning. This healthy competition of confidences eliminates any possibility of biasing the outcome of the experiment by choosing instructional designs that are acknowledged as superior.

Specification of Weekly Learning Activities

This and the next two sections specify the entirety of the instance of blended learning developed for the Software Engineering course. The main parts of the new instructional design are the weekly (repeated each week) and semester (conducted once in the semester) learning activities, sequences of activities also known as the learning journeys, and educational technology facilitating the activities and their sequences. The weekly learning activities are examined in this section, and the semester activities in the learning journey section.

The behaviour of select learning activities and journeys is modeled in compliance with the UML Activity diagram. This behaviour is quite complicated, and UML ideally suited to representing such a high degree of complication. Each model is accompanied by extensive explanation in text form. Finally, a primer on the UML Activity diagram notation is provided to assist in understanding the notation details.

Intro to Learning Activities

Learning activity is an informal term adopted by the teacher to facilitate an ontology for all the educational interventions in the converted course, since no such ontology exists presently. In this study, a learning activity is a set of physical and mental actions tailored to promote learning in accordance according to the learning strategy explained in the previous section. The actions are structured, scripted, sequenced, and managed with a scaffolding to be carried out within a fixed period time. Lastly, the activity is an adaption of an instructional design.

Clearly, the pedagogical and contextual—as in the university ethics and undergraduate experience—success of the converted course depends largely on the integrity of formulated linkages from learning theories and sound instructional design, through strategy to learning activity. Regrettably, there are no tools or quality assurance processes to boost the rigour of the migration process of "theory to activity". It is dependent exclusively on the experience, creativity, thoroughness, and eruditeness of the teacher involved. One dependable way of increasing the performance of any learning activity is to design it to espouse as many as possible of Gagné's learning events while not incurring incoherence.

There are abundant physical and mental actions—for example, book report, case study, debate, essay, journal, modeling, one-minute paper, panel discussion, pop quiz, practice, presentation, role play, thought experiment, and web search—in numerous combinations that are appropriate for higher education learners. As explained earlier, the learning activities must be monitored in their inceptive runs to determine which are under performing or are in conflict with the contextual environment.

After much deliberation and "what-if?" analysis, a total of eight weekly learning activities are devised for the research platform instance of blended learning. They are shown in alphabetical order in Table 3.3 along with their purpose and estimated duration in hours per week. (The estimated durations correlate to those for F2F and eLearning in Table 3.1.) Also in the table are the activities' relations to the sub-classifications of blended learning and instructional design.

The learning activities are detailed in the following sections; most are accompanied by a UML Activity diagram that models the behaviour of each.

Primer on Activity Diagram Notation

The behaviour model shows the units of behaviour that a student executes in the learning activity and the allowable 'sequence'[6] of those executions. The rounded-corner rectangle shape is the notation for a unit of behaviour, referred to as an 'activity'. Those with a solid outline represent one unit, and with a dashed outline are repetitions of several units as listed. The small boxes on the dashed outline indicate each entrant into the loop has his/her own degree of progress.

The solid arrowed line, called a 'flow', indicates the direction of the sequence of units. Diamond and thick bar shapes control the progress of the sequences, and the dot and "bulls-eye" indicate respectively start and stop of an activity. A diamond with a question inside is a branching point, with one input and several outputs. The answer in square brackets to the question corresponds to the branch to be taken. A diamond that is blank inside is a merging point, with many inputs and one output. It operates on a simple first-in-first-out sequence. Finally, the thick bar is a synchronizer point, stopping the output from occurring until all inputs arrive.

[6]This follows the mathematical connotation of a collection of objects that is designated as an object and whose membership is fixed and ordered.

Table 3.3 Summary of weekly learning activities and related instructional designs

Learning activity	Purpose	Time hrs	BL aspect	Instructional design
Conspectus part one	Clarifying and reinforcing the newly established knowledge base	1	eLearning	Active and collaborative learning
Conspectus part two	Regularizing each learner's newly constructed knowledge base	1	F2F	Active learning
Online learning exercise	Constructing the knowledge base of the course content, one topic at a time	2	eLearning	Active learning
Project	Applying prior knowledge from multiple disciplines to resolve a large-scale realistic problem	2	F2F	Active and collaborative learning
Reflection-individual	Cultivating introspection by the learners concerning their progress	0.1	eLearning	Active learning
Review	Providing meaningful feedback to learner of his/her achievement	1	F2F	Active learning
Seminar part one	Constructing new knowledge about the topic	1	F2F	PBL
Seminar part two	Building a collective online knowledge repository for the cohort	0.5	eLearning	Collaborative

Explanatory text is entered into the diagram via a box with the top right corner folded over, which is called a 'comment'. If the position of the comment is not sufficient to indicate the target of its explanation, a dashed line is used to indicate this precisely.

Conspectus Parts One and Two

Conspectus is a comprehensive survey or digest, derived from Latin of the same spelling meaning "range or power of vision". So, the term is intended to convey the twin notions of the learner digesting their version of the newly acquired knowledge and then sharing it with other learners. Clarification and reinforcement of the knowledge base newly acquired from the 'online learning exercise' is part one. Sharing or regularizing the cohort's understanding of the new knowledge from several perspectives is the second part. The two parts of the 'conspectus' are merged into one Fig. 3.2, with part one commented as "eLearning", and part two as "F2F".

Part one. After constructing an initial knowledge base for a topic, the learners join their team to share their understanding of the topic and build consensus on any uncertainties or conflicts. Next, the team answers a question concerning an informative aspect of the topic, and crafts a presentation to share that answer with the cohort; another team is working concurrently but in unanimity on the same problem. Finally, each learner individually submits a written summary of the topic that is not greater than 250 words. The teacher uses these submissions to identify any deficiencies in the topical learning, and addresses them later in the review activity. This delay in teacher's feedback is offset by the immediacy of the team's; such is the strength of collaboration. The learning events for this activity are {prior learning, guidance, performance, feedback, retention}.

Part two. One or more learners from the team present the problem and their answer to the cohort. Immediately after, the other team with the same problem gives their presentation. The cohort evaluates the soundness of each answer against their own understanding of the topic; in other words, the two teams are not competing with each other, but are being contrasted with the understanding of the cohort. After each team pair is peer evaluated, the teacher provides supplemental assessment of the session. The learning events for this activity are {attention, objective, prior learning, stimulus, performance, feedback, assessment, retention}.

Although it seems simpler to execute than the 'online learning exercise', the 'conspectus' is quite complex in its intended learning and assessment.

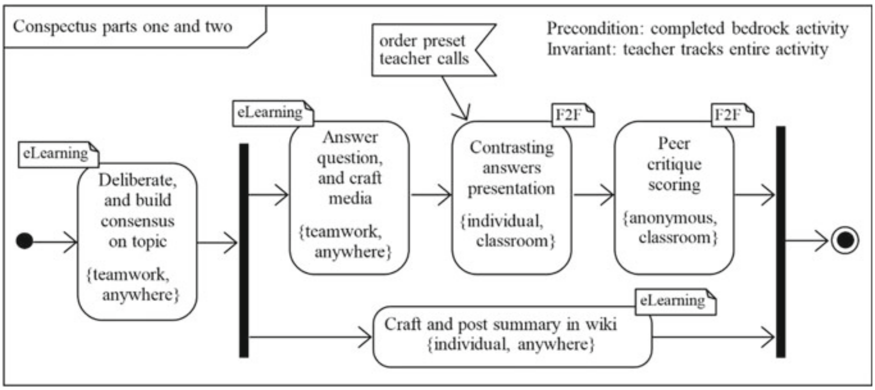


Fig. 3.2 Conspectus parts 1 and 2 (UML Activity diagram)

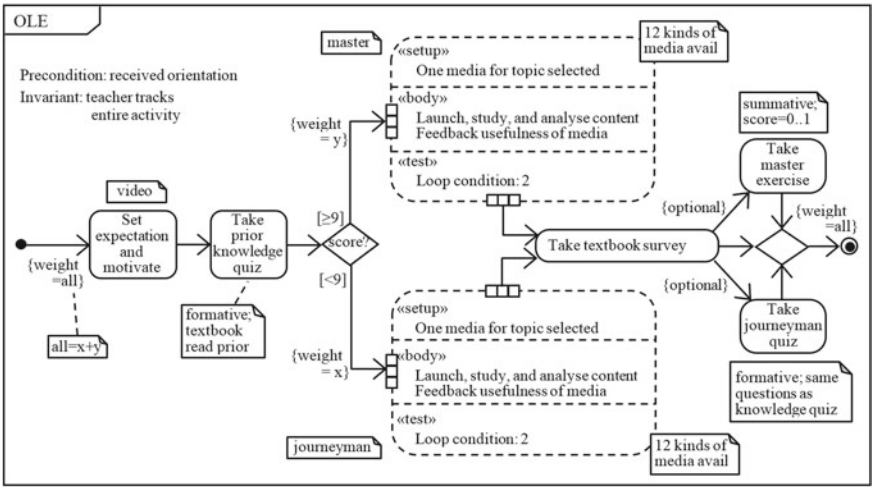


Fig. 3.3 Online learning exercise (UML activity diagram)

Online Learning Exercise (OLE)

This activity (see Fig. 3.3) is a contiguous online sequence conducting the following actions in order from start to finish: engage learner, multiple choice question (MCQ) quiz of prior knowledge, explore topic, survey textbook, and quiz of new knowledge. Learners scoring 9 or 10 in the prior knowledge quiz are placed into the 'master' stream where the topic content and exercise is more challenging, and the reward is slightly higher. The remainder follows the 'journeyman' stream where the topic content is more basic and the confirmation assessment is a repeat of the earlier-taken prior knowledge quiz.

The contrasts are built into the sequence, where the student is steered to one of two streams {journeyman, master] depending on the degree of prior knowledge of the topic, and offered up-to 12 kinds of media (including slide, speaker note, handout, textbook, chapter questions, journal paper, and video) representing the topic content. The teacher tracks the performance of every learner for the entire sequence. Following Gagné's learning condition-events closely, the online sequence flow is attention, objective, prior learning, stimulus, guidance, performance, assessment, and retention.

Project

As stated earlier, by virtue of its recent inception and innovative design, this learning activity is continued in blended learning, unchanged from its operation in traditional lecturing. The students work in teams to build a software to simulate a public bus service for an inhabited area. Each team builds one of seven subsystems—city map editor, control centre, database, navigator, scheduler, setup, tracker—and the team leaders integrate their subsystems into a single coherent system. This project requires the learners to apply hard skills (modeling, designing, programming, testing) and soft skills (documentation, negotiation, critical thinking) in a multi-disciplinary encompassment. The teacher works with the students to guide their learning and manage the overall construction of the software system. This activity espouses all nine of Gagné's learning conditions-events.

Reflection Individual

The learner submits a written value judgment of their learning and the factors influencing his/her learning, in fulfilment of 'conspectus part one'. The teacher tracks the learners' submissions and intervenes privately with any learner whose progress appears impeded. Its learning events are {attention, objective, prior learning}.

Review

The student undertakes a 10 question MCQ using clickers (an audience response system), during which the teacher critiques the responses and discusses the answers in real time. Subsequently, the teacher conducts either/both planned and ad-hoc exercises to clarify any misunderstandings apparent from the quiz and the earlier 'conspectus part one' topic summary submission. The 'review' takes up a full F2F session. Its learning events are {attention, objective, stimulus, performance, feedback, assessment}.

Seminar Parts One and Two

The intention of this activity is to expand the learner's knowledge of the topic beyond the initial acquisition and reinforcement in the 'OLE' and 'conspectus'. Similar to the approach used in the 'conspectus', there are twin notions of acquire then share. Part one is the acquisition of an additional aspect of the new knowledge base, and part two is sharing it with the cohort. The two parts of the 'seminar' are merged into one Fig. 3.4, with part one commented as "F2F", and part two as "eLearning".

Part one. At the commencement of the session, the team is assigned a challenging topical problem not seen before, and proceeds to research, answer, and develop a short presentation. In the next available F2F session, the teams consecutively deliver their presentations. Each presentation ends with a brief peer 'question and answer' followed by the teacher's wrap up. Gagné's learning events in this activity—prior

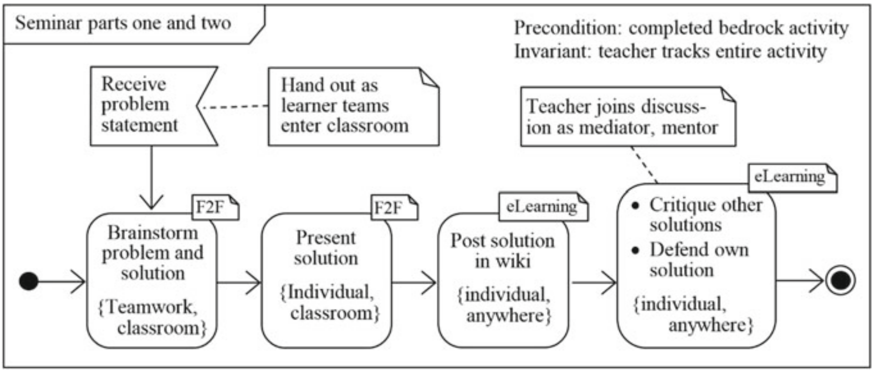


Fig. 3.4 Seminar parts 1 and 2 (UML activity diagram)

learning, guidance, performance, feedback, and retention—are more intensified due to the time pressure.

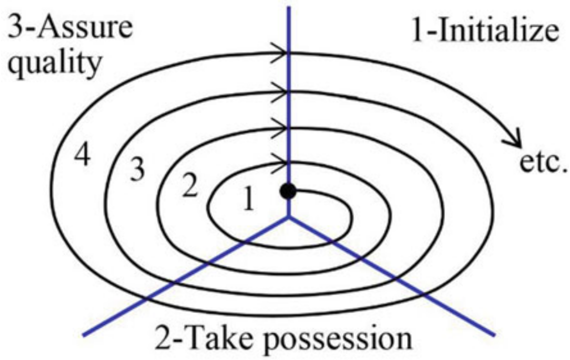
Part two. One student from every team uploads their team's problem and solution into the course wiki. Thereafter, every student peruses the wiki, and challenges the soundness of other study teams' posted solutions and/or defends the soundness of his/her team's own solution. The teacher tracks the comments, and supplements the online discourse to provide additional learning considerations. Its learning events are {prior learning, feedback, retention}.

Specification of the Learning Journey

The learning journey in blended learning has two dimensions, weekly and semester. For each dimension, the learning journey sequences its learning activities such that their combined effect on the student's learning is iterative and reinforcing. In other words, the sequence generates a synergy designed to enhance the learning beyond that of the activities singly. The weekly learning journey contains weekly learning activities, and the semester learning journey contains semester learning activities. The weekly learning journey is repeated every week for up to 13 weeks, while the semester learning journey is conducted just once for the semester.

The weekly learning journey is designed to follow Gagné's learning conditions-events in their order as per his design theory. Accordingly, a model (Fig. 3.5) is proposed showing the progression of weekly learning in three phases, initialize, take possession, and assure quality. Initialize provides the extent of curricula content promoted for learning. Take possession has the student enhancing his/her fluency and building retention. Assure quality has the student transferring his/her knowledge to the course project, reflecting on his/her learning, and receiving final feedback to confirm the completeness of learning.

Fig. 3.5 Spiral model of phases in the weekly learning journey



Importantly, the apportionment of the course content must be consistent with the weekly learning model. So, the teacher adapts the content to the model in *weekly chunks* that cognitively "flow" from one to the next, and that are not too much to overwhelm the weaker learners, and not too little to disappoint the stronger learners.

The model is patterned on Boehm's spiral diagram of 1988. Each trirant represents one phase, and each revolution, one week's content. The numbers inside the revolution represent one week. One revolution begins from the vertical axis, traversing left, down, and around until it returns to vertical axis. When a revolution ends, another begins immediately thereafter. In this experiment, there are up to 13 revolutions in the model, one for each week in the course.

Figure 3.6 shows the weekly learning journey with its weekly learning activities following the flow specified in the model. 'OLE' fulfils the "initialize" phase, 'conspectus' and 'seminar' fulfil the "take possession" phase, and 'project', 'review', and 'reflection/individual' fulfil the "assure quality" phase. The "trident" symbol indicates the activity actually comprises many actions that are detailed in another diagram. This is the case, with the 'OLE', 'conspectus', and 'seminar' all unpacked in the previous section to reveal the detail of their actions and sequence.

In the case of the semester learning journey, some milestones, such as first day of classes, midterm break, last day of classes, and final examination, are all set

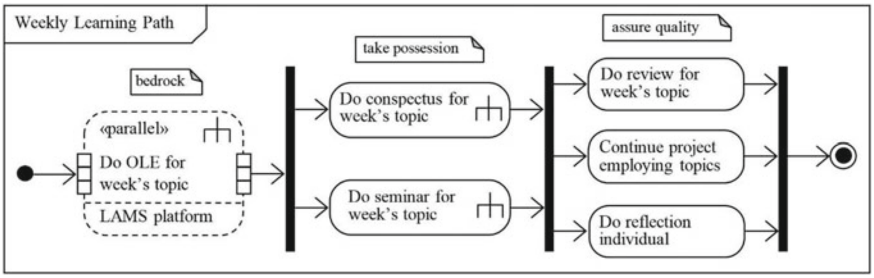


Fig. 3.6 Weekly learning journey (UML activity diagram)

and timetabled by the University. Super-imposed onto these are additional learning activities for the research platform, such as ‘orientation’ and ‘reflection/team’. The semester learning journey complete with all the semester learning activities is depicted in Fig. 3.7.

A corollary to the weekly learning journey is that the semester learning journey is precedent in week seven for the midterm exams, and week 13 for the team reflection and project assessment. Another clarification is that a study week interceded between the seventh and eighth weeks of the semester, causing the semester to takes 14 weeks calendar-wise to complete.

There are five learning activities in the semester learning journey. Table 3.4 summarizes these activities in alphabetical order, following which each is explained in more detail.

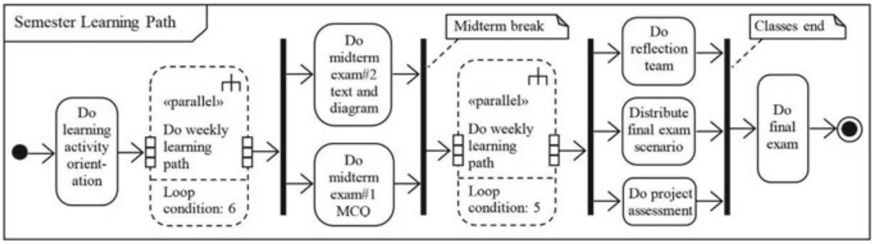


Fig. 3.7 Semester learning journey (UML activity diagram)

Table 3.4 Summary of semester learning activities

Learning activity	Purpose	Time hrs	BL aspect	Instructional design
Exam final	Confident solidification of new knowledge with lower percentage for exam weighting and release of case study scenario weeks before	2	F2F	Active and collaborative learning
Exam-midterm	Providing feedback on the quality of learning midway	2	F2F	Active learning
Orientation	Engaging and preparing the learner for the innovative learning and new instructional design	3	F2F	Active learning
Project-assessment	Introducing the learner to the IT commercial process	2	F2F	Active and collaborative learning
Reflection-Team	Building consensus on the performance of the new instructional design in the course	1	F2F	Collaborative learning

Exam Final

This learning activity is a significant update of the standard and archaic practice. Firstly, its weighting is only 40% of the course total mark, far below the University's anecdotal norm of 60% or more, thus significantly decreasing the unpredictable degree of anxiety that it would otherwise generate. Secondly, the entire question set in the exam is bound to a single, life cycle style scenario; that scenario is released to the students three weeks prior to the exam date. By design but not direction, this becomes a group learning project, the last of the course. The students study the scenario, formulate possible emergent questions and the answers to them, and then (optionally) discuss these with the teacher for feedback; they set their goals and control the process. Its learning events are identical to the 'conspectus' weekly learning activity.

Exam Midterm

There are two contrasting exams—MCQ and short text-diagram answer—each taking one hour for conduct. The learners receive their marks quickly by virtue of an automated scoring function in the technology. Its learning events are {feedback, assessment, retention}.

Orientation

This activity is inspired by the orientation exercise conducted by the School before classes to prepare its freshmen for the new challenges that await them in the undergraduate experience. Similarly, the orientation in blended learning is conducted to prepare the cohort for the new challenges that await them in the new instructional design. The orientation is conducted on the Friday before the first day of classes, and repeated on the subsequent first F2F session designated as a lecture period in the students' timetables. Typically, a sizeable proportion of the cohort attends the Friday session. So, the primary purposes of repeating the session is to reinforce the concepts as they may be just too innovative for the students to grasp on the first exposure, and to collect their signatures on the informed consent forms. Its learning events are {attention, objective, guidance}.

Project Assessment

The activity entails a demonstration of the beta version of "public bus service simulator" software product developed by the student teams. The product is loaded and launched in a random PC to eliminate biased installations, and then projected onto a large screen to allow viewing by the entire cohort and judging team. The functionality, performance, and "wow-factor" are judged by a team of teachers including an external examiner. All nine learning events are in action.

Reflection Team

In this activity, each team of students individually engages the teacher in a free-form and privileged-platform discussion on the new instructional design, progressive pedagogy, and impacts of these on their learning experience. It is believed that the students will feel less inhibited and be more communicative with the presence of their teammates than as individuals. Plus, the teammates may be able to help each fill in details or add reinforcement to certain ideas that one person may have trouble with. From the discussions, the teacher garners lessons learned and implements the appropriate changes to the course between semesters. The learning events are {attention, objective, prior learning, guidance, performance, feedback}.

Educational Technology

This section discusses all the new educational technologies employed in the research platform. Table 3.5 provides a summary in alphabetical order of these educational technologies.

Educational technologies may become a significant obstacle to teachers attempting to integrate them into their classrooms (Ertmer, 1999). Several measures are taken to minimize this with the technologies in the research platform. Two thirds of the technologies are COTS and readily available and supported with training and maintenance in the University. The one-third of the technologies that are custom-built (by the teacher) are programmed with user-friendly java script and HTML. All these educational technologies worked well for the duration of the experiment.

Clickers and Office

This COTS hardware from Turning Technologies is a recent addition to the University's inventory of educational technology. It is an audience response product: people

Table 3.5 Summary of educational technologies in the research platform

Technology	'ware kind	Status
Clickers by turning technologies	Hardware	COTS
Course content navigator	Software	Custom
Course helpdesk	Software	Custom
Course portal	Software	Custom
Course wiki	Software	COTS
edveNTUre	Software	Custom[a]
Learning activity management system	Software	COTS
Messenger	Software	COTS
Office by Microsoft	Software	COTS
PreseNTUr/AcuStudio	Software	COTS
Steaming video	Software	COTS

[a]*Note* This is customized by the University, not by the teacher

in an audience respond individually with a single digit {0–9, "?"} message to a person posing some question to them. These responses are written to a data file for statistical analysis. The product comprises a transmitter (see Fig. 3.8) and receiver connected by radio frequency signalling. Clickers are eminently suitable for use by teachers to obtain an empirical measurement (instead a show of hands) of the acquisition by every member of the cohort of some new knowledge. This may be done by quantity with the responders being anonymously, or by pre-loading clickers with a classlist—student name and the id of the transmitter he/she is issued—for the cohort, allowing every response to be associated with the student holding the device. Clickers are used in 'conspectus part two' (for the peer assessment) and 'review' (for MCQ) learning activities.

Clickers integrates with two Microsoft Office software products, PowerPoint (ppt) for the triggering and management of the capture of the audience responses, and Excel (xls) for the statistical analysis of the responses. Different instances of ppt-xls

Fig. 3.8 Illustration of clicker transmitter hardware

are required every week for these sessions: orientation, seminar, and project (for attendance taking), 'conspectus part two' (for peer scoring), 'review' and 'midterm first quiz' (for answering MCQ), and 'midterm second quiz' (for displaying each question and its elapsed time). To heighten student engagement, evocative pop culture images comprise the backgrounds in the slides. Over 250 clickers-enabled slides are now in service.

Course Content Navigator

This software custom built by the teacher provides breadth-wise and depth-wise access to the course content. The content in all weeks is available to the student from day one; there is release by date. The navigation is by week (numbered tab), then by active link to the bedrock learning activity and its content items. The software is written offline in a HTML file, then copied into a Blackboard building block for edveNTUre to distribute.

Figure 3.9 shows the display when tab "1" (short form for Week 1) is selected (see 13 tabs resting above the colour banner); the selection is highlighted on the left side.

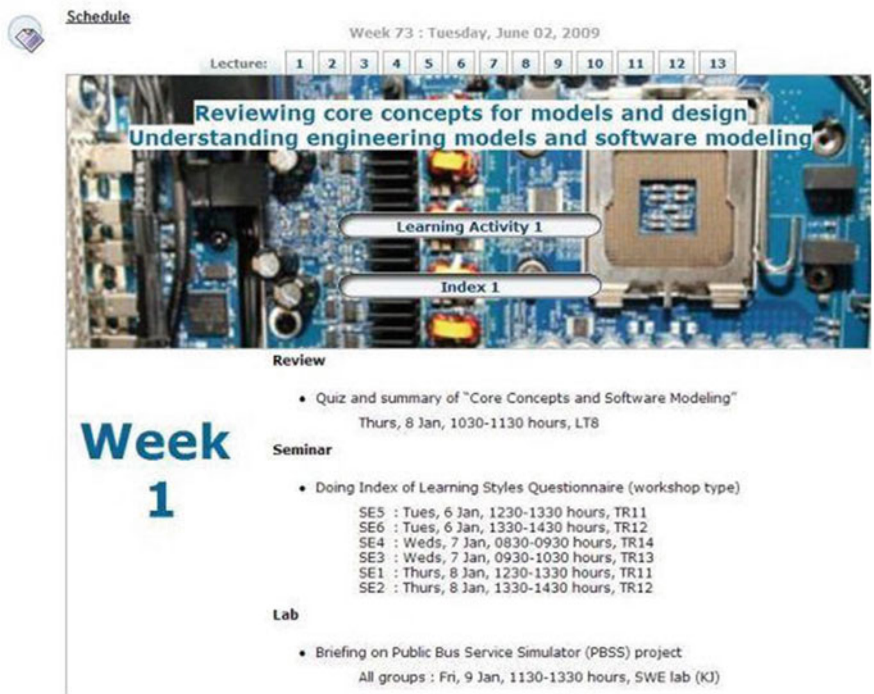


Fig. 3.9 Screen snip of course content navigator

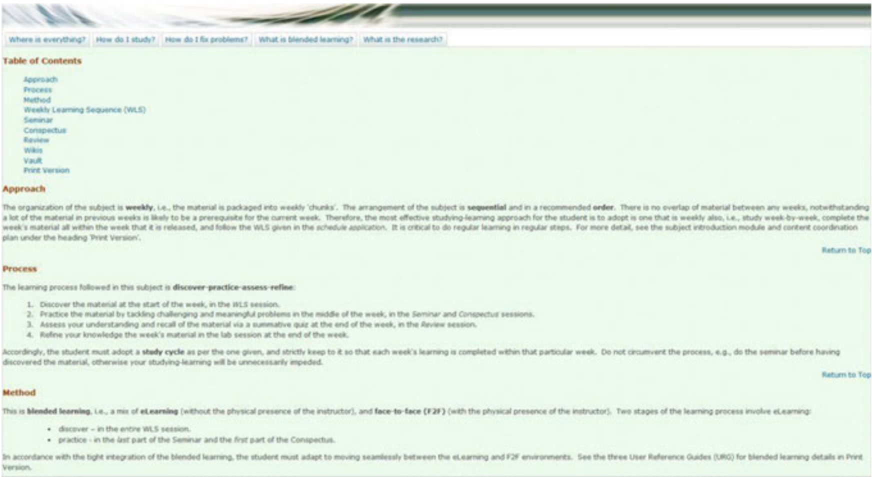


Fig. 3.10 Screen snip of course helpdesk

The colour banner is unique for each week, adding to the freshness and richness of the visuals. The main information panel identifies what, when, and where the F2F learning sessions are for the selected week.

Course Helpdesk

This software custom built by the teacher is the scaffolding for the new instructional design to give learners full self-sufficiency. It includes downloadable material on learning theory, the new instructional design planning and research proposal, user guides, and fixes to common software faults. The software is written offline in a HTML file, then copied into a Blackboard building block for edveNTUre to distribute. Figure 3.10 show the content displayed when the tab “How do I study” is selected.

Course Portal

This software custom built by the teacher is the front-end of the course, providing essential information and access to content, schedule, weekly progress marks, and wikis. The navigation is by aspect (titled tab), then by active link to aspect item. In Fig. 3.11, the selection is tab “Introduction”. All aspects are available from day one to the learners.

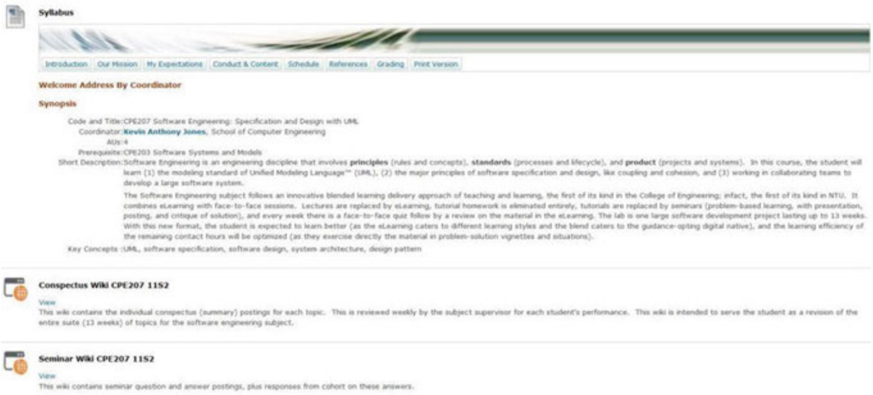


Fig. 3.11 Screen snip of course portal

Course Wiki

This COTS software product manages and delivers the cohort's online knowledge repository, with a different instance for the 'conspectus part one' and 'seminar part two' activities. The knowledge can be any form, although for the sake of engagement, rich media is encouraged (see example in Fig. 3.12). Two critical functionalities for this software is keeping a history of versions, and handling multiple edit requests with no information loss. Wiki is used in 'reflection/individual' and 'seminar part two' learning activities.

Fig. 3.12 Screen snip of video posting in the course wiki

EdveNTUre

This software is a home-grown custom system built by the University for its faculty to conduct online management of their students, some aspects of classroom activities, and content distribution. The engine for edveNTUre is a market-leading COTS software product called Blackboard, with native functions such as adaptive release, building blocks, connect, discussion board, email, and group management. In the case of the research platform, edveNTUre services were particularized for the Software Engineering course in blended learning to deliver online the 5 GB of course content to the learners. edveNTUre also has a plugin for deployment of the learning activity management system which is detailed next.

Learning Activity Management System (LAMS)

This COTS software product creates sequences of actions such as "listen to instructions", "read this material on a topic", "answer these questions", "check your score and feedback", and "do this survey", and reports every students progress through them. The actions may contain documents, animations, embedded video, hyperlinks, and interactive question and answer. The paths between actions may have branches, options, repeats, and synchronization such as event release. Each sequence is rendered as a digraph[7] using flash animation technology, and details of each action are entered into the vertices. Figure 3.13 shows the basic skeletal design of the 'OLE' activity's sequence.

All the sequences for 'OLE' and 'conspectus part one' eLearning activities are created with LAMS. After a basic skeleton of action and sequence is constructed according to the Activity diagrams, the content with its assessments, feedback, and practice questions, are entered into each action. Since appropriate for the week in the LAMS sequence. Since each week has its different content, as per the weekly chunk protocol mentioned earlier, the LAMS sequence for each week is unique. So, 13 weeks of eLearning require 13 different LAMS sequences to be constructed. Accounting for the iterations in the instructional design, over 30 sequences are now in service.

[7]This term comes from the graph theory lexicon. The basic entities in graph theory are vertex (notated by a shape with an outline and internal area, such as a circle) and edge (notated by a line), where typically two vertices are joined by an edge. Digraph refers to a directed graph in which every edge in the graph is uni-directional and typically annotated with an arrowhead.

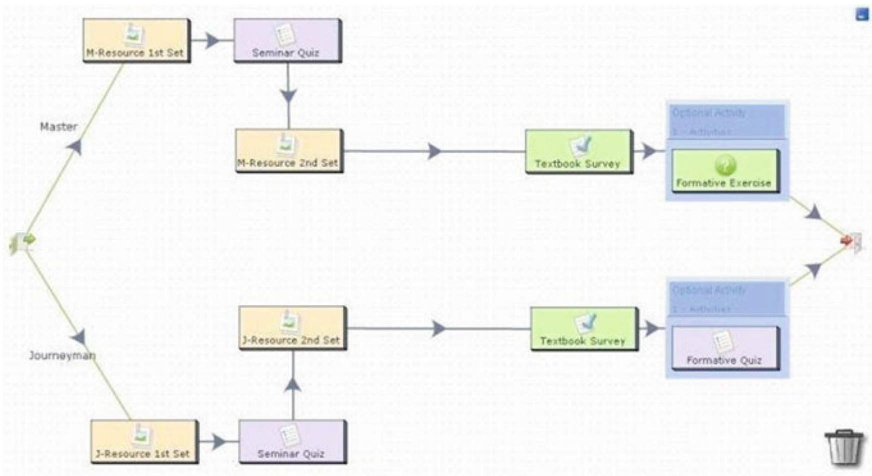


Fig. 3.13 Screen snip of 'OLE' in LAMS sequence editor

Messenger

This COTS software provides instant rich media messaging for the teacher to provide real time mentoring to the students as they undertake their eLearning activities. Any web-enabled online chat software is suitable; it is left to personal discretion of the students and teacher. The protocol for this communication is that the teacher announces in advance a time period he is to be online, and subsequently conducts discussions with the students during that period. Though initially reluctant to utilize this mode of communication, most students eventually adopted it as their standard weekly practice.

PreseNTUr/AcuStudio

This COTS software product is used by the University to create and delivers video recordings of traditional lecturing sessions. This product is integrated into edveN-TUre which manages its function and content distribution for all University faculty and students. From a central control centre, AcuStudio accesses video cameras installed in every lecture theatre. These capture the teacher's full-body image in-front of the presentation screen. The video is edited before distribution on PreseNTUr to include a slideshow of the lecture powerpoint slides as a side bar (see Fig. 3.14).

Since the F2F sessions in the lecture theatres are now active learning, and as such not congruent for video capture, videos of them are discarded. Instead, PreseNTUr plays back traditional lecture sessions recorded in the years 2006–7, as one of the 12 kinds of media offered in the 'online learning exercise' activity. During the duration

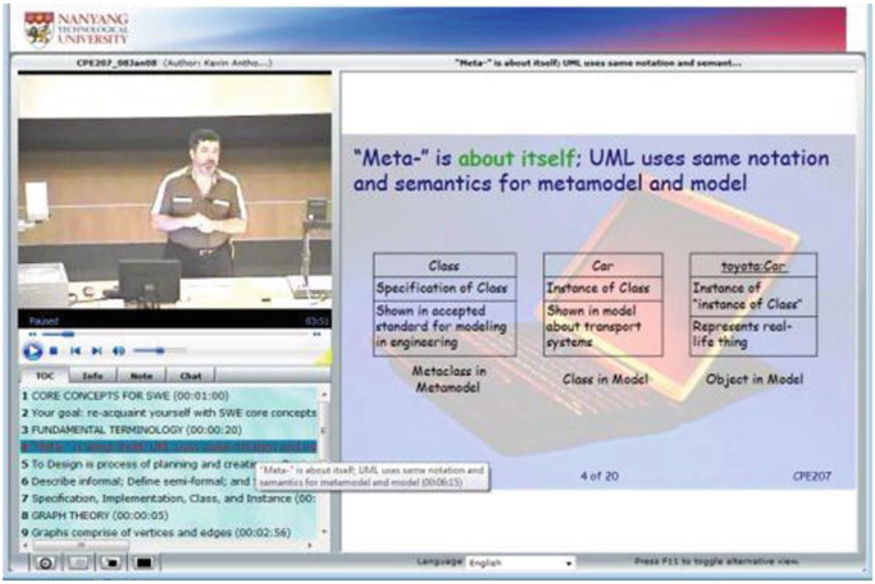


Fig. 3.14 Screen snip of PreseNTUr display

of the experiment, PreseNTUr was not upgraded, so issues of compatibility in playing back the older content are eliminated.

Streaming Video

This COTS software provides online viewing of videos from public sites such as YouTube, and private sites such as Blackboard, as one of the 12 kinds of media offered in the bedrock activity. This software must be capable of handling multiple simultaneous requests for viewing of any sized video file. This is not an issue for public sites, however, it may be so for private sites. edveNTUre is the primary private site for the students, and fortunately, it supports several versions of stream video players that are capable of massive viewership.

This chapter is crucial because it provides the substantiation for the conduct of the research. Now, it must be evident that design-based research methodology is mainstream for educational research, and that it meets all the necessary qualities of rigor, relevance, warrant, that are evident in "gold star" research. The rationales for the duration of the experiment and the congruity of the semester-on-semester data collection are forcefully argued. Finally, the research platform also known as the instance of blended learning, is painstakingly unpacked to show the details of its learning activities, learning journeys, and facilitating educational technology. So, with the veracity of the experimental process duly established, the data specification, analysis and findings, and final conclusions, can proceed with the confidence of a solid foundation.

Chapter 4
The Learning Model

This chapter details the 'learning model', the first tier of the 'two-tier composite model' used to trace the prevailing and pertinent learning, and teaching theories discussed in Chap. 2 with the data processing. In its completed form, the learning model constitutes the data requirements discussed in a subsequent chapter.

A new model could have been developed from scratch interpreting the conceptions in Chap. 2. In reiteration, it is in the interests of any educational research to exercise the highest degree possible of representativeness, repeatability, and rigour. Therefore, the well-endorsed Prosser and Trigwell (1999) model of learning and teaching of higher education students is adopted as the learning model for this study.

This chapter addresses the following aspects of the learning model:

1. Minor departures from the Prosser and Trigwell specification;
2. Modelling language employed to render the learning model diagrammatically;
3. All concepts in detail; and
4. Which concepts are traceable to the data model in this study.

Overview of the Learning Model

"Understanding Learning and Teaching, The Experience in Higher Education" (Prosser & Trigwell, 1999) is a pre-eminent treatise in educational practice with 2478 citations by Google Scholar's count. For that reason, and also because it focuses on learners at the higher education level, it is considered a superlative basis from which to derive a reliable and relevant model for higher education student learning. But it is not without minor flaws, so this section introduces three understandability and completeness-wise modifications of the learning model for this study.

The diagrams in the book do not conform to any modelling language specification, making them susceptible to misinterpretation even with textual accompaniment, and decidedly unusable for this study in their current form. So, replacement diagrams

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https://doi.org/10.1007/978-981-33-6683-1_4

are composed in UML, the modelling language identified in Chap. 1 as the standard for this study. While adhering to the perceived train of thought in the originals, there are enhancements in the new diagrams; appearance-wise, they are substantially distant from the versions in the book. These enhancements are an extension of the phenomenographic principles advocated extensively in the Prosser and Trigwell book; they conform to the practices established in the University and School; and they are an adaption of a software discipline's way of thinking.

Another flaw, uncritical but nonetheless conspicuous, is their use of the term constitutionalism to signify the set of beliefs that underpin their learning model. Firstly, the term appears to not be used in any other learning publications except those authored by Prosser and Trigwell. Secondly, the term is extensively used in social studies discourse to mean a system of government whose power is distributed and limited by a system of laws, namely a constitution that the rulers must obey. Consequently, using the term in the connation of learning is rejected.

The final change in the Prosser and Trigwell model is the replacement of the "disintegrated" learning approach with the "strategic" one. Both are structurally equivalent—a mixture of unspecified ratio of surface and deep learning—but are posited as having diametrically opposed behavioural outcomes. The disintegrated approach is the archetype ineffectual learning approach that achieves worst outcomes than surface learning. Contrastingly, strategic learning is an exemplar of efficiency that enhances the student's productivity and hence his/her achievement of the learning outcomes. Both are supported by numerous respectable references, the earliest of which seem to be Entwistle and Ramsden (1983) for the disintegrated and Belmont (1989) for the strategic. Both cannot be used in this learning model as they are clearly incompatible. Therefore, for this study, the strategic approach supersedes the disintegrated one because it is aligned more closely to what is known to be the truer of the University's students.

The learning model comprises two diagrams accompanied by instructions for interpreting the diagrams and an elaboration of the meanings of all the elements in the diagrams.

Interpretation of the Learning Model's Diagrams

Figures 4.1 and 4.2 are the diagrams depicting the learning model, a conjunction of the structure and behaviour pertaining to a higher education student's learning; in other words, the diagrammatic perspective is that of a student entering/launching the learning model, and then executing all its elements until it has been fully consumed.

Recall from earlier chapters, a structure diagram shows the 'set'[1] of interacting parts comprising a mechanism either physical or virtual, and a behaviour diagram shows the 'sequence' of units of behaviour that a student executes in a process.

[1]This follows the mathematical connotation of a collection of objects that is designated as an object and whose membership is fixed and unordered.

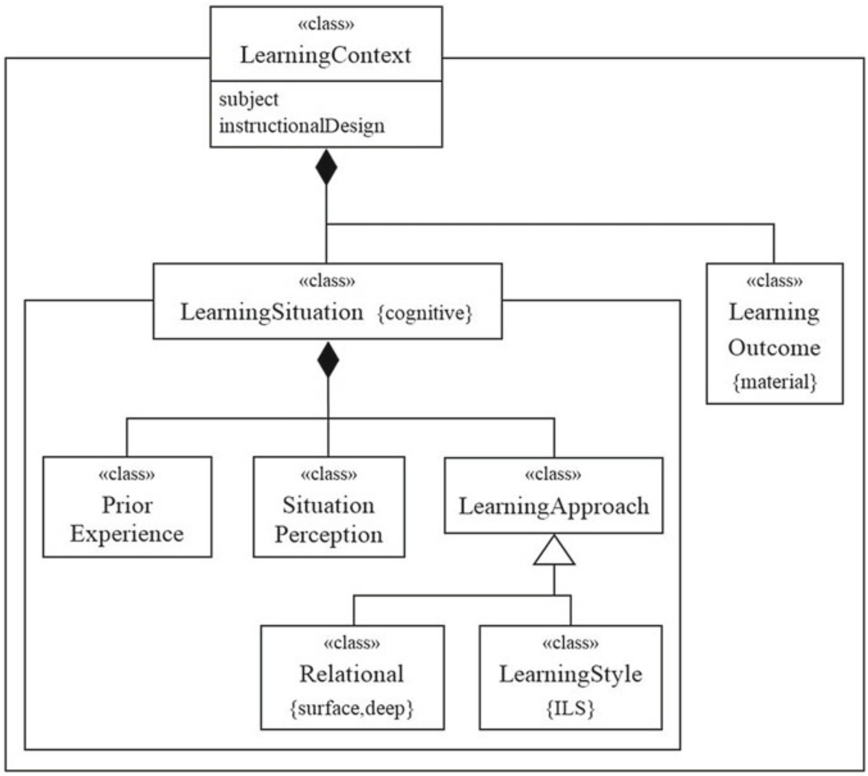

Fig. 4.1 Structure diagram of the learning model, based on Fig. 2.2 in Prosser and Trigwell (1999)

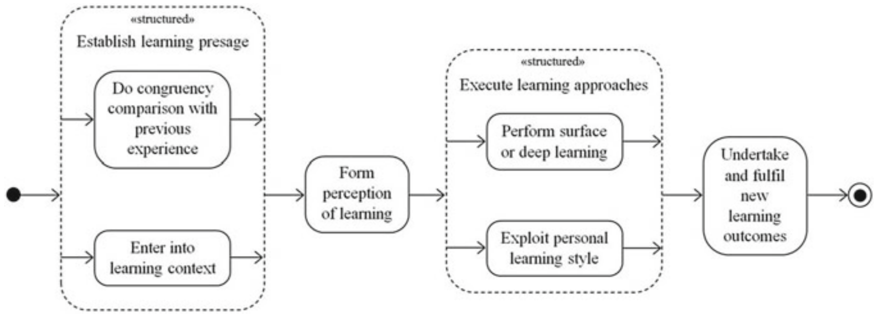

Fig. 4.2 Behaviour diagram of the learning model, based on Fig. 2.1 in Prosser and Trigwell (1999)

The structure diagram for the learning model is a UML Class diagram, with its interacting parts being in the shape of boxes called ‘classes’. The behaviour diagram for the learning model is a UML Activity diagram, with its units of behaviour in the shape of rounded-corner rectangles called ‘activities’. While it is correct to interpret Classes as being permanent entities within a permanent structure, the Activities have the characteristic of transience. Lastly, while the diagram set is consistent in specifying the learning model, as individual members of the set they do not overlap, i.e., Classes do not specify behaviour, and Activities do not specify structure. This multi-diagram approach for specifying a model is in complete accordance with the tenets of UML, and is understood by its practitioners to be a facilitation and not a debilitation.

Structure Diagram

The structure diagram (Fig. 4.1) shows an outer container, LearningContext, that nests another container, LearningSituation, and a Class LearningOutcome. The two containers are each a Façade design pattern, a construct with the specific meaning that everything inside the container cannot directly associate with anything outside the container. Instead, all association is channelled through the single Class straddling the outline of the container; that Class is designated the Façade. The notation of the filled-in diamond means that the object with the diamond owns—in a belonging-to or whole-part sense—all the objects at the opposing ends of the line emanating from the diamond. Once the Façade is entered, the interactions of its owned objects remain inside the Façade for the duration established by the Façade.

As the channel into the container, a Façade Class can be very expansive. Accordingly, the LearningContext is conceived as the machinery of the University that establishes the School’s degree programme, registers the student into the course, employs the teacher, sanctions the curriculum and course and instructional design, purchases educational technology, mandates the grading and assessment criteria, and provides all the required learning spaces such as lecture theatre, tutorial room, laboratory, and examination hall. The LearningSituation is conceived as the internalized world of the student that includes his/her prior experiences, perceptions of the new world of the learning challenge at hand, and approaches put into effect to get through the situation. To highlight its cognitive nature, the LearningSituation is annotated with the constraint {cognitive}.

The unfilled triangle joined to the LearningApproach Class indicates a ‘taxonomic’[2] relationship: the two objects at the opposing ends of the line emanating from the triangle are children or specialization Classes of LearningApproach. Once the period of learning dictated by the LearningContext is complete, then the

[2]This follows the science connotation of a hierarchy of objects whose classification changes from general to specific in the direction away from the root, a.k.a., “subsumptive hierarchy” and “Is-A” hierarchy.

LearningOutcome belonging to the LearningContext generates an evaluation of the student's achievement that is subsequently recognized outside of the LearningContext. Unlike the situation, LearningOutcome is more {material} in nature. To facilitate speedy recognition of the LearningContext's role in the structure, its two important properties, course and instructionalDesign, are connoted textually. Finally, the size to which all the Classes can grow with the construction and accumulation of pertinent information is a design variation; it is consistent with the diagram's perspective to consider the capacity for growth as an intrinsic characteristic of the individual undertaking the learning. The concepts of PriorExperience, SituationPerception, LearningApproach, and LearningOutcomes are elaborated in the next sections.

Behaviour Diagram

The behaviour diagram (Fig. 4.2) shows two 'structured' Activities, "establish presage" and "execute approaches", and six ordinary Activities, "compare to priorX", "enter context", "form perception", "perform surface/deep", "exploit style", and "fulfil outcomes"; note these titles are abridged from that in the diagram. 'Structured' means that the Activity is an organizational nesting of ordinary Activities that are not explicitly sequenced or synchronized therein; 'structured' is not to be misconstrued as implying an owning structure such as a Class. The sequence has one each starting and finishing points, notated respectively by the filled circle and target symbols. The sequence is read in the direction of the arrows, from start to "establish presage" to "form perception" to "execute approaches" to "elaborate outcomes" to finish.

The "establish presage" structured Activity nests "compare to priorX" and "enter context"; the order between them is a design variation, and their only stipulation being that they both have to happen before the next Activity, "form perception", happens. Similarly, "perform surface/deep" and "exploit style" inside the structure Activity "execute approaches" must both happen for "elaborate outcomes" to happen.

Activities are self-determined and fully encapsulated. In other words, the operation of one Activity does not moderate the operation of another, and side-effects, e.g., clashes of coincident effect, are understood to be non-existent. The only transferable effect being allowed is the legal and valid outputs generated from one Activity and apprehended as legal and valid inputs by the next. The nature and longevity of the outputs-inputs, the medium of their transmission, and the mechanism for their receipt and acceptance are all design variations. For some of this, the reasonable presumption is that the medium and mechanism are a student's thoughts. Another design variation, alluded to earlier, is the transience of the Activities. A reasonable interpretation of the diagram is as an unbroken process that runs once through to completion process, inferring that each Activity ceases operation once its following Activity begins. Nevertheless, an equally valid interpretation is that each Activity remains active and continuously evokes the next Activity in the sequence the Activities; under this interpretation, the process is more continuous than stepwise. All the concepts underpinning the Activities are elaborated in the next section.

In summary, the dual-diagram learning model may be internalized and applied as follows:

> The structure diagram is a bureaucracy of physical and information entities that the students joins or enters, and the behaviour diagram is the thinking and actions that the student executes once inside. Must the success of the behaviour be dependent on its relegation to specific locations inside? In the case of learning, the reasonable approach is the exact opposite. Learning must be allowed and even encourages to occur wherever and whenever within the learning bureaucracy.

Elaboration of the Learning Model

The following is an elaboration of the concepts comprising the learning model. Each concept is written as a phrase and not as a Class name, e.g., "learning context" not "LearningContext", to facilitate their transference to the structure and behaviour diagrams both. Keep in view that "student" means any student going through higher education.

The learning model stipulates that new knowledge is constituted within an internalized relationship between the student and the world. Knowledge is not a coherent object existing in the world, that when learned is transferred intact and unchanged into a waiting space in the student's head; this ignores the phenomena of resistance to learning and sensory input transformation. Principally, learning is a mediation whereby the student develops perspectives on new knowledge by contrasting it to existing internalized knowledge. Then, on his/her own terms, the learner progressively constructs new knowledge and experience conceptions. Being that the student and the world are unified in an internalized structure that the student could keep unchanged for any period, there has to be some agency that impels the student to keep engaging in new learning. That agency is the biological need for cognitive development and growth innate in the species, and which is manifested by a person unconsciously outgrowing their current conceptions in favour of new perceptions; this is known as developmentalism.[3] At this point, the learning theory could be either Piaget's constructivism or Papert's constructionism (Ackermann, 2001).

The deciding factor emerges from the application of phenomenography (Manton, 1981) into the learning model. Phenomenography states that people's conceptions of their world experiences are specific and unique, and may not be a rubric that subsequently can be applied successfully to similar activities. In other words, variations in conception by people immersed in the experience of the phenomena must be accounted for in any serious study of a phenomena. According to phenomenography, the study of the phenomena and its effect on people is a first-order perspective, and

[3]This field of psychology was founded by Jean-Jacques Rousseau with the publication in 1762 of "Émile, or Treatise on Education". Developmental psychologists of the twentieth century that are and continue to be influential in the philosophy of education are Jean Piaget and Lev Vygotsky.

the study of the people's conception of the phenomena and its effect on them is the second-order perspective. Both perspectives are complementary and the use of both is advocated. Until recently, study of learning and teaching has been only first-order; this model raises the study of learning and teaching to the second-order perspective. Consider this phenomenographical statement concerning learning and teaching.

> In the teaching process, students have various conceptions which we try to change, modify, or successively replace. The conceptions held by the students as a rule differ from those which the author of the textbook or the teacher is trying to make the students acquire (or construct). This discrepancy is certainly there during the learning process and it is not infrequently there too when the class has to proceed to the next topic. (Manton, 1981, p. 183)

Additionally, phenomenography vigorously discredits the assumption that the precepts of general learning can always be applied successfully to specific learning disciplines or contexts. Instead, it purports that the context will generate unique and non-generalizable variations in the student's experience, that becomes the student's second-order perspective, and that contributes to actions, attitudes, and achievements in the learning challenge. It turns out that the context is a key factor of causation in learning.

Returning to the question of whether the learning theory of constructivism or constructionism, it is the significance of context that tips the scales in favour of the latter. More to the point, the learning theory is bound to the concept of situated learning, an extension of constructionism, where the "learners invent for themselves the tools and mediations that best support the exploration of what they most care most about" (Ackermann, 2001, p. 4).

The distinguishing concepts of the learning model are the learning context—this is from the student's perspective; from the teacher's, the context is learning and teaching—prior experience, learning situation (again solely the student's), learning approaches (a perspective that both the student and teacher share but may constitute differently), and learning outcomes (again, a perspective that student and teacher share). These are unpacked in the next sections.

In summary, this learning model involves students in higher education. It consolidates the constructionism learning theory and phenomenography research methodology into one. In the learning model, the student enters a new learning context by the agency of developmentalism. Already possessing coherent and robust conceptions, the student mediates these with currently constructed perceptions of the new knowledge, to gradually—the slowness being a product of spurious resistance and input transformations—build up new internal knowledge and experience.

Prior Experience

People are continuously experiencing the world and internalizing that experience for use at any time in the future. Whether it is useful in the future depends on the relevance—specifically, generally, or both—of the current situation to the internalized experience. By "specifically", it is meant that the person's conceptions emanate from an inductive qualification of the situation, and by "generally", the conceptions are from a deductive qualification. In the case of a learning context, inductive qualification is exemplified with academic disciplines, e.g., a strong prior experience in physics is not particularly relevant for a computer engineering course, so it must be for all other non-engineering experiences. A deductive qualification is exemplified by a learning truism, e.g., doing is more effective than knowing, so the student should always do some coding to experience first-hand the soundness of his/her software design.

Descriptively, prior experience may be simplified as follows. The student enters a new learning context with internalized prior experience traceable to experienced learning situations. The learning context in which the student enters organically evokes the student's prior experience; this is not a deliberative phenomenon that the student can switch off or on by will. Finally, the student perceives congruence (or lack thereof) between the new learning context and the evoked aspects of his/her prior experience. The congruence is measured on one or both of the context's specific-ness or a learning generalization; additionally, the congruency measure will be coloured by the conception of personal success achieved in prior experience. Going forward, the perception of this congruence impacts on what and how the student learns in the new learning context.

From the behavioural perspective, the evoking of prior experience happens in synchrony with student entering the learning context. The pre-condition is relevance and the post-condition is congruency measure. From the structural perspective, the prior experience object belongs to the learning situation which is the internalized world built by the student to prepare for and conduct his/her learning.

Perceptions of Learning Situation

This concept is perhaps best explained by a colloquialism as expressed from the student's perspective: "What have I gotten myself into?". In this concept, the student constructs an awareness of all the understood-to-be-relevant aspects of context including prescriptions of learning outcomes (what has to be demonstrated), and contrasts this with his/her prior experience (congruence of existing internalized knowledge) so as to construct and internalize a perception of the learning situation. But it is not necessarily fixed after initialization; this varies by student. The learning model promotes the student's continual re-evaluation of his/her perception with subsequent editing, discarding, or advancing of new perception as the learning period set by the context progresses. The student designs compensatory measures to deal with congruence (or lack thereof) of prior experience. Going forward, this perception and compensation impacts the student's selection of learning approach.

The crucial factor in clinching a positive perception is the teacher's effectiveness in promoting awareness of the entirety and forward relevance of the new learning context. The key ways that this may be best accomplished is by the: effectiveness of the teaching practice, establishment of clear goals, assignment of appropriate workload, conduct of appropriate assessment, and proffering of choices in learning (Ramsden, 1991).

From the behavioural perspective, the perception of the learning situation happens after the presage and before the learning approach. From this point on, the pre-and post-conditions are set by the preceding and succeeding activities. From the structural perspective, the situation perception object belongs to the learning situation.

Learning Approaches

These are the strategies and methods that when implemented, support the student's expectation that he/she will achieve the learning outcomes belonging to the learning context. In its basic conception, the student adopts a learning approach that is recalled in his/her prior experience as being successful, perceptions of the learning situation, and confidence in managing an approach, as well as appreciation of the learning outcome. Additionally, the teacher's commitment and effectiveness towards promoting to his/her students the better approaches and devaluing the worse approaches, is an important success factor for the students. Though many teachers may disagree, Prosser and Trigwell believe that there is a best way for students to learn and they should not be left to practice familiar learning approaches if they are known by the teacher to be ineffective. Numerous independent studies agree that learning approaches are positioned on a effectiveness spectrum with 'deep' learning (being the best) at one end and 'surface' (being the worst) at the other end. For this study, a third approach in the middle of the spectrum is the 'strategic' approach (McManus, Richards, Winder, and Sproston (1998) provide a superior treatise on relation of strategic learning to examination performance) is incorporated into the learning model. Fundamentally, the selection of learning approach directly impacts the degree of achievement of the learning outcomes.

A deep learning approach reveals the meaning and relationships or connections within the content, while the surface learning approach identifies the composition—analogous to an inventory, and most often associated with the action of covering—of the content. In the deep approach, the student is seeking understanding and fulfilment (and perhaps even enjoyment), while the surface approach embodies a perfunctory execution of an imposed (probably even unwelcome) task with the goal of surviving the work up until the end. The strategic learning approach is the conjunction of deep and surface approaches concocted by the student as a strategy to pass. The student rationalizes that the context is not homogenous but a mixture, each part warranting a different approach with the aim that the entirety of the workload is covered in an expeditious manner. Emerging from this is an ensemble of understanding, partly deep and partly superficial. If the teacher has accurately stated the learning outcomes, then the strategic approach is moderately successful. If the learning outcomes are not well-articulated, then achieving success with the strategic approach is a gamble. To summarize these learning approaches as conceptions, deep learning is qualitative, surface learning is quantitative, and strategic is situational.

A corollary is that memorization and rehearsal are not learning approaches, but activities or techniques employed in a learning approach. If the student conducts memorization and rehearsal to cover the topic highlights for a test, then the student is engaging in a surface approach. However, if the student is memorizing the variance and distinctions between concepts in order that he/she can rehearse them in a teaching-to-peers scenario, then the learning approach is deep.

An effective way for the teacher to motivate the student into adopting a deep learning approach is to imbue the instructional design of the course with learning activities that espouse or necessitate a deep learning approach. Activities requiring the students to collaborate are reliable invokers of deep learning approach. Writing position papers on an issue, conducting regular debates, posting and being peer-assessed for reflections on the nature or usefulness of something, and constructing 50 word abstracts on thematic concepts, are all activities that encourage a deep learning approach.

Finally, in addition to the student's confidence and skilfulness with certain approaches, and the motivation by the teacher to a particular approach, the student's learning style (explained in a previous section) will unconsciously incline him/her to a certain learning approach. While this is part of the psychological make-up of the student, and thus a reasonably stable characteristic, with enough awareness and motivation the student can be facilitated to partly override his/her learning style.

So, what started out as a simple process of the student exercising conscious thought and deliberation in the adoption of a learning approach, is in actuality a complex phenomenon of that plus motivation in all its many forms from the teacher to choose the deep approach, plus the unconscious predisposition to a particular learning approach by virtue of the learning style.

From the behavioural perspective, the execution of the learning approach happens as the prerequisite to the learning outcome. From the structural perspective, the situation perception object belongs to the learning situation.

Learning Outcomes

These are demonstrable aspects of the learning context, in particular the course, that after being assessed in their completed forms, render an adjudication of the level of learning achieved. Upon entry into the learning context, the student must apprehend its learning outcomes almost immediately, so as to build the necessary perception of the learning situation and later adopt the learning approach that most correctly relates to the learning outcomes.

Learning outcomes are different to learning objectives that specify the aspects of the course that will covered. Outcome goes one step further than what is the content (a quantitative measure), and additionally evaluates the degree to which the content has been learned (a qualitative measure). The seeming subjectiveness of this endeavour is addressed using phenomenographic thinking: the degree of learning is revealed in the variation of the student's response. For example, does the student incorporate several concepts via sound relationships that are purposefully formed from a holistic and ever-expanding pool of experience? The variance of this exemplar to a response that lists several associative items, is notable and evaluable. When marking the response, the teacher can then ask “how much is understood” instead of “how much has been remembered”.

It is clearly evident that adoption of a deep learning approach will result in a superior learning outcome due to the purposeful adjudication of the student’s understanding, while the surface learning approach would be substandard, and the strategic inferior. Furthermore, there is evidence that the higher the achievement in the learning outcome, the longer the retention (Dahlgren, 1988; Ramsden, 1992). About his students, Ramsden notes that,

> … many are able to pass examinations, but many are unable to show they understand what they have learned, when asked simple yet searching questions that test their grasp of the content. They continue to profess misconceptions of important concepts; their ideas of how experts in their subjects proceed and report their work are often confused; their application of their knowledge to new problems is often weak; their skills in working jointly to solve problems are frequently inadequate. (p. 33)

The deficiencies listed above can all be addressed in the instructional design in the learning context, therefore the teacher’s effectiveness in implementing an instructional design that encourages deep learning will directly impact the level of success that his/her students enjoy in achievement of the learning outcomes. Also, conventional assessment methods are unreliable when applied to revealing qualitative variation, so the teacher must adopt instruments attuned to highlighting qualitative variation such as Structure of Observed Learning Outcome (SOLO; Biggs & Collis, 1982). As a side note, the pre-eminent Bloom’s taxonomy first released in 1956 and then revised in 2001, remains relevant and effective in the learning model because it does address qualitative assessment of learning outcomes, as expressed in this uncompleted phrase “The student shall be able to…” (Krathwohl,[4] 2002, one of the original authors of the 1956 taxonomy and the co-author of its 2001 revision), and provides for the assessment of meaningful learning along a scale from none to understanding at the level of a teacher (Mayer, 2002).

The extent of awareness by the teacher in the different ways that the subject could be understood by students, is an enhancer for the achievement of the learning outcomes. So informed, the teacher can help the students to sharpen their articulation of these perspectives, and also be attentive to recognize them in their incarnations in the students’ responses in the assessment.

From the behavioural perspective, the learning model runs-to-completion, and the student has altered and enhanced his/her situational awareness by fulfilling the learning outcomes. This altered awareness carries the learning imprint from the concluded approaches and outcomes, and becomes the inputs that the student applies

[4]Krathwohl’s article is written with the confidence and flair of a senior statesman. It is both an overview of the 2001 revision of Bloom’s original taxonomy of 1956 and a teacher’s simple guide for establishing a correlation between course objectives and Bloom’s cognitive outcomes. It has 3085 citations by Google Scholar count.

in the next learning event or undertaking. From the structural perspective, the student exits the LearningContext Class having completed its conditions of utilization, and takes with him/her cognitive property alterations such as prior experience and inventory of learning approaches. The work products produced by the student in fulfilment of the learning outcomes, such as textbooks, handouts, reports, videos, and experiment by-products, form a personal and sometimes substantial material legacy of external objects available to the student for other LearningContext Classes.

Traceability of the Learning Model

In cases of research where a conceptual model is hypothesized and then tested, all the conceptions in that model trace to the data model; in fact, the conceptual model and the data model are typically one and the same. However, in this study, the two models, learning and data, are separate entities constituting a 'two-tier composite model'. The learning model establishes the learning and teaching conceptions for higher education students, and the data model specifies the data items to be processed. Thereupon, the learning model stipulates the requirements for the study's data processing, and traces to the data model.

Though the learning model sets the requirements for the data model, possibly not all the elements in the learning model can be manifested into measurable and evaluate-able data items. However, the learning model is well-conceived and very authentic in its design, so most of its Classes successfully passed vetting and are determined to be evaluate-able as data items. The Context, Outcome, PriorExperience, Relational, and Style Classes are considered to be measurable and evaluate-able as data items.

- LearningContext Class—this is the setting for the learning and teaching. Consequently, it can be manifested into many data items, including the course, degree program, instructional designs, semester, student, teacher, and year of study;
- LearningOutcome Class—this is any demonstration of a student's learning. Marks are the universally accepted symbolization of the degree of learning. The University requires exam and coursework marks, and provides the weighted average of them, final mark. Additionally, there are many marks generated by the teacher, including for documentation, feedback, paper, participation, peer assessment, post in forum/wiki, presentation, project, quiz, report, and workshop;
- LearningStyle Class—this is manifested by one schema for cognitive and behavioural responses of a student to a learning activity already in action, used in this study, Felder and Silverman (1988);
- PriorExperience Class—this traces to the students' perceptions of formal learning originating prior to taking the course. This can be manifested by many data items, including learning and teaching experience in national schools, poly/JC, and even the University. Other kinds of prior experience are culture and nationality, teamwork, and innovative learning program; and

- Relational Class—this is any choice of how to learn that is not forced by the teacher or the School, and that enhances learning even to the point of evoking 'deep' learning. There are many choices of learning approach, for example, asking questions, attending F2F sessions, completing assignments every week, conducting a forum discussion, leading a class discussion, reading a chapter in the textbook every week, and volunteering for TeamLeader.

The remaining two Classes in the learning model, LearningSituation and SituationPerception, are considered to be not measurable and evaluate-able as data items because they represent personal cognitive states. Even Prosser and Trigwell do not provide concrete readings of the personal states that are possible in these two Classes.

Development of the data model based on the learning model, is elaborated in the next chapter.

Chapter 5
Data Model and Collection

This chapter discusses the ‘data model’, the second tier of the ‘two-tier composite model’ used to trace the prevailing and pertinent learning and teaching theories discussed in Chap. 2 with the data processing. The data model maps to the conceptions learning model detailed in the previous chapter, and provides the specification of data that is used in the statistical testing in the next chapter.

In reiteration, the conceptions from the learning model that trace to the data collection are learning context, learning outcomes, relational learning approach, learning style (kind of learning approach), and prior experience. There must be variables enough in the data model to provide data to enable all these concepts to be tested.

This chapter addresses the following aspects of the learning model:

1. The data dictionary with a tabular summary (Table 5.6);
2. Modelling language employed to render the model diagrammatically;
3. Mapping of the variables in the data model to the previous section’s learning model concepts (Table 5.7);
4. Process of collecting the data set; and
5. Statement of provision of auditability and verification of the data set.

Overview of the Data Model

The data model comprises one diagram accompanied by instructions for interpreting the diagram and a data dictionary defining the meanings and technical specifications for all the 27 variable Classes therein.

To maintain consistency and enhance readability of all model diagrams, the data model is drawn according to the UML specification, just as is done for the learning model. However, unlike the learning model, the data model comprises only one diagram, a UML structure diagram in the notation of a Class diagram, i.e., containing Classes. There is no pre-existing template to base the layout and orientation upon, so the diagram is completely original.

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The data model fits the particularities and necessities of this study, but is also consonant with other studies of learning in higher education. This means that there are a few Classes in the data model pertaining to learning studies in general and for which data is not collected in this study. This will be discussed further in an ensuing section.

Interpretation of Data Model Diagram

The data model diagram (Fig. 5.1) is organized into four hierarchies under these roots: Attendance, FinalMark, LearningStyle, and InstructionalDesign. The InstructionalDesign hierarchy is 'taxonomic' (distinguished by the unfilled triangle notation), and the rest are 'compositional' (distinguished by the filled diamond notation). Additionally, there are six standalone Classes: Semester, SchoolAffiliation, Nationality, TeamLeader, Teacher, and Course.

Interconnecting the four hierarchies and six standalones is the Student Class. The Student Class is the 'primary key' for the data model, i.e., the unique identifier for a coherent set of values taken from every one of the connected hierarchies and standalones, and that belong to the identifier. An example of the use of a primary key is as follows: studentA scored 65 on his exam, attended 98% of the sessions, etc., and studentB scored 68 on his final exam, and attended 97% of the sessions, etc.; so,

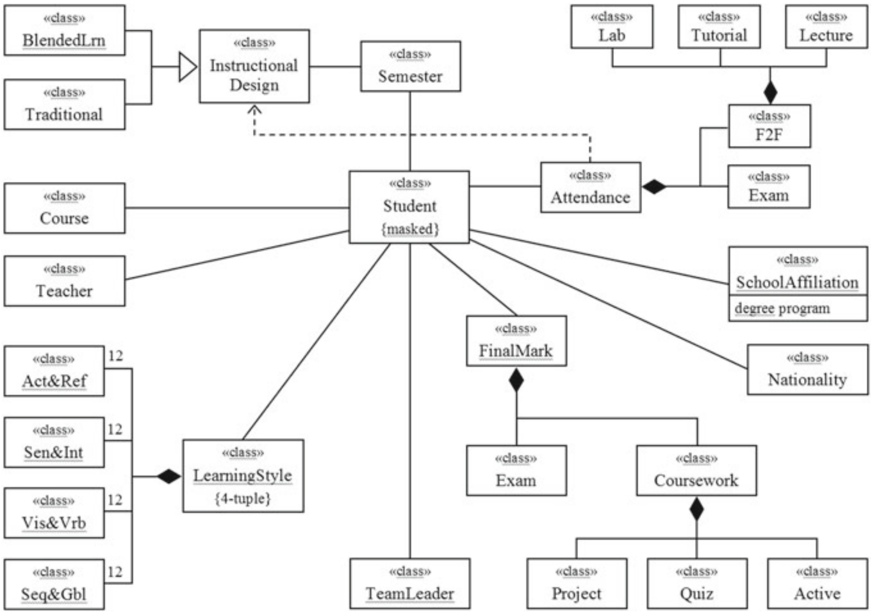

Fig. 5.1 Structure diagram for the data model (UML Class diagram)

to determine the relationship between exam scores and attendance, the researcher analyses those variables in a 'tuple' {exam score, attendance} belonging to each student, and not as a list of unconnected variables that can be independently summed and averaged. Lastly, Attendance has a dependency to the InstructionalDesign Class. A dependency is a relationship of need; Attendance needs the attendance monitoring criteria that is established as part of the InstructionalDesign.

Elaboration of Data Model

The following is an elaboration of the variables comprising the data model, intrinsically the data dictionary. The variable is written as a Class, e.g., "InstructionalDesign", and the real-life concept or entity that relates to the variable is written as a phrase, e.g.,"instructional design".

Student and Nationality Classes

The test subjects for this study are students (symbolized by the Student Class) enrolled in the University. These students are organized into groups called cohorts according to their year of enrolment and degree program, e.g., CE 2008 is the cohort of all students in the CE degree program that enrolled in the year 2008. The cohorts are exclusively from the CE degree program, except for one special grouping that comprises cohorts belonging to other engineering, science, and business degree programs. There is an additional small quantity of students that belong to exchange programs and not to the University's cohorts; such students stay with the University for usually just one or two semesters (see Table 5.1 for details). The data set comprises a total of 856 students.

As part of their application for enrolment into the University's degree programs, the students declare their countries of residence (symbolized by the Nationality Class). As per Table 5.2, the prevalent country of residence is Singapore along with a small percentage of other nationalities in Asia. There are 18 values of nationality in this data set, i.e., {BU, CA, CN, FI, FR, HK, ID, IN, KZ, LA, LK, MY, SE, SG, SG PR, TH, US, VN}. All the values except two, "BU" and "SG PR", follow the ISO 3166 (International Organization for Standardization, 1999) two-letter encoding of countries, dependent territories, and geographic special areas. "BU" is assumed to mean Burma, and "SG PR" definitely means Singaporean permanent resident. This data is qualitative and nominal.

In accordance with the University's review board stipulation (Lee, 2011), the identity of each student in the data set is to be anonymous. So, it is masked in the data set by a derived replacement string. In the absence of intended ordering, i.e., the replacement string for the test course's name is not intended to retain the same order that would be for the before-masked-identity, this data is qualitative and the values are deemed nominal not ordinal.

Table 5.1 Frequency of students by represented cohorts

Cohort	Code	Students
Art, design and media	ADM	1
Aerospace engineering	AERO	3
Biomedical engineering	BIE	4
Business	BUS	1
Chemical and biomolecular engineering	CBE	1
Chemical engineering	CHEM	1
Computer engineering	SCE	814
Economics	ECON	1
Electrical and electronics engineering	EEE	1
Engineering (basic)	ENG	6
Exchange program	EX	13
Materials science and engineering	MAT	1
Mathematics	MATH	7
Mechanical and production engineering	MPE	1
Physics	PHY	1

Table 5.2 Frequency of students by represented nationalities

Nationality	Code	Students
Burma	BU	2
Canada	CA	2
China	CN	123
Finland	FI	1
France	FR	2
Hong Kong	HK	1
Indonesia	ID	30
India	IN	101
Kazakhstan	KZ	13
Laos	LA	1
Sri Lanka	LK	2
Malaysia	MY	31
Sweden	SE	1
Singapore	SG	462
Singapore permanent resident	SG PR	32
Thailand	TH	1
United States of America	US	2
Vietnam	VN	49

Semester and Course Classes

The semester (symbolized by the Semester Class) is a 13 week period in which the learning of one academic course is undertaken. At the time the study was conducted, the normal schedule of two per academic year at the university had been just increased to three for the discretion of academically higher-performing students. Semesters are designated by a code value comprising the last two digits of the year followed by an alphanumeric abbreviation for the semester, i.e., "S1" is semester one, "S2" is semester two, and "ST" is special term. S1 starts in August of the year in its coded designation, e.g., 07S1 starts in August of 2007. S2 starts in January of the next year, e.g., 07S2 starts in January 2008. Finally, ST starts in May of the next year, e.g., 07ST starts in May 2008. The cycle then repeats, starting with 08S1, and so on. This makes the data qualitative and the values ordinal, though the manipulation of the ordering scheme is complicated, involving an initial determination of numeric order according to the first two digits as a number with 'zero padding', followed by a determination of order of the fourth/last digit as a character with custom ordering {1 ⇨ 2 ⇨ T}. Table 5.3 summarizes the size of the student cohorts for each of the 11 semesters accounted for in the data set.

Two trends in the cohort size per semester are clearly evident. The first is the disparity of cohort size between S1 and S2. S1 is always the smaller because S2 is the primary engagement for the course, i.e., the semester aligned with the degree program's standard scheduling followed by the majority of students. S1 is the alternate engagement for students either repeating a course (alluding that they are weak academically), or taking a compressed degree program (alluding that they are exceptional academically). The second is that the average cohort per academic year decreases from 233 for 07S1-S2 to 129 for 11S1-S2. This is due to the introduction of a new degree program in the school that took away increasingly more students from the existing degree program as it slowly lost its allure with joining students. Note that as its designation suggests, the ST semester contains the special grouping of cohorts belonging to other engineering, science, and business programs that is alluded to earlier; the sum of all the cohorts in Table 5.1 except CE and EX is 29 which is the number displayed in Table 5.3 of students undertaking the ST semester.

The University is organized into operational units called schools that are assigned full responsibility to operate degree programs. Each degree program is comprised of courses (symbolized by the Course Class) that encompass all the knowledge and skill to be taught to and learned by the students. The School is responsible for two degree programs pertinent to this study: CE and CM. For all but one semester, 07ST, the course taken by the cohorts is "Software Engineering" belonging to the CE program. In 07ST, the course taken is "Reasoning With Objects", a minor course belonging

Table 5.3 Frequency of students (or cohort size) by semester

Data	07S1	07S2	07ST	08S1	08S2	09S1	09S2	10S1	10S2	11S1	11S2
Students	83	150	29	55	118	34	124	48	86	57	72

to the CM program and that may only be undertaken by University students from outside the School. This minor course is a downsized Software Engineering intended to give non-computer engineering students some tools to meaningfully contribute to computing projects in industry. Being so, the comparison of ST semester's data subset with the other semesters' data is circumspect and valid since the topics are the same and the difficulty for the different students is relatively equivalent. That is, the CE students having a higher degree of competence in the discipline undertake the more difficult Software Engineering course while the CM students having little competence in the discipline undertake the same basic Software Engineering course but in a reduced embodiment. Note that the student chooses the semester in which he/she will undertake the Software Engineering course. Ostensibly, the student is the correlator of semester and course, not the University or the School.

InstructionalDesign and Teacher

Every course in every semester is delivered teaching-and-learning-wise to the students via one of two standardized instructional designs. Instructional design (symbolized by the InstructionalDesign root Class) is the amalgamation of instructional theories and their translation into teaching practice including learning session organization and scheduling, learning activities, educational technology, classroom management, and monitoring/feedback (Smith & Ragan, 1999; an accessible book with 2262 citations by Google Scholar's count that contains hundreds of case studies and examples). There are two mutually exclusive designs in this study, traditional lecturing (symbolized by the Traditional Class) and blended learning (symbolized by the BlendedLrn Class). As discussed in a previous section, lecturing is the old instructional design that is being replaced with blended learning, a new and innovative instructional design in which lectures are replaced with more active F2F learning sessions. As also mentioned earlier, instructional design data per se is not collected; instead, instructional design is implied through another Class for which data is collected, namely Semester. The 'traditional lecturing' instructional design operates during semesters {07S1, 07S2, 07ST}, and the new blended learning instructional design operates after that for the remainder of the semesters {08S1, 08S2, 09S1, 09S2, 10S1, 10S2, 11S1, 11S2}.

Notwithstanding this indirect scheme of indicating the instructional design through the serialization of semesters, such as < if sem=="08S1" & sem=="08S2" & … == "11S2" >, derived data for InstructionalDesign, is added into the data set. The new derived data is qualitative and binary, i.e., {bl, trad} where "bl" is blended learning and "trad" is traditional lecturing. It is a welcome and substantive enhancement to the conception and writing of the superabundance of statistical tests to be conducted.

The teacher (symbolized by the Teacher Class) designs and implements the instructional design for the course and conducts instructing, tutoring, and supervising of the students enrolled in the course. This study had no mandate to collect data on any aspect of the performance of teachers. However, the University collects its own data concerning the student's satisfaction with the teaching in a course, STF; this instrument is highlighted in Chap. 3. An extract of this STF data pertaining to the author of this study who also is the teacher of the Software Engineering course is incorporated in the data sample for this study.

Mark and TeamLeader Classes

There are six classifications of marks data generated by the teacher for this study.

- Final (symbolized by the FinalMark root Class)—summation of the weighted values of Exam and Coursework. For all semesters, the weighting of Exam and Coursework in the final mark is 40:60 respectively;
- Exam (symbolized by the Exam Class)—assessment of the course learning via University examination that occurs in a three week period immediately following the 13 weeks of learning;
- Coursework (symbolized by Coursework Class)—summation of the weighted values of quiz, active, and project marks. For the blended learning, the weighting of quiz, active, and project in the coursework mark is 20:20:60 respectively. For the traditional lecturing, the weighting is 10:10:80 respectively;
- Active (symbolized by the Active Class)—assessment of effort expended and work products generated in PBL-type activities not included with the Project;
- Quiz (symbolized by the Quiz Class)—assessment of the midterm tests and all other tests during the 13 weeks of learning; and
- Project (symbolized by the Project Class)—assessment of all gradable activities associated with the construction of a large software program in a software laboratory. Note that the student's attendance in these activities is imbedded into the Project Class, and this anomaly went unnoticed until after the data was collected. Since it would be very tedious and error-prone to separate the attendance out of the Project Class for all eleven semesters, this anomalous condition has been regrettably retained.

Three of these marks, Final, Exam, and Coursework, are the proprietorship of the University; the other three are managed by the teacher. The proprietary marks are high-level indicators of academic performance, while quiz, active learning, and project are indicative of performance in the particular activities that are their namesake. The impact of the proprietorship of the marks to the auditability and verifiability of the data set is discussed in a later section.

Marks are quantitative data with the final, exam, and coursework marks being discrete, and the active, quiz, and project marks being continuous; since zero is a bona fide value, the mark data is ratio. The smallest magnitude of mark for final and coursework is "1", and for exam is "0.5". To normalize the comparability of the different mark kinds with different weightings over the different semesters, all mark values are a raw score out of 100. This in conjunction with the continuity of mark adjudication promotes the reliability of comparing marks given the longitudinality of the data set and the variety of marks classifications.

For every project, several students volunteered and were accepted through a “show of hands” by the student majority, to be the technical leader (symbolized by the TeamLeader Class) of each of the teams established for the project. Allowing all students to vote meant that the team leaders would have credibility with their own team and all other teams. This is crucial because collaboration of all the teams is a significant part of the project. The TeamLeader data is qualitative and binary, i.e., 1 = is leader, and 0 = not leader.

This achievement pattern is consistent with the Software Engineering course being considered very difficult by the students. Since the taxonomy is a set of rich qualifiers instead of just numbers, the teacher can utilize the year-on-year taxonomy surveys to target specific outcomes for increased achievement, e.g., change case studies from research to coding as a way of moving from ‘analysing’ to ‘applying’.

Adjudication and Uniformity of Mark Data

The marks are determined using Bloom’s taxonomy (Anderson, Krathwohl, & Bloom, 2001) in the construction of the assessment instruments and later in the grading of the students’ responses to them. Bloom’s six cognitive categories of outcomes—shortened to ‘cognitive outcomes’—provide distinct definitions of understanding and achievement that the teacher can anchor the goodness of some work product and devise a commensurate mark. Table 5.4 is the scheme established by the teacher in this study for mapping the observable qualitative variance of each cognitive outcome to the appropriate mark range between zero and 100. The teacher sets an assessment item to the cognitive outcome at which the answers of the majority

Table 5.4 Teacher’s personal mapping of Bloom’s cognitive outcomes to mark ranges

Cognitive outcome	Aspects of response where qualitative variance may be revealed	Mark range
Creating	creative thinking ǁ conversion of existing solution ǁ invention new solution ǁ speculation ǁ integration	85–100
Evaluating	critical thinking ǁ priorization of solution ǁ justification and persuasion ǁ conclusion and recommendation	80–84
Analysing	causality of problem ǁ breakdown of solution ǁ comparison to other case ǁ relationship to other case ǁ test	75–79
Applying	demo of problem ǁ solution correctness ǁ interpretation of use (novel case) ǁ notation fidelity	70–74
Understanding	classification of problem ǁ explanation coherence ǁ paraphrasing ǁ summarization ǁ ambiguity use	60–69
Remembering	recognition of problem ǁ solution recollection ǁ notation wellformedness ǁ definition exactness	50–59

of students are expected to reach, e.g., “students are expected to be able to apply [some knowledge] to [some problem]. The teacher identifies within a student’s response the qualitative variance that best matches the key words in Table 5.4, and assigns a mark within the commensurate range. This method is proven to be especially effective for the end-course examination.

The University expects a normal distribution for the mark assignment, but the teacher set his expectation of achievement pattern against the cognitive outcomes, striving for his students to reach the ‘applying’ outcome, with as few as possible just ‘remembering’. The teacher is also resigned to very few students achieving the ‘creating’ outcome. To give a rudimentary sense of how Bloom’s taxonomy may be applied, the cognitive outcome distribution in this study for the entire data set across all 11 semesters is:

- ‘creating’—0.1%, i.e., only one student reached this outcome;
- ‘evaluating’—1.4%;
- ‘analysing’—13.3%;
- ‘applying’—31.2%;
- ‘understanding’—43.6;
- ‘remembering’—7.4%; and
- fails—3.0%, however, 77% of these are because the students did not attend their end-course examination, not because the student did not understand the course material.

In Chap. 3, it is surmised that the congruity of the marks data semester-on-semester may be actualized as some non-uniformity in the data. Table 5.5 shows the data for the three classifications of marks that are the proprietorship of the University.

Definitely, the marks in traditional lecturing, semesters {07S1, 07S2, 07ST}, appear more uniform, and the marks in blended learning, semesters {08S1-11S2}, appear less uniform. However, it is also clear that the marks in two blended learning semesters, {09S1, 10S1}, appear to be outliers. The marks in 09S1 are significantly higher than the rest, and in 10S1 are significantly lower. In Chap. 6, this data will be analysed to determine what is the underlying cause.

Of note is that the marks data in semester 07ST is prominently more consistent with those of blended learning than traditional lecturing. As indicated earlier in this chapter, this semester comprises entirely students in the CM degree program; the rest of the semesters are populated by CE degree program students. The next chapter reveals that the CM students exhibit a higher achievement of learning outcomes than CE students in the same instructional design.

Table 5.5 Distribution of marks means by semester

Mark	07S1	07S2	07ST	08S1	08S2	09S1	09S2	10S1	10S2	11S1	11S2
final	65.5	65.9	68.5	68.7	65.8	72.2	68	64	67.1	68	68.6
exam	60.7	61.8	65.4	62.4	62.4	69.8	65.9	58	62.1	65.4	65.6
crsewrk	70	70.3	70.9	72.8	67.9	73.7	69.3	67.9	70.5	69.6	70.6

Attendance and School Affiliation Classes

The Attendance compositional hierarchy is composed of the following six data sets:

- Attendance (symbolized by the Attendance root Class)—average of the unweighted values of exam and face-to-face attendance;
- Exam (symbolized by the Exam Class)—attendance in the University's standard 2 h period for conducting the formal and final examination within three weeks of the completion of the scheduled 13 weeks of learning.
- Face-to-face (symbolized by the F2F Class)—average of the unweighted values of lecture, tutorial, and lab attendance;
- Lecture (symbolized by Lecture Class)—attendance for the set of the University's standard 1-h periods that bring the course teacher together with the entire cohort of registered students. These are conducted between two and three and times a week for 13 weeks;
- Tutorial (symbolized by the Tutorial Class)—attendance for the set of the University's standard one-hour periods that bring a tutor together with a fixed subset of the student cohort. These are conducted once a week for 13 weeks. Enough tutorial periods are scheduled in the week to ensure that every student is assigned to a tutorial; and
- Lab (symbolized by the Lab Class)—attendance for the set of the University's standard 2-h periods that bring a lab supervisor together with a fixed subset of the student cohort. These are conducted once a week for 13 weeks. Enough lab periods are scheduled in the week to ensure that every student is assigned to a lab.

Similar to the marks data, the attendance data is quantitative and ratio with a raw score out of 100; unlike the marks data, the attendance data is all continuous. The attendance data may be perceived in two ways: as an outcome of the new instructional design, and as the learning approach in the learning model. Finally, as mentioned earlier, lab attendance is imbedded into the Project marks and impractical to separate out. So, data for the Lab Class is not available for this study.

Most but not all of the attendance variables directly associate with marks variables. Figure 5.2 shows the conceptual association, with a solid line depicting a strong association and a dashed line depicting a weak association.

Affiliation of the student to the School (symbolized by the SchoolAffiliation Class) is derived from the cohort and nationality data. The data is qualitative and binary, with "1" meaning not affiliated with the School, and "0" meaning affiliated with the School. 'Not affiliated' identifies all exchange students plus all students in cohorts other than CE, and all students from KZ who were recruited under a special two-year exchange program, for a total of 55 students; those affiliated with the School are the remainder of the students.

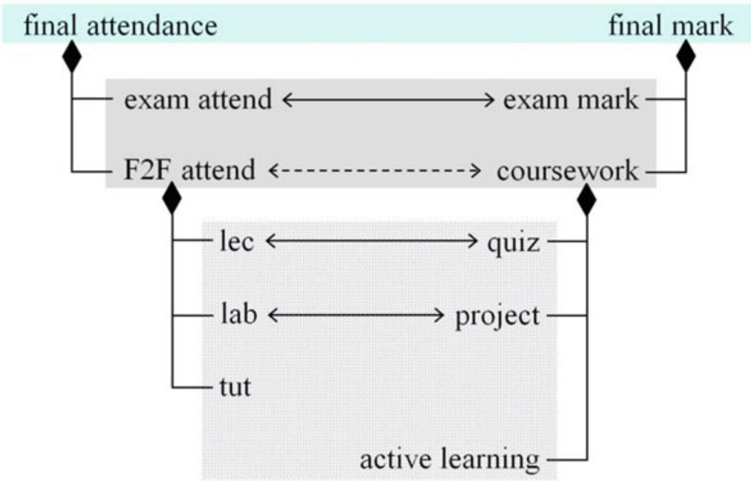

Fig. 5.2 Association of attendance variables to mark variables

Learning Style Classes and Data Dictionary

Learning style (symbolized by the LearningStyle root Class) data is a 4-tuple of scores placed one each into custom scales that are one each in four bands (see the previous Learning Style section for a detailed explanation). Each score is a two-digit alphanumeric code that has no inherent ordering scheme, so the data is qualitative and the values nominal. Each band has a fixed scale of 12 possible scores. The Classes for the four bands are:

- Active ⇔Reflective (symbolized by the Act&Ref Class);
- Sensing ⇔Intuitive (symbolized by the Sen&Int Class);
- Visual ⇔Verbal (symbolized by the Vis&Vbl Class); and
- Sequential ⇔Global (symbolized by the Seq&Gbl Class).

Note there is an annotation "12" adjacent to each of the above four Classes in the model diagram. This indicates the fixed scale of 12 available score options in each band. The LearningStyle Class can be appreciated as the online report that is sent to the person that submits the completed index of learning styles (ILS) questionnaire, and that specifies the scores for the four bands.

However, due to the requirement for intra- and inter-band analysis of the 12 scores in each of the four bands, the old data of the two-digit alphanumeric code is replaced with derived qualitative data whose values are binary {0, 1} where "1" means the particular score is assigned to the student and "0" means it is not assigned (Fig. 5.3). This derived data is expected to be useful in determining the prediction capability of the ILS.

Table 5.6 shows the data dictionary summarizing the naming, descriptions, and technical characteristics of all 27 variables in the data set.

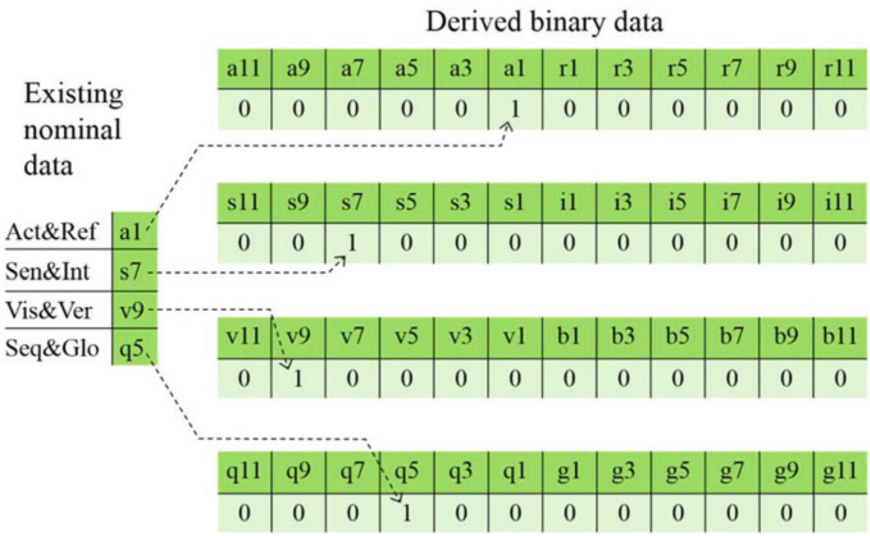

Fig. 5.3 ILS nominal values replaced with binary

Mapping Data and Learning Models' Elements

The guideline followed in the planning of the data collection activity is that whenever possible, the naming of variables mimic those learning concepts they are intended to map to, or mimic key words in the research question as an indirect links to the concepts. A summary of the mapping of the data and learning model's elements is in Table 5.7.

Variable Class LearningStyle with its four child Classes, Act&Ref, Sen&Int, Vis&Vbl, and Seq&Gbl, map directly to the LearningStyle Class—being an intrinsic kind of LearningApproach Class—in the learning model.

The InstructionalDesign Class in the data model mimics key words in the research question. Those keywords in the research question trace to LearningContext. Therefore, InstructionalDesign Class maps to the LearningContext Class.

The six classifications of marks, FinalMark, Exam, Coursework, Quiz, Active, and Project Classes, map to the LearningOutcome Class. As a side note, it is accepted that marks are only one of several indicators of learning outcomes, however their use is a deferment to necessity and practicality; incorporating other indicators to assess learning outcomes, such as demonstrated capability in front of real customers or the field trial of some machine built by the student, is not entertained by the University. Ergo, marks are the only learning outcome data being collected in this study.

The remaining two learning model concepts, learning approaches and prior experience, are cognitive in nature and as per the previous chapter have a plethora of choices for their realization as variables. To support auditability, the inevitable subjectiveness of the choice of realizing variables is not obscured by having their classnames

Table 5.6 Data dictionary

Class name	Summarized description	Data type	Data sub-type	Value
Student	test subject in research; name masked	qualitative	–	nominal[D]
Semester	13 week period for learning one course	qualitative	–	ordinal
Attendance [R]	average of unweighted F2F and exam attendance	ndc	ndc	ndc
Exam	attendance in end of course examination	quantitative	continuous	ratio
F2F	average of unweighted lecture, tutorial, & lab attendance	quantitative	continuous	ratio
Lecture	attendance in two/three weekly cohort w/teacher pds	quantitative	continuous	ratio
Tutorial	attendance in weekly student group w/tutor pd	quantitative	continuous	ratio
Lab	attendance in weekly student group w/lab supervisor pd	ndc	ndc	ndc
SchoolAffiliation	affiliation to the school, exchange & KZ	qualitative	–	binary[D]
Teacher	same instructor for course in all 11 semesters	ndc	ndc	ndc
FinalMark [R]	sum of weighted exam and coursework marks	quantitative	discrete	ratio
Exam	end-of-course University examination	quantitative	discrete	ratio
Coursework	sum of weighted active, quiz, and project marks	quantitative	discrete	ratio
Active	PBL activities not project	quantitative	continuous	ratio
Quiz	midterm and all other tests	quantitative	continuous	ratio
Project	activites for laboratory plus attendance	quantitative	continuous	ratio
TeamLeader	team leader in project appointed by popular vote	qualitative	–	binary
LearningStyle [R]	student's preferred way to learn	ndc	ndc	ndc
Act&Ref	active⇔reflective	qualitative	–	binary[D]
Sen&Int	sensing⇔intuitive	qualitative	–	binary[D]
Vis&Vbl	visual⇔verbal	qualitative	–	binary[D]

(continued)

Table 5.6 (continued)

Seq&Gbl	sequential⇔global	qualitative	–	binary[D]
Nationality	country of student's foundational learning	qualitative	–	nominal
Course	Software Engineering == Reasoning With Objects	ndc	ndc	ndc
InstructionalDesign [R]	organization of the learning activites & tech	qualitative	–	binary[D]
BlendedLrn	new instructional design with no lectures	ndc	ndc	ndc
Traditional	old instructional design entirely lecturing	ndc	ndc	ndc

Notes (1) Superscript "R" in Class name column signifies root Class
(2) Superscript "D" in Value column indicates derived data values
(3) "ndc" in data columns is an acronym for 'no data collected'
(4) "–" in data columns means the cell is intentionally blank

mimic the learning concepts; instead the variables' designations are as meaningful and categorically cogent as possible.

It is posited that attendance and team leader are instances relational learning approaches because they are chosen at the student's discretion and their choice relates to the level of achievement in learning outcomes desired by the student. That is, if the student believes that, higher attendance opens more opportunities for learning than less and taking up the role of team leader increases his/her involvement in the learning of the course than a student in a non-leadership role, then attendance and team leader are bona fide approaches to learning.

Nationality and school affiliation are posited to be instances of prior experience. The formal education system is different for each nation, and the learning experience resulting from these different education systems would also be different. The common understanding of teachers in the School as explained in the preface is that students in the School exhibit different attitudes and approaches to learning than other schools in the University. Presuming this to be an accurate observation, then school affiliation would be a differentiating prior experience when a student from outside of the School undertakes a course in the School. Based on these reasons, prior experience in this study maps to the variables Nationality and SchoolAffiliation.

Description of Data Collection Methodology

The data set for this study is accrued over a five-year period from August 2008 to July 2012 inclusive. The period being five years is not a requirement or stipulation of the

Table 5.7 Mapping of learning and data models' elements

Attendance R	Relational ⇨ LearningApproach R
Exam	
F2F	
Lecture	
Tutorial	
Lab	
TeamLeader	
LearningStyle R	LearningStyle ⇨ LearningApproach R
Act&Ref	
Sen&Int	
Vis&Vrb	
Seq&Gbl	
FinalMark R	LearningOutcome
Exam	
Coursework	
Active	
Quiz	
Project	
Student	–
Semester	–
–	*LearningSituation*
–	*SituationPerception*

Notes (1) Superscript "R" in Class name column signifies root Class
(2) "–" in data columns means the cell is intentionally blank
(3) Classnames in italics signify Classes that are unmapped

design-based research methodology. Instead, it is believed to be sufficient duration to enable the collection of data pertaining to both instructional designs—traditional lecturing and blended learning—so that the contrast between them can be analysed. Also, newly launched instructional designs must always undergo several rounds of optimization. Being the first of its kind innovative instructional design in the School, setting aside such a buffer for optimization of the blended learning is deemed prudent.

The data for this study is generated from three sources:

- teacher—creates the marks and attendance information for every student on the University's course registration lists. Although conventional practice is for two

instructors and several tutors and lab supervisors to be assigned to teach the course in a semester and mark its students, the author of this thesis is the one and only teacher for all of the eleven semesters of data collection. This substantively increases the confidence level for the consistency of this data for all activities including the examination across all semesters;
- University—provides identity, nationality, and school affiliation of every student officially registered to undertake the course in the current semester. The data is posted on the University's password-protected campus intranet for the teacher to download (Nanyang Technological University, 2016), and is subsequently taken offline shortly after the cessation of the course. (Screen prints of the website and generated report are provided in Appendix A). The confidence level for the consistency of this data is high; and
- ILS questionnaire internet site—provides personalized ILS report on submission of a completed questionnaire (Felder & Soloman, 1991). The internet site is hosted by North Carolina State University. The student sends a softcopy of their personalized report by email to the teacher. (Listing of the questions and two-choice responses in the ILS questionnaire are provided in Appendix B). The confidence level for the consistency of this data is also high.

During each semester, the teacher extracts the data for the variables specified in the data model from all three sources into three Excel workbooks for processing and permanent secure storage. The first is an ILS organizer that holds an extract of every ILS report submitted by a student; the reports are aggregated in separate worksheets according to their students' semesters. The second is an attendance planner that links the University data with the student's attendance and other participation information for all the F2F learning sessions; there is one workbook for each semester. The third is a marks planner that links the University data with all the marks including end-of-course examination for all gradable learning activities; there is also one such workbook for each semester.

The teacher marks the student answer scripts for the end-course examination, and then enters these and the coursework marks into the University's secure online system for generation of the final mark, consistency checking, and acceptance. At the end of this activity, a hardcopy listing of the three online marks for each student is signed and retained by the Chair of the School (see Appendix C). It is known that additional moderation of those marks is conducted within the University by authorized management. So, the marks data collected by the teacher is before the University moderation.

Note that the marks planner workbook for semester 08S1 is corrupted and so its data is a reconstitution based on the marks in the signed hardcopy marks listing held by the Chair of the School. All other workbooks are in good order.

Upon completion of the final semester in the data collection period, the information from all workbooks is cross-correlated by student identity and semester, and then copied into a single Excel worksheet. This worksheet is then imported into the database format specified by the statistical analysis software, in this case Stata.

Data is not collected for the variable Classes Attendance (root), LearningStyle (root), InstructionalDesign (root), Teacher, Course, Student, BlendedLrn, Traditional, and Lab. As discussed earlier, the data model both fits this study and other more general studies of learning in higher education. For example, no data collected for the three Classes specifying the instructional design, but they are included in the model because they connote a primary experimental variable for this and other studies. For this study, the instructional design in vogue is gleaned from the semester. Other Classes for which there is no data, such as Course and Teacher, while not experimental variables in this study, are nevertheless formative aspects of learning that can be experimental variables in other learning research. So, while this data model exhibit the unique choices of variables for this study such as nationality and school affiliation, it also includes some general variables for learning research such as teacher and course.

Auditability and Verification of Data Set

The database used in the statistical analysis activity in this study and the Excel worksheet from which the database is constituted, are uploaded for verification. If audit of the data from source is needed in conjunction with this verification, note the following guidelines.

Access to the data from source is clarified by the University's Institution Review Board: the student's confidentiality is to be ensured, and releasing the direct linkage of the unmasked identity of a student to his/her official marks can be granted only by the student (Lee, 2011).

The teacher is prohibited from releasing the student identity masking scheme.

As alluded to in the earlier section, final, exam, and coursework marks are the proprietorship of the University; the other three are of the teacher. Therefore, requests for official marks have to be made through the correct channel, i.e., to the registrar of the University for final, exam, and coursework marks, and to the teacher for quiz, active learning, and project marks, but with student identities masked.

Finally, recall from the previous section that two official sets of University marks exist and they may not be identical. The Chair of the School holds the listing before moderation, and the University holds the listing after moderation.

The statistical analysis of the data model is explained in the next chapter.

Chapter 6
Exploratory Statistical Analysis and Discussion

This chapter summarizes the results of the statistical analysis on the data set conforming to the data model in the previous chapter. In the next chapter, these results are distilled and rationalized into conclusions accounting for the higher education performance in and of the blended learning design.

Several references are considered as a foundation for a suitable statistical analysis method in this study. A thorough but accessible resource by Marusteri & Bacarea (2010) targeted at biomedical researchers, seems most suitable. Figure 6.1 depicts the relations of the fundamental structures in the statistical analysis for this study in a non-UML form.

The main structural scheme of the statistical analysis is the successive divisions of population (top "cloud" symbol) into data set (middle "cloud" symbol), followed by data set into traditional lecturing and blended learning groups (two bottom "cloud" symbols; their size disparity illustrates that the traditional lecturing group is approximately half the size of the blended learning group). Population refers to the larger collection of persons that the data set is intended to represent and towards whom the results of this study apply. (The population is identified in the next section.) Descriptive statistics concerning learning outcomes, prior experience, and learning approaches are drawn from the data set. Once the data set is divided into the two groups, the traditional lecturing group assumes the role of the known baseline or control against which the blended learning group is compared. Then, the blended learning group is analysed for benefits, detriments, and prediction. Other than in its capacity as the study's control, the traditional lecturing group is not analysed.

In accordance with the design-based research methodology, there is no hypothesis of the impact that blended learning exerts on the students. Accordingly, the analysis in this study is breath-wise, not depth-wise, covering all prospective permutations of inter-elements effects. (These are the elements specified in the learning model.) The intention is to identify those with significance in respect to learning at the higher education level, hence, the statistical analysis in this study is exploratory.

This chapter elaborates the following aspects of the exploratory statistical analysis activity:

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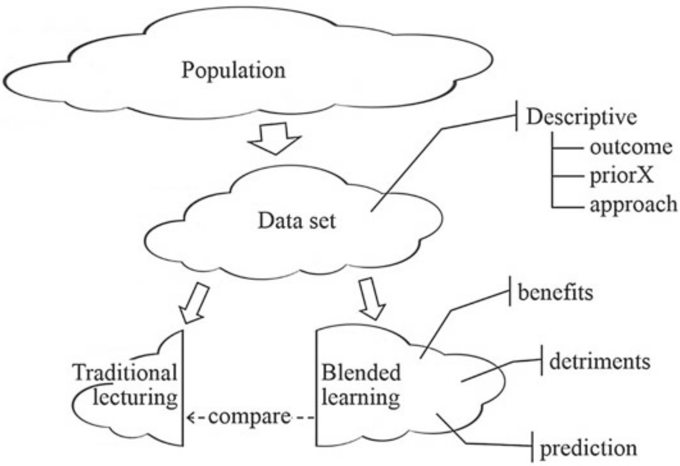


Fig. 6.1 Decomposition of the statistical analysis relations

1. Identification of the inferenced population;
2. Impact of prior learning variables (nationality and school affiliation) and learning approaches (attendance and leadership) on learning outcomes (marks);
3. Benefits, detriments, and predicting good performance in and of blended learning; and
4. Validation of findings via a congruity check of semester-on-semester blended learning marks data.

Overview of the Statistical Analysis

In facilitation of selecting and running the quintessential analytical tests, the research question of "what effect will a change of instructional design have on the academic performance of students enrolled therein, the change being from traditional lecturing to blended learning" is unpacked into these more-finely-grained questions consistent with a teacher's perspective:

- Question #1—do students exhibit higher academic performance in blended learning? Traditional lecturing is the benchmark against which the measure of "higher" is computed. "Students" can refer to all or some, so the issue is reframed to the majority of students experiencing higher academic performance. As noted in the two-tier composite model, marks are the accepted indicator of academic performance in the University;
- Question #2—do students exhibit lower academic performance in blended learning? Student achievement of learning outcomes is typically a normal distribution, so some students will be low achievers; this is not the substance of this question. Instead, the question asks if a coherent student group, such as those with

a similar prior experience or using the same learning approach, is hindered by the instructional design from achieving what they would have in traditional lecturing; and

- Question #3—can a student's predilection for higher academic performance in blended learning be predicted? Typically, past performance is employed as the predictor of the student's future performance. However, the blended learning in this study is a first-of-its-kind learning context in the University for which there is no past performance that can be relevant or useful. Therefore, another predictor to supplement prior experience for blended learning is deemed prudent and pragmatic. ILS is proposed as this supplementary predictor.

This section establishes the inferred population, considers inductive reasoning, identifies the dependent and independent variables, discusses the statistical analysis software, and summarizes the tests used in the analysis.

Population

The University is primarily a local institution providing opportunities for local higher education candidates plus international applicants, hence the majority of its students are from Singapore (SG). The distribution of SG versus international students in the School is depicted in Fig. 6.2. On average over ten semesters—not counting the special semester, 07ST, because it is not new recruitment but assignment students already enrolled in the University—the School has 61.8% SG and 38.2% international students.

Table 6.1 provides a detailed breakdown of the student intake by the School. The bulk of the intake is from Southeast Asia with the inclusion of a few countries from South Central Asia (namely India, Kazakhstan, and Sri Lanka) and East Asia (namely China and Hong Kong). The intake of exchange students from outside of Asia is so miniscule, 0.93%, that it doesn't dilute the Asian predominance in the data set. In other words, the statistically inferred population for this study is fundamentally exclusive of university-eligible youth outside of Asia.

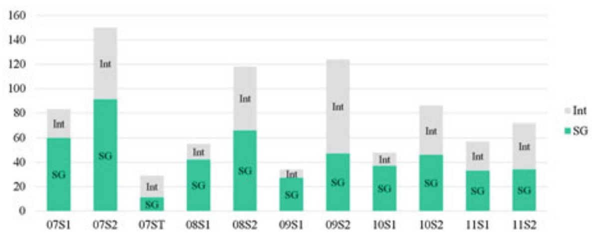


Fig. 6.2 Distribution of SG versus international students in the School by semester

Table 6.1 Proportions of nationalities represented in data set

Region	Sampled countries	Percentage	
		By region (%)	In data set (%)
Southeast Asia	Burma	0.33	0.23
	Indonesia	4.93	3.50
	Laos	0.16	0.12
	Malaysia	5.10	3.62
	Singapore	75.99	53.97
	SG Permanent Resident	5.26	3.74
	Thailand	0.16	0.12
	Vietnam	8.06	5.72
100.00%			**71.03**
South Central Asia	India	87.07	11.80
	Kazakhstan	11.21	1.52
	Sri Lanka	1.72	0.23
100.00%			**13.55**
East Asia	China	99.19	14.37
	Hong Kong	0.81	0.12
100.00%			**14.49**
International exchange	Canada	25.00	0.23
	Finland	12.50	0.12
	France	25.00	0.23
	Sweden	12.50	0.12
	United States of America	25.00	0.23
100.00%			**0.93**

Notes: (1) Frequency of students is delineated in Table 5.2
(2) Regional organization is as per Clifton and Hervish (2013)

The data set contains students from two degree programs, CE and CM (explained in the previous chapter). In the case of the CE, it is presumed that the recruitment of students into the School closely follows the norms established by the University. That along with the Software Engineering course being core,[1] attests that within the University this segment—827 in number—of students making up the data set is learning-wise random.[2] The loading of the CM students is considered less random, since they choose to take the program, and they are expected to be in the higher

[1]This is a course that all students in the CE degree program must complete within a contiguous period not exceeding seven years, otherwise their eligibility for the degree program is nullified.

[2]This kind of randomness means no bias to better learning performance, and that they exhibit a 'normal distribution' of marks as expected by teachers in University (see Chap. 5).

percentiles of learning performance in their own schools.[3] Fortunately, this segment is only 29 strong (3.4% of the entire sample), thus not sufficient to skew the overall results of the testing. However, it is 52.7% of the school affiliation variable, and this may distort its testing results.

It is reasonable to presume that all other schools in the University have proportions of SG and international students similar to that of the School. Therefore, the statistically inferred population for the study is the University, i.e., the findings of this study apply to the University population that in the period 2008–2011 was 21,687–23,698, or on average 22,700 (Nanyang Technological University, 2012).

Inductive Reasoning

Statistical analysis testing belongs to the scientific process of inductive reasoning where specific and consistent instances or observations are premises used to construct generalizations of some epistemological classification.

> Inductive reasoning, to be correct, must satisfy certain statistical principles. Concepts should be discerned and applied with more confidence when they apply to a narrow range of clearly defined objects than when they apply to a broad range of diverse and loosely defined objects that can be confused with objects to which the concept does not apply. Generalizations should be more confident when they are based on a larger number of instances, when the instances are an unbiased sample, and when the instances in question concern events of low variability rather than high variability. Predictions should be more confident when there is high correlation between the dimensions for which information is available and the dimensions about which the prediction is made, and, failing such a correlation, predictions should rely on the base rate or prior distribution for the events to be predicted. (Nisbett, Krantz, Jepson, & Kunda, 1983, p. 339).

These principles are strictly adhered to in this study. Concepts in the data set such as attendance, marks, nationality, school affiliation, team leadership, and traditional lecturing are fundamentally clear and tenable for all the test subjects. ILS and blended learning being not familiar are summarily introduced in the first week and continuously scaffolded throughout the remainder of the semester. The data set contains 856 observations, which is substantial enough, and the constituent values of all variables except nationality have frequencies greater than or equal to 30. It is only in respect to the third principle that this study's adherence is tenuous with just five dimensions, three for learning approach and two for prior experience. Furthermore, there are no prior distributions nor data sets for blended learning studies targeting Asia higher education students; this is truly inceptive research. Nonetheless, the author has a high degree of confidence that the application of inductive reasoning in this study is not adversely affected by this tenuousness.

[3]It is the author's considered opinion that lower performing students would not be able or willing to undertake the additional work load of the CM degree program.

Dependent and Independent Variables

In review, learning outcome is dependent on prior experience and learning approach, where learning outcome maps to marks, prior experience maps to nationality and school affiliation, and learning approach maps to attendance, team leader, and ILS (recall Table 5.6). The variable relations for the statistical analysis are as follows:

- Dependent variable is Mark (outcome); and
- Independent variables are InstructionalDesign (this is learning context in the learning model (Fig. 4.1)), Nationality and SchoolAffiliation (both are PriorExperience in the learning model), Attendance, TeamLeader, and LearningStyle (all three are LearningApproach in the learning model).

Figure 6.3 models the relations between the dependent variable and the independent variables in UML specification form. The unfilled diamond symbol in the top half of the diagram is an annotation to the associations (solid lines) that indicates the independent variables collectively associate with the dependent variable, similar to the concept of a signal splitter. The dot in the bottom of the diagram is a "hub" for the dependencies. The directions of the associations and dependencies are noteworthy as follows.

- Associations are all one-way from the independent variables to the dependent variable;
- The two PriorExperience variables are not dependent on any other variable. This is shown with the one-way and "X" symbol;

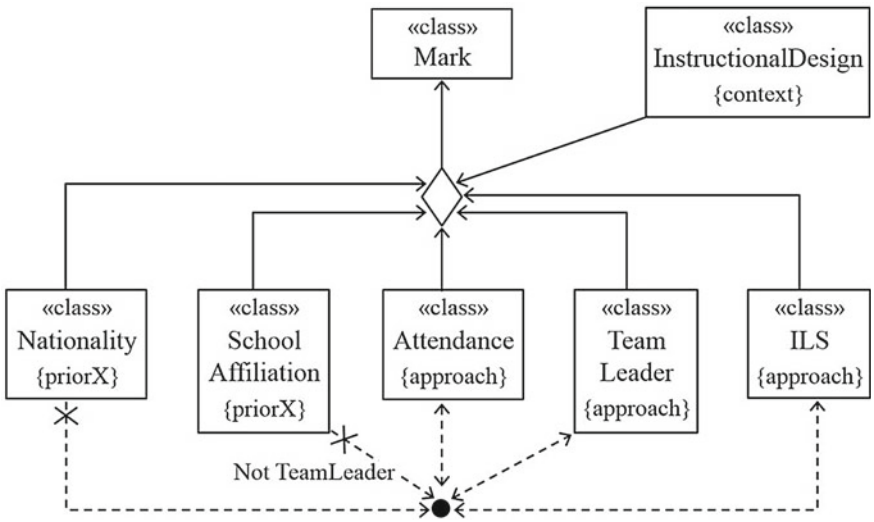


Fig. 6.3 Relation of dependent and independent variables (UML Class diagram)

- LearningApproach Classes may be inter-dependent on PriorExperience and other approaches, hence the two-way dependencies; and
- SchoolAffiliation cannot impact TeamLeader; this will be explained in the descriptive statistics section.

Statistical Software

The software for conducting the statistical analysis tests of the data and rendering the detailed histograms is StataCorp's Stata. The software for rendering simple column charts, and ILS reports is Microsoft Office 2010 Excel and Powerpoint respectively. The charts and slides are exported into image files with Microsoft Windows 10 Snipping Tool.

The University provides IBM's SPSS and MathWorks' Matlab products under licence to teachers and students. However, these software exceeded the requirement of this study's analysis; a general purpose, user-friendly software seemed more suitable. Hence, Stata is used as it is quick-to-learn and well-supported by effective documentation, with an easy-to-use interface and graphics package ideal for the analysis. As not all statistical analysis software is reliable (Keeling & Pavur, 2007), Stat's credentials and market performance were investigated. It is confirmed that Stata is widely recognized as a mainstay in the statistic software market (Muenchen, 2012) as well as a top-choice by several ranking universities such as UCLA and Stanford.

The Microsoft software, particularly Excel and Powerpoint, is reliable, fast, and well-suited for elementary statistics analysis and graphics/modeling work.

Synopsis of Tests and Significance Level

Table 6.2 identifies the 1874 statistical tests conducted in this study in order to develop a deep understanding of the data set and to carry out the analysis in accordance with its goals.

The high quantity of statistical tests are a result partially of the number of kinds of marks (six), attendance (four), and nationality (18), and a side effect of the new derived data for the ILS band scores. Additionally, the volume of linear regression testing is necessary to decipher the predictive pattern of the ILS variables because of the uncovered inconsistencies in the test results when multiple independent variables are involved. This is elaborated in the next section.

In review, the purpose of statistical analysis is to determine if the results of an experiment conducted on a sample are sufficiently true to apply to the population stated in the statistical inference. In the experiment, an extrinsic or intrinsic variable is changed for a group of test subjects and observations are taken of any consequent effect. The position that there will be no effect is called the null hypothesis H_0, and

Table 6.2 Synopsis of statistical tests conducted

Test	Brief description of function	Freq
describe	list observations, variables, datatypes, and labels in data set	1
tabulate	list values w/their frequency & percentage of occurrence in column	56
summarize	calculate mean, min and max value for each variable in data set	45
count	calculate frequency and percentage in data set	768
tab w/sum	calculate mean, frequency, and std dev for each value in column	176
t-test (two-tailed)	calculate significance of deviation at both critical regions between two independent normal distributions (parametric)	257
Wilcoxon (Mann-Whitney)	calculate significance of deviation of not-normal distributions (non-parametric)	112
correlation (pairwise)	calculate association between two variables	8
regression	determines model of independent variables affecting dependent variable	451

the contrary position that there will be an effect is called the alternate hypothesis H_1 or H_A. The possibility that a sampling bias might introduce the illusion of an effect is reduced by enlarging the sample size and carrying out a random selection of the sample. The *p*-value is the calculated probability of finding the observed or more extreme effect—where the definition of 'extreme' depends on how the variance in values is measured—when H_0 is presumed to be true. In other words, the lower the *p*-value, the less likely H_0 is true. The significance level, alpha or α, is the threshold assigned to the *p*-value lower than which H_0 is rejected. The assignment of α is crucial: too large generates a Type I error (false rejection of H_0) and too small a type II error (false acceptance of H_0). The α is assigned at the judgment of the researcher before the testing commences. The default value of α in most statistical software applications is 0.05[4] (Cowles & Davis, 1982) manifesting a one-in-20 chance of making a type I error.

For this study, the:

- sample is 856 observations in the data set modelled in Chap. 5;
- statistical inferred population for which the study applies is the on average 22,700 undergraduates in the University;

[4]Cowles and Davis (1982) provides an excellent explanation of how and why $\alpha = 0.05$ emerged and became mainstream. Its 213 citations by Google Scholar count is an under-valuation of the paper's true worth. It is strongly recommended as introductory reading for any statistical analysis course, especially those at the University.

Table 6.3 Frequency of students by instructional design

Student	Freq	%
In traditional lecturing	262	30.61
In blended learning	594	69.39

- high-level H_0 is "blended learning instructional design is no more effective in higher education student's learning than traditional lecturing". This will be altered in accordance with the more-finely-grained research questions in the next sections; and
- α is assigned the value of 0.05.

Descriptive Statistics for Data Set

The descriptive statistics for the data set are presented in the following order of variables:

1. Instructional design;
2. Marks;
3. Nationality and school affiliation;
4. Attendance and team leader; and
5. Learning style.

All the statistical analysis tests conducted in descriptive statistics are 'count', 'summarize', 't-test', and Wilcoxon (Mann-Whitney).

Instructional Design

The InstructionalDesign (derived) variable maps to InstructionalDesign element of the learning model (recall Table 5.6). The division of the data set into traditional lecturing and blended learning, the two contrasting instructional designs is the most important of all groupings in this study, so it is crucial that the frequency of students be high for both; however, they need not be equal. The distribution of the 856 observations is depicted in Table 6.3: approximately two-thirds are associated with blended learning and one-third with traditional lecturing, which is a near ideal distribution.

Marks

There are six kinds of marks, all mapping to the learning outcome element of the learning model (recall Table 5.6). This section focuses on the University-proprietary marks (coursework, exam, final); when presented together in either an image or table, they are referred to as "CEF". When the teacher-proprietary marks (quiz, active learning, project) are presented together in either an image or table, they are referred to as "QAP".

The CEF values are listed in Appendix D in Tables D1 (for coursework), D2 (for examination), and D3 (final) to provide an appreciation of the data. The sum of value frequencies in each table is 856, confirming that every student has his/her compliment of marks. The sequence and density of the values' frequencies suggest that each mark's data follows a normal distribution. This is confirmed by the histograms fitted with the corresponding normal curves—Figures D1 (for coursework), D2 (for examination), and D3 (for final)—following the tables in the Appendix.

Contrasting the coursework and examination data raises several noteworthy discussion points. But, the final mark data is excluded because it is a weighted average of coursework and examination that advances nothing new to the discussion.

From Fig. 6.4—an overlay of Figures D1 and D2 into a single chart—the coursework's mean and 'density at its mean' are clearly higher than those of examination, indicating that in a coursework activity, a student tends to achieve a better learning outcome and there is less variance in achievement between he/she and fellow student. In both distributions, the upper and lower critical regions break the symmetry of the "bell" curves. The upper critical region in both distributions truncates at the mid-80s, thus leaving a gap between the curve and the X-axis. The lower critical region of the coursework distribution trails off with a very low but non-zero density to eventually terminate just prior to 0; this indicates that the few students that fail do so in unique circumstances of their own choosing. In other words, it is not a shared categorical failure. The lower critical region of the exam distribution terminates at 20 (earlier than coursework), but then exhibits a significant spike at 0, indicating that several students received a categorical failure. (The reason for this, being absent from the examination without approval, is confirmed in the attendance section.)

Table 6.4 presents a detailed accounting of the fit of the coursework and examination data to the mark-ranges established by the teacher for Bloom's cognitive outcomes (recall Table 5.6). In review, the teacher endeavours to have his students

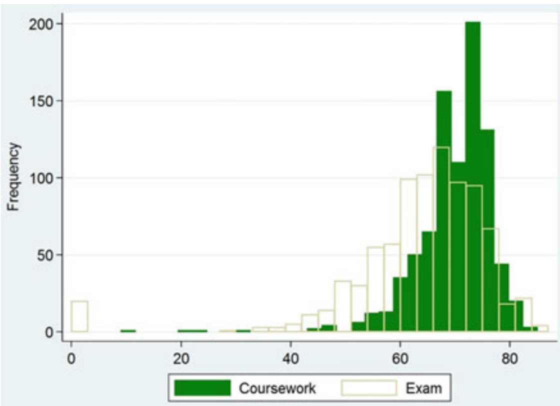


Fig. 6.4 Overlay of coursework and examination mark histograms

Table 6.4 Frequency of final marks per cognitive outcomes' mark ranges

Mark	100–85	84–80	79–75	74–70	69–60	59–50	49–0	
Coursework	1	22	175	311	300	37	10	Freq
	0.12	2.57	20.44	36.33	35.05	4.32	1.17	%
Exam	4	26	81	160	353	156	76	Freq
	0.47	3.04	9.46	18.69	41.24	18.22	8.88	%

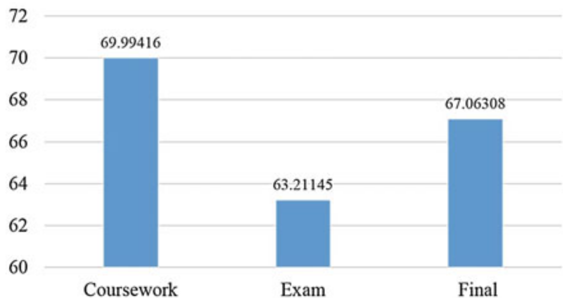


Fig. 6.5 Comparison of CEF marks

majorly achieve the 'applying' (74–70) outcome. This is clearly met in coursework data, but falls short for examination with a 41.2% frequency density in the 'understanding' (69–60) outcome, i.e., the largest concentration in any mark-range. Also, using Bloom's taxonomy suitably diminishes the perception of the achievement variance or spread portrayed in the histograms. For example, in the marks-range 74–50—allegorically "good-to-acceptable" learning—coursework has 76% of its frequency density while examination has 78%; the density difference is negligible. Fortuitously, that remaining emphatically highlights the distinctions in the higher and lower categories, such as examination failures (7% higher than those in coursework) and achievement of higher-order learning outcomes (10% more in coursework than in examination[5]).

The calculated means for the coursework and examination data are consistent with the coursework just reaching the lower bound of 'applying' outcome, and the examination resigned to the lower half of the 'understanding' outcome (Fig. 6.5).

To determine if the difference between the coursework and examination means is significant, a t-test is conducted on the equation "mean(diff) = mean(coursework −

[5]This discussion elucidates with the long-standing strategy practiced by teachers in the School to use the higher marks in coursework to compensate for the expected lower marks in examination. Since there are only these two inputs into the final mark, the degree of compensation is fine-tuned by weighting them. Courses have their own chosen or assigned weighting scheme. For the Software Engineering course, coursework is weighted as 60% and examination as 40%.

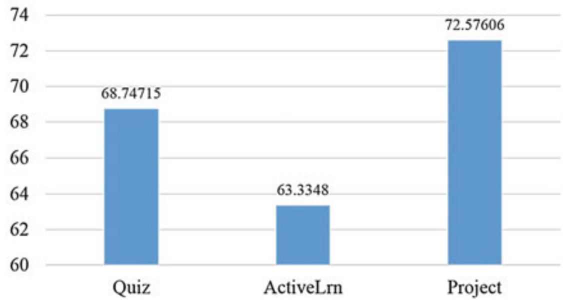


Fig. 6.6 Comparison of QAP marks

examination)", where H_0 is mean(diff) = 0. Since the t-test is two-tailed, it calculates three *p*-values, one for each of the following conditions:

mean(diff) < 0, i.e., coursework's mean is smaller than examination's
mean(diff) ! = 0, i.e., coursework's mean is not equal to examination's
mean(diff) > 0, i.e., coursework's mean is larger than examination's

If the *p*-value for any result is below the threshold $\alpha = 0.05$, then H_0 is rejected, and the particular condition for that *p*-value {<0, !0, >0} is the H_A that is accepted. The result of this t-test is "*p*-value = 0.0000" for diff(mean) > 0, ergo the H_A that the coursework's mean is significantly greater than the examination's mean is accepted.

The project component is designed to challenge the student's ability to apply his/her new knowledge with the support of a team, and clearly the goal of the students 'applying' that knowledge is achieved. In Fig. 6.6, the project mean mark is the highest of the three components of coursework.

Nationality and School Affiliation

Nationality and SchoolAffiliation variables map to the PriorExperience element of the learning model (recall Table 5.6). Eighteen nationalities are represented in the data set (Table 6.1), but many have a very low frequency of member students. Only the following seven nationalities (shown in their ISO 3166-1 code form) have a frequency ≥30 that is reasonably commensurate with the inductive reasoning second principle.

$$\{\text{CN, ID, IN, MY, SG, SG PR, VN}\}$$

When referenced collectively, this group of seven nationalities is designated "N7". The number of students belonging to N7 is 828 or 96.73% of the total observations. Table 6.5 shows a detailed breakdown of the frequencies and percentages—against the cohorts' sizes given in Table 5.3—for each of the N7 members across all 11 semesters.

Table 6.5 Frequency of students in N7 by semester

Semester	CN	ID	IN	MY	SG	SG PR	VN	
07S1	14	2	0	2	54	6	3	Freq
	16.87	2.41	0	2.41	65.06	7.23	3.61	%
07S2	18	9	18	7	84	7	6	Freq
	12.00	6.00	12.00	4.67	56.00	4.67	4.00	%
07ST	1	7	0	10	11	0	0	Freq
	3.45	24.14	0	34.48	37.93	0	0	%
08S1	8	2	0	0	42	0	1	Freq
	14.55	3.64	0	0	76.36	0	1.82	%
08S2	24	3	12	2	63	3	9	Freq
	20.34	2.54	10.17	1.69	53.39	2.54	7.63	%
09S1	2	0	2	0	24	3	3	Freq
	5.88	0	5.88	0	70.59	8.82	8.82	%
09S2	23	4	27	4	47	0	8	Freq
	18.55	3.23	21.77	3.23	37.90	0	6.45	%
10S1	4	0	2	1	33	4	2	Freq
	8.33	0	4.17	2.08	68.75	8.33	4.17	%
10S2	12	0	15	4	43	3	6	Freq
	13.95	0	17.44	4.65	50.00	3.49	6.98	%
11S1	8	3	0	1	31	2	10	Freq
	14.04	5.26	0	1.75	54.39	3.51	17.54	%
11S2	9	0	25	0	30	4	1	Freq
	12.50	0	34.72	0	41.67	5.56	1.39	%

The most (all seven) nationalities are represented in semesters {07S2, 08S2}, and the least (four) are represented in semesters {07ST, 08S1}. SG constitutes the largest proportion of students in every semester. However, national representation in the remaining proportions fluctuates substantially, with {CN, ID} being the second largest proportion the most times (five and three respectively), and {MY, VN} being the smallest non-zero proportion the most times (four and three respectively).

After classification according to instructional design (Table 6.9a, 6.9b), the frequency of students in both subgroups for {ID, MY, SG PR} and in one subgroup for {IN, VN} drops to less than 30. The percentage is calculated against the appropriate observation subtotal of instructional design in Table 6.3. Consequently, the risk of type I or II errors for these subgroups increases (Table 6.6).

The second prior experience variable, SchoolAffiliation, has a frequency of students (Table 6.7) greater than these four members {ID, MY, SG PR, VN} of N7.

The distribution of 'not School' students across the 11 semesters (Fig. 6.7) is fairly consistent except for semesters {07ST, 09S2}. The 07ST spike is the CM degree program class comprising entirely non-School students registered in 13 cohorts of other engineering, science, and business degree programs (recall Table 5.1). The 09S2 spike is the influx of KZ students recruited under a special two-year exchange program.

Table 6.6 Frequency of students in N7 by instructional design

InstrDsgn	CN	ID	IN	MY	SG	SG PR	VN	
Trad	33	18	18	19	149	13	9	Freq
	12.60	6.87	6.87	7.25	56.87	4.96	3.44	%
Bl	90	12	83	12	313	19	40	Freq
	15.15	2.02	13.97	2.02	52.69	3.20	6.73	%

Table 6.7 Frequency of students by school affiliation

SchoolAffiliation	Freq	%
School	801	93.57
'Not school'	55	6.43

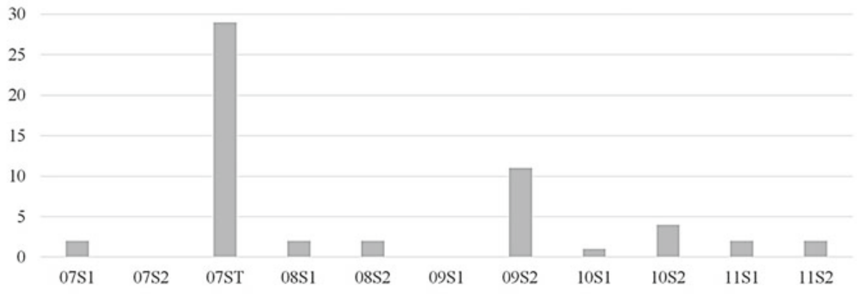


Fig. 6.7 Distribution of 'not School' by semester

Table 6.8 Frequency of 'Not School' by instructional design

'Not School'	Freq	%
In traditional lecturing	31	56.36
In blended learning	24	43.64

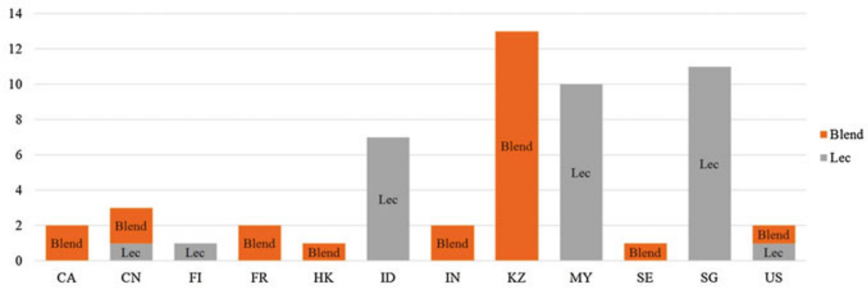


Fig. 6.8 Distribution of 'not School' by nationality and instructional design

After classification according to instructional design (Table 6.8), the 'non-School' student frequency drops to less than 30 in one subgroup. Here too, the risk of type I or II errors for these subgroups increases.

Figure 6.8 shows a moderate and even nationality diversity, {ID, MY, SG}, of 'not School' students in traditional lecturing, in contrast to the singular concentration of KZ in blended learning.

Attendance and Team Leader

Attendance and TeamLeader variables map to the Relational ⇨ LearningApproach (root) element of the learning model (recall Table 5.6). There are four kinds of attendance data, but the F2F attendance data, being an unweighted average of lecture and tutorial, is ignored when it has nothing more to add to the discussion. Thus, the appreciation of the attendance values in Appendix E is limited to lecture (Table E1), tutorial (Table E2), and examination (Table E3). When the lecture, tutorial, and exam attendance are presented together in either an image or table, they are referred to as "LTE".

The sum of value frequencies in each table is 856, confirming that no student is missing attendance data. The sequence and density of the lecture and tutorial values' frequencies suggest an exponential function distribution—without the negative X-axis values—and not a normal distribution. This is confirmed by the histograms, Figures E1 (for lecture), E2 (for tutorial), and E3 (for examination) that follow the tables in the tables in the Appendix. Since the data is matching, non-parametric tests are most appropriate for analysing the attendance data.

When compared as if they are unmatching data, lecture and tutorial attendance distributions appear nearly identical. This is evidenced when the histogram of one is overlaid on the other as in Fig. 6.9, and in a column chart of their means as in Fig. 6.10. However, the data is in actuality matching, so "H_0 lec = tut" is analysed using a Wilcoxon signed-rank test for matching non-parametric data. The test revealed that the difference, though it is quantitatively small (lecture attendance is approximately 4% higher than tutorial), is statistically significant notwithstanding.

Figure 6.11 shows the distribution of F2F and exam attendance levels across the 11 semesters. F2F attendance shows a sharp increase from the first two semesters to the third up to the sixth semesters, and subsequently settling into levels oscillating in the range of 85–95%, Contrasting the low F2F attendance in {07S1, 07S2} with the much higher attendance in 07ST markedly establishes the problem with students belonging to the School alluded to in the preface. It is a definite breakthrough to have School students attending at the higher levels in 08S1 onwards. The exam attendance across the 11 semesters is consistently hovering around the 95% level.

In the University, the only formal learning session with mandatory attendance is the examination; being absent is an automatic failure of the course. Attendance in the lab is recorded by the lab technicians, but absenteeism only results in a lower

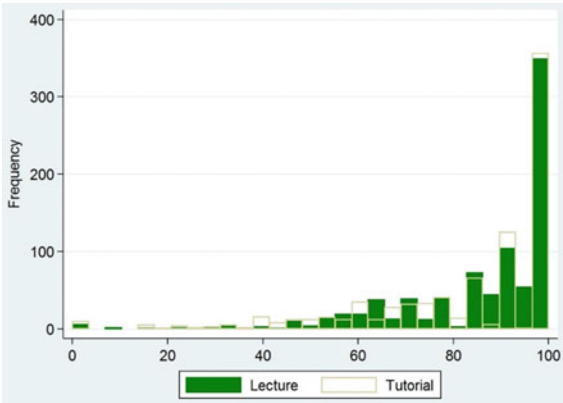


Fig. 6.9 Overlay of lecture and tutorial attendance histograms

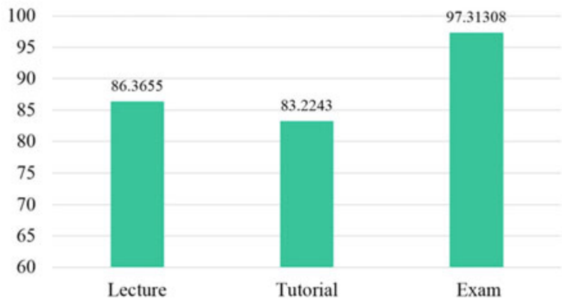


Fig. 6.10 Comparison of LTE attendance

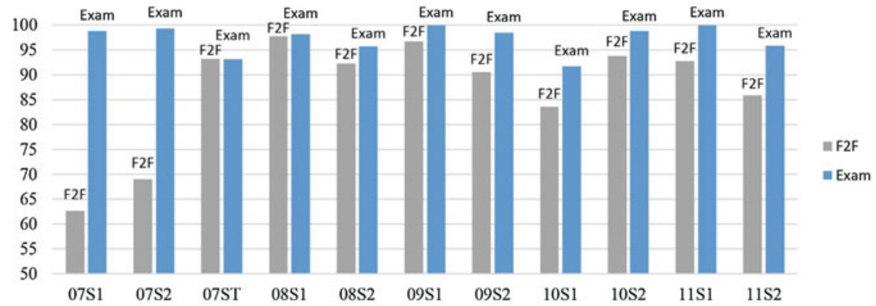


Fig. 6.11 Comparison of F2F and exam attendance by semester

Table 6.9a Means of LTE attendance for N7

Nationality	Freq	Lecture	Tutorial	Exam
China	123	84.672439	81.096341	94.308943
India	101	78.672871	77.45396	94.059406
Indonesia	30	90.628333	81.225667	100
Malaysia	31	79.790322	79.675806	100
Singapore	462	89.189718	85.347056	98.917749
Singapore PR	32	85.694375	78.17	100
Vietnam	49	83.322653	84.506123	97.959184

Table 6.9b N7 sorted in descending order of F2F attendance

Nationality	F2F
Singapore	87.287229
Indonesia	85.926667
Vietnam	83.920408
China	82.895122
Singapore PR	81.937501
Malaysia	79.735484
India	78.068317

project mark, not a failure of the course. Attendance for lectures and tutorials may be determined with educational technology such as audience response devices. Finally, the lecture periods are recorded and the videos published on the University learning resources distribution network. So, choosing to attend strongly suggests that the student perceives the F2F learning session as a deep learning opportunity. And, if

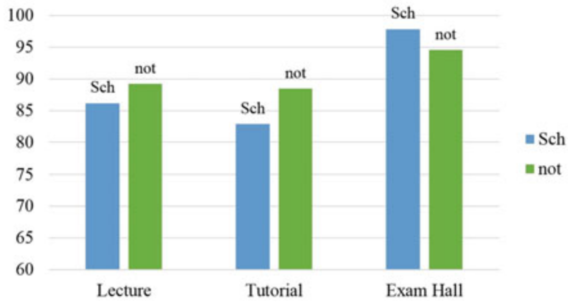


Fig. 6.12 Comparison of LTE attendance by school affiliation

the session conduct is concordant with that expectation, then attendance is rightfully categorized as a deep learning approach.

Tables 6.9a, 6.9b show the attendance norms of the students for each of the N7 members, with two noteworthy highlights.

- In F2F sessions, SG students are the highest attending, and IN students are the lowest; and
- In examination, {ID, MY, SG PR} are the highest attending, and {CN, IN} are lowest.

As alluded to in the preface, it is the majority view of teachers in the School that attendance in F2F learning sessions by students in the School is observably lower than by students in other schools. The data supports that view, though not to the extent observed by the teachers in the School (Fig. 6.12). Only the tutorial difference of 5.6 is statistically significant (p-value = 0.0294).

One hundred percent attendance traces to 13 lectures and 11 tutorials per semester, so the attendance differences in Tables 6.9b and Fig. 6.11 equate to periods as follows:

- Up to 7.7 is one lecture period, and to 15.4 is two lecture periods; and
- Up to 9.1 is one tutorial period, and to 18.2 is two tutorial periods.

The second learning approach variable, TeamLeader (Table 6.10), also has a healthy frequency of students.

Figure 6.13 highlights three notable characteristics of the leadership data. Firstly, there are zero team leaders in semester 07ST, the CM class, because the teams for their project are small—pairs or threes—and independent. With no need for team leaders, none were authorized. Contrast this with the Public Bus Simulator Software project assigned to the CE cohorts. The project is developed by large teams—up to 12 members—that are obliged to cooperate in order to accomplish the design,

Table 6.10 Frequency of students by leadership

Teamleader	Freq	%
'Not leader'	749	87.5
Leader	107	12.5

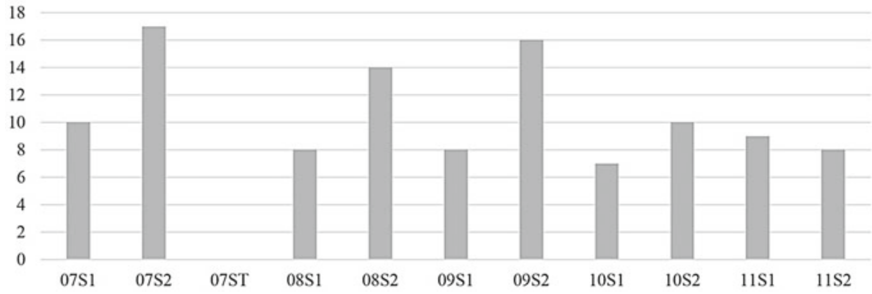


Fig. 6.13 Distribution of leadership by semester

Table 6.11 Frequency of leadership by instructional design

Teamleader	Freq	%
In traditional lecturing	27	25.23
In blended learning	80	74.77

coding, integration, and demonstration of the software. For a task of this scale and complexity, project leaders are a necessity. Secondly, the S2 semesters required more team leaders because they had a larger student registration than the S1 semesters. The only exception is semester 11S2 that is slightly smaller than semester 11S1. The final characteristic is the downward trend of the team leader frequency across the 11 semesters. This originates with the inception of the computer science degree program that diverts recruited students away from CE; with the decrease in the CE cohort size, less team leaders are needed.

Finally, the division of the team leaders group according to instructional design (Table 6.11) renders one subgroup that is less than 30. Consequently, the risk of type I or II errors for this subgroup is also increased.

Of the 107 team leaders, 104 come from N7 members. The three not from N7 comprise one US (who is a leader in traditional lecturing) and two CA (who are leaders in blended learning); these three are also ‘not School’ students. One CN student in blended learning is also ‘not School’. Table 6.12 shows a detailed breakdown of the frequencies and percentages within each semester of the 104 leaders from the N7 members. SG contributes the greatest share of leaders for every semester’s project, while MY contributes the least (only one leader in semester 10S1).

Figure 6.14 shows that attendance for leaders appears nearly identical to all other students. Wilcoxon tests indicate that the differences, if any, in all categories of attendance are insignificant. This suggests that the student’s choice of attendance as a learning approach is entirely independent of leadership, and that some students choose both. This is consistent with the learning model which places no limit on the quantity of learning approaches that a student may employ to achieve his/her desired learning outcome.

Table 6.12 Frequency of leadership for N7 by semester

Semester	CN	ID	IN	MY	SG	SG PR	VN	
07S1	3	0	0	0	4	1	1	Freq
	30	0	0	0	40	10	10	%
07S2	1	0	6	0	9	0	1	Freq
	5.8824	0	35.294	0	52.941	0	5.8824	%
07ST								Freq
								%
08S1	2	2	0	0	4	0	0	Freq
	25	25	0	0	50	0	0	%
08S2	2	1	2	0	6	1	2	Freq
	14.286	7.1429	14.286	0	42.857	7.1429	14.286	%
09S1	1	0	2	0	3	2	0	Freq
	12.5	0	25	0	37.5	25	0	%
09S2	3	0	5	0	6	0	0	Freq
	18.75	0	31.25	0	37.5	0	0	%
10S1	0	0	0	1	5	0	1	Freq
	0	0	0	14.286	71.429	0	14.286	%
10S2	3	0	2	0	4	0	1	Freq
	30	0	20	0	40	0	10	%
11S1	2	2	0	0	3	0	2	Freq
	22.222	22.222	0	0	33.333	0	22.222	%
11S2	2	0	2	0	2	1	1	Freq
	25	0	25	0	25	12.5	12.5	%
Total %	17.76	4.67	17.76	0.93	42.99	4.67	8.41	

Learning Style

The five LearningStyle variables map to the LearningStyle ⇨ LearningApproach (root) element of the learning model (recall Table 5.6). In review, learning styles is an array of preferred approaches that the student instinctively enacts and follows

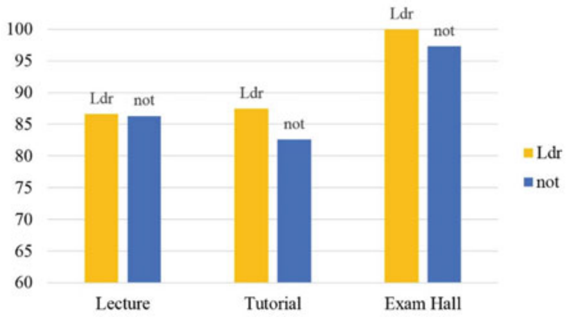


Fig. 6.14 Comparison of LTE attendance by leadership

whenever he/she is involved in a learning situation. Learning style is not a conscious impetus to initiate or advance learning—in other words, it is not synonymous with developmentalism—or a set of learning heuristics, but a subconscious cognitive and behavioural response to a learning activity already in action. The learning style model applied in this study (Felder & Silverman, 1988) has eight distinct cognitive responses arranged into four pairs of inverse-proportional responses:

- Band one: ACT/'active' ⇔ REF/'reflective'—collaboration and participation versus solitary deliberation;
- Band two: SEN/'sensing' ⇔ INT/'intuitive'—accumulation of facts concerning what a phenomena is versus derivation of causal factors or rationale of why the phenomena occurs;
- Band three: VIS/'visual' ⇔ VRB/'verbal'—pictures versus words; and
- Band four: SEQ/'sequential' ⇔ GLO/'global'—contiguous and ordered progression through an activity or resource versus a non-contiguous and ad hoc compilation of the big picture.

This study employs a unique re-design of the Felder and Soloman (1999) ILS report that resolves the deficiencies of the original format in depicting many ILS scores in one report. Appendix F provides a full explanation of the evolution of the new design. Appendix G provides a repository containing the individual ILS reports for semesters, nationality, high-achievers, 'not school', leader, and prediction mechanism correlations.

In designing the blended learning course, the teacher set an ILS profile (Fig. 6.15) to act as a guideline for him to promote deep learning approaches for the students in the blended learning:

- A balance of 'active' and 'reflective' responses, though with a slight emphasis on the former;
- A balance of 'sensing' and 'intuitive' responses, though with a slight emphasis on the latter;
- Moderate emphasis on 'visual' responses (graphs are crucial part of the course); and

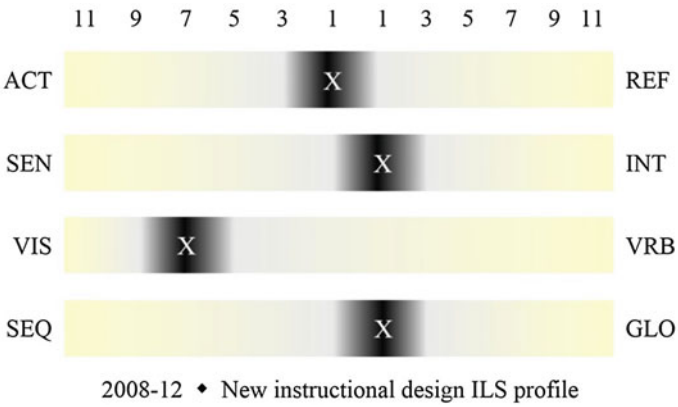


Fig. 6.15 Deep learning ILS report for blended learning

- A balance of 'sequential' and 'global' responses, though with a slight emphasis on the latter.

The contrast curve—this concept is explained in Appendix F, and displayed in Figures F10-11—for this ILS report is designated the 'deep learning curve'.

Figure 6.16 models the ILS report for the data set that represents the statistically inferred population of the University. This ILS report suggests a learning approach exhibiting the following traits.

- There are times when they are learning actively and other times when they are reflective. They will participate in teams, but will also retreat into a personal space for 'quiet alone time';
- To build an adequate picture of the course knowledge, they accumulate facts and harvest examples of applications. They are not interested in the connections

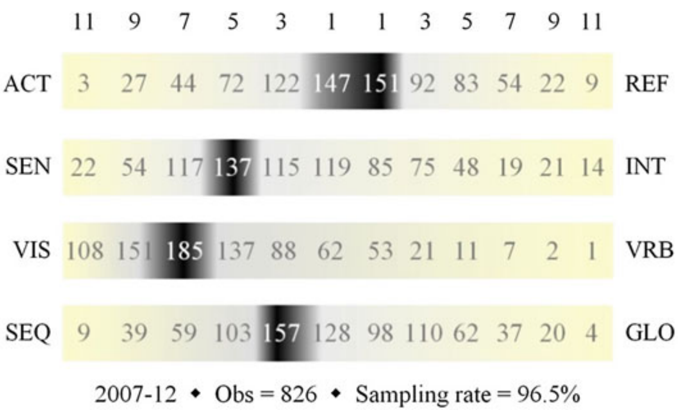


Fig. 6.16 ILS report for the University

between facts and examples or their causality; instead, they believe learning is an aggregation exercise followed by memorization;

- They are drawn strongly to pictorial representations of information. They read minimally if at all; they may buy the text book but sell it immediately after the course is over, and most probably in pristine, barely opened condition; and
- Learning of the course content is effective only if it is released in an accepted sequence. Also, the learning is a contiguous activity that cannot have breaks in any part of the sequence otherwise learning ceases until the broken part is eventually learned and released.

Figure 6.16 also highlights the occurrence of Type I ‘score matching within band’ in band one {ACT 1 = “147”, REF 1 = “151”}. In this case the score matching is not due to a small sample size; there are well greater than 100 observations. Instead, this means that the students’ active and reflective processing of their learning must be more of an internal duality than just a balance. Quite likely, these students can turn quite suddenly from being active to being reflective, such as being active one day and the next being reflective.

However, since it is a common trait of the University population, it is expected that this duality is well managed and understood within the population, and not a source of difficulty in their learning.

The contrast curve tracing the ILS report scores in Fig. 6.16 is designated the ‘University curve’ abridged to ‘Uni curve’.

A residual of the ‘score matching within band’ phenomenality is evident in only band one at {{ACT, 1}, {REF, 1}}; all other scores are substantial frequency spikes. It is expected that ILS reports pertaining to groups and subgroups that are divisions of the 826 observations will exhibit more of this phenomenality.

There are 826 observations of ILS reports for 856 students in the data set, meaning that 30 students did not submit an ILS report to the teacher; ergo, the response rate is less than 100. In Fig. 6.17, it is evident that the rate was low in 2007–08 and quickly climbed, plateaued, and then dropped slightly in the final three semesters. 2007 is the first year that the teacher conducted the ILS survey, and discovered that the students required suitable motivation to be a participant. In the last semesters, the teacher

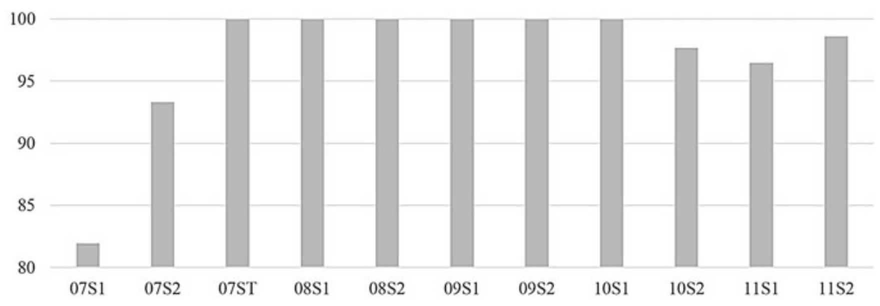


Fig. 6.17 Rate of ILS report submission by semester

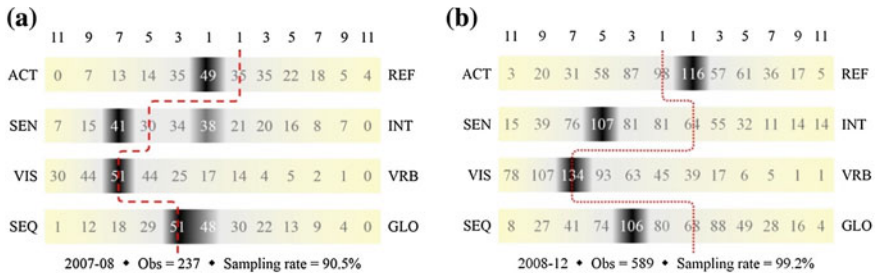


Fig. 6.18 **a** Traditional lecturing ILS report with the 'Uni curve', **b** Blended learning ILS report with the 'deep learning curve'

experimented with relaxing the motivation, and the submission rate declined, thus reinforced the notion that suitable motivation is a permanent necessity when assigning University students to partake in education-related surveys.

Figures 6.18a, b are ILS reports for the two contrasting instructional designs, traditional lecturing and blended learning. In other words, they are the merger of the ILS reports by semester in Appendix G: Figures G1-3 merge into Fig. 6.18a, and Figures G4-11 merge into Fig. 6.18b. Also, Figs. 6.18a, b are overlaid with different contrast curves, the 'Uni curve' in Fig. 6.18a, and the 'deep learning curve' in Fig. 6.18b. The reports for both instructional designs are identical in the strong 'visual' and 'sequential' scoring, while the band one and two scores in blended learning are shifted one-to-the-right. (The blended learning curve happens to be identical to the 'Uni curve', so the 'Uni curve' overlay on the traditional lecturing report highlights the right-shift in blended learning report.)

Close similarity between the students in each instructional design is expected since all originate from the same population, and ILS is considered to be a subconscious and not a deliberated response of a learner. However, the right-shift in the blended learning students suggests that a learner may be capable of consciously overriding (temporarily) or mutating (permanently) particular responses according to situational awareness that factors in the instructional design. Since traditional lecturing and blended learning evoke different learning approaches, it is reasonable that learning responses commensurate with traditional lecturing are partly overridden in the blended learning. In Fig. 6.18b, blended learning conforms to the 'deep learning curve' in band one and three, but not in band two and four. This indicates that the majority of students are not able to override their strong tendencies in 'sensing' and 'sequential' enough to match the prescribed deep learning.

Finally, while suitable as a summary, nevertheless Fig. 6.18a unintentionally suppresses a notable aspect of its source, Figures G1-3 in Appendix G. Interestingly, contrasting Figures G1-2 (for School students) with Figure G3 (for 'not School' students) reveals the differences in the learning styles of School versus 'not School' students alluded to in the preface. 'not School' students are much more 'reflective', and exhibit balances of 'sensing' and 'intuitive' and of 'sequential' and 'global'. In

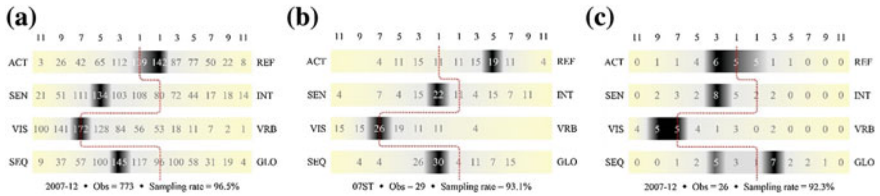


Fig. 6.19 **a** Students in the University and the school. **b** Students in the University and 'not school'. **c** Students not in the university

other words, they align more closely to the 'deep learning curve' than do School students.

Figures 6.19a, c present a three-way comparison of learning styles of students: from the University and School (in the CE program), from the University but 'not School' (in the CM program), and from other universities (in the exchange programs). All reports are overlaid with the deep learning contrast curve. The following ILS report differences are evidence in the figures.

- Students in the University but 'not School' are much more 'reflective', while those from other universities are more 'active';
- While School students have a strong reliance on facts and examples, 'not School' and exchange students exhibit much lower reliance on facts and examples;
- Strong visual response is prevalent to all students regardless of region, university, or school; and
- While the School students follow sequences of content and activities, 'not School' and exchange students approach the content and activities in an ad hoc manner and from a big-picture perspective.

In Appendix G Tables G12-18, the ILS reports for {SG, MY} are identical to the 'Uni curve', while {CN, SG PR} are nearly identical. {IN, ID} deviate from the 'Uni curve' in three bands, and VN in two. ILS reports for {ID, SG PR, VN} indicate stronger 'active' response. ILS reports for {CN, VN} indicate a stronger 'global' preference.

Figure 6.20 indicates that the University student who is a consistently high achiever in cognitive outcomes of 'analysing', 'evaluating', and 'creating' ($\geq$75 in their marks) follows learning approaches that are near identical to the 'deep learning curve' (balances of 'active' and 'reflective' as well as 'sequential' and 'global', plus a strong 'visual'). Yet he/she also deviates significantly from the deep learning in the heavy reliance on facts and examples. It is likely this is because there is still a significant promotion of lesser cognitive outcomes, particularly 'remembering' and 'understanding', in the assessment instruments.

Figure 6.21 depicts the ILS report for students that have 100% F2F attendance, and it too is nearly identical to the 'deep learning curve', except that it is stronger in 'sensing' and 'sequential'.

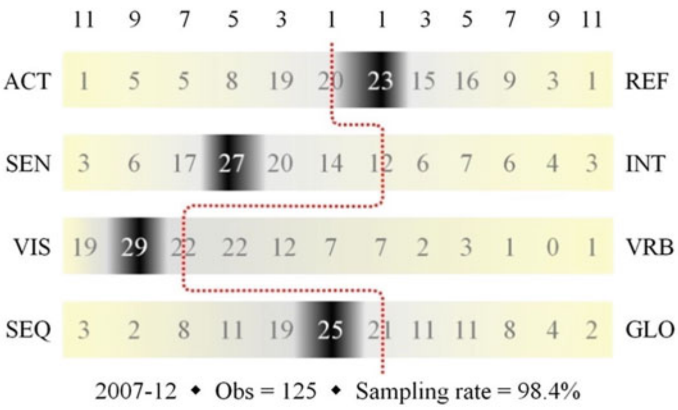


Fig. 6.20 ILS report for high-achieving University students

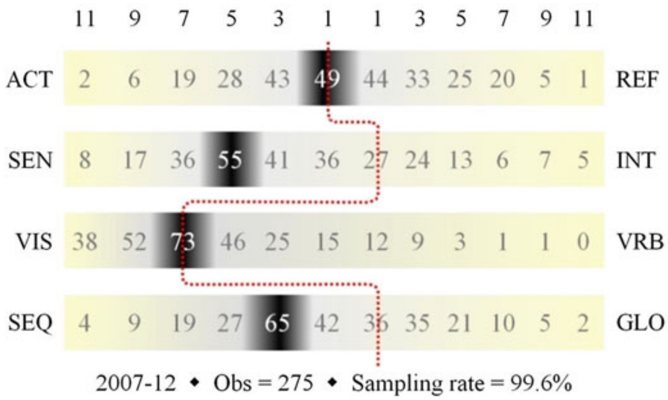


Fig. 6.21 ILS report for 100% attendance

Figure 6.22 depicts the ILS report for team leaders, and it too is nearly identical to the ‘deep learning curve’, except that it is slightly stronger in ‘active’ and ‘sensing’.

Impact of Prior Experience and Learning Approaches on Overall Learning Outcomes

This section explores the impact of the independent variables on the dependent variable for the statistically inferred University population that averages 22,700 undergraduates.

In review, the difference equation for H_0 in the t-tests is “diff = mean(var1) − mean(var2) = 0”, where var1-2 are the dichotomous values of {CN, ID, IN, …, VN},

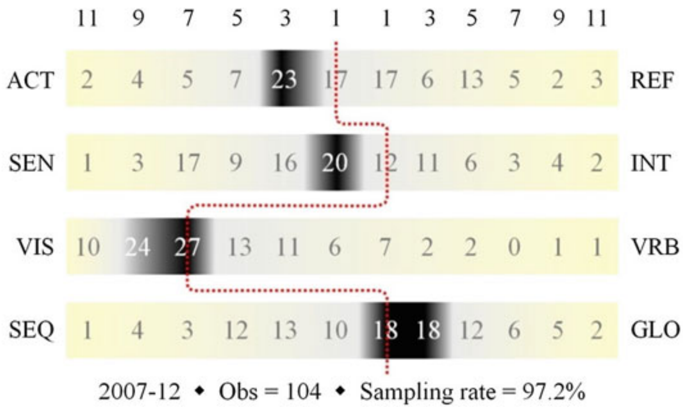


Fig. 6.22 ILS report for leaders

{School, 'not School'}, and {leader, 'not leader'}. The same three conditions, "diff < 0", "diff ! = 0", and "diff > 0", are tested, and for the condition having a *p*-value < 0.05, the H_A is accepted.

In this section, impacts on marks are analysed according to prior experience first and learning approaches second.

Impact of Prior Experience

The results in Table 6.13 show that for the inferred University population, the students in N7 exhibit a nearly uniform level of achievement of marks. The difference between the highest and lowest final mean marks is only "2.49". The follow-on t-test between the two nationalities having that difference indicates that it is not statistically significant.

The other two highest-to-lowest differences in marks means are "4.1" for coursework and "5.1" in exam. However, the subsequent t-tests between the pertaining nationalities indicate that both differences are statistically significant. This suggests

Table 6.13 Means of CEF marks for N7

Nationality	Freq	Coursework	Exam	Final
China	123	69.162602	61.512195	65.97561
India	101	67.188119	63.193069	65.544554
Indonesia	30	69.166667	66.633333	68.033333
Malaysia	31	70	63.790323	67.322581
Singapore	462	70.974026	63.54329	67.722944
Singapore PR	32	71.25	63.015625	67.53125
Vietnam	49	68.959184	63.173469	66.408163

that the differences in nationality's achievements that are visible separately in coursework and exam, then dissipate to almost nil when they combined into the final mark. Therefore, it seems that ordering the nationalities according to marks achieved is incongruent.

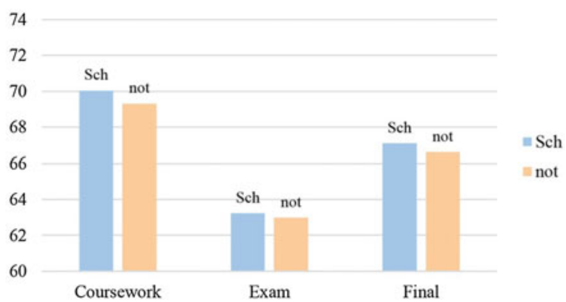
This is corroborated by a battery of t-tests for determining the statistical significance if any of all possible nationality-to-nationality marks differences. The result is that only 26% of the 126 total possible differences are significant. Clearly, there is no justification for ordering the nationalities by the marks of their students. (The total of 126 tests is the sum of all one-time pairwise of seven nationalities each in six marks categories; the formula is $\{(6 * 6) + (6 * 5) + (6 * 4) + \cdots + (6 * 1)\}$.)

The negligible differences and the futility of ordering suggests that, from the perspective of the University population, nationality does not have an impact on the marks achieved by the students. In other words, there is negligible difference between the marks that students from different nationalities achieve.

For the other prior experience variable, SchoolAffiliation, the difference between the mark achieved by students in the School and those who are 'not School' is also negligible. Figure 6.23 shows that the marks for School students are marginally higher than marks for 'not School' students. t-tests on the three differences indicated that they are not statistically significant. Evidently, school affiliation also has no impact on the marks of the University population.

The condition of the prior experience of sophomore students having negligible effect upon their marks is the perfectly rational state of affairs of an institution with a student population that it has cultivated to fulfil its academic priorities. A population of high achieving students are a boon to any higher education institution's global ranking and reputation. Yet, for those reasons, this population must be drawn from a very large and diverse pool of candidates having an ensemble of different and even discordant prior experience. Therefore, to grow and maintain such a diversified population, the institution entrenches a process that recruits the kind of students that conform to its standards of academic expectations in a consistent and sustainable modus. Assuming that this process is effective in its purpose, the resultant student population becomes academically homogenous, and all of their different and unique prior experiences are either inert (they have no discernible impact on the marks achievement), necessitous (they are mandatory and continually active) or in-between.

Fig. 6.23 Comparison of CEF marks for school affiliation



In other words, the prior experiences of the present students cannot alone evoke divergent achievements because candidates with deleterious prior experiences are not accepted into the population.

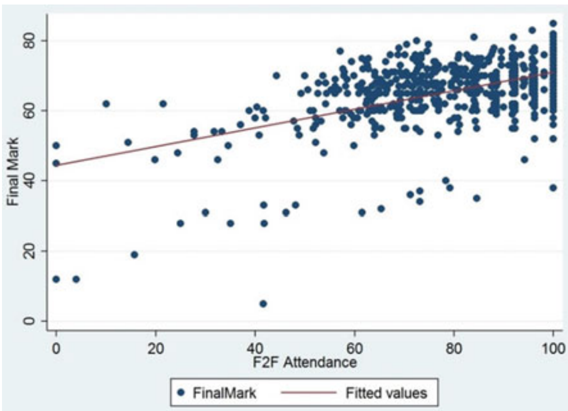
However, it is expected that learning approaches (next section) will impact marks since it is determined and practiced by the student completely outside the control and expectations of the University.

Impact of Learning Approaches

Marks, though continuous, are classified into groups of particular levels which may be cross-compared. The specification of these levels is not considered arbitrary because it is long established practice in most if not all education systems in the world. However, there is no analogous practice, perhaps in most education systems and certainly in the University, for attendance. To classify groups of particular levels of attendance against which comparisons to marks could be conducted for this study would be arbitrary. Instead, the impact of attendance on marks is analysed by correlation and regression, since all the categories of marks and attendance, except exam attendance, are continuous. The scatterplot of F2F attendance and the final marks shows a linear and positive correlation (Fig. 6.24). Note the bunching of points into vertical lines in the upper far-right area of the scatterplot correspond to concentrations of similar attendance, especially at the 100% level. This is an expected side-effect of the attendance distribution being more exponential-like than normal.

The positive and significant correlation of marks and attendance is confirmed by pairwise correlation tests. All four categories of attendance correlate with all six categories of marks except lab attendance and active learning marks. This positive correlation is corroborated by linear regression tests that suggest the following relation between marks and attendance,

Fig. 6.24 Scatterplot of final and F2F with best fit line



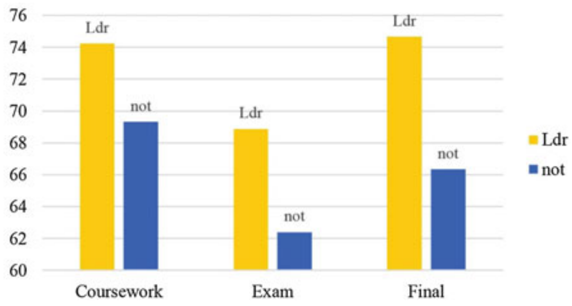


Fig. 6.25 Comparison of CEF marks for leadership

$$\text{final} = 22.67 + (0.08 * \text{lecA}) + (0.108 * \text{tutA}) + (0.29 * \text{exmA}) + \text{error}$$

As a deep learning approach, attendance is clearly effective: high-achieving students are also high attenders. This finding is echoed in other studies (Massingham & Herrington, 2006; Cleary-Holdforth, , 2007; Thatcher, Fridjhon, & Cockcroft, 2007). For example,

> … it is clear that attendance has an impact on performance. Students who attended lectures and tutorial had a better chance of success on all assessment tasks in particular the final exam. Successful students attend lectures and tutorials; less successful students may have genuine reasons for non-attendance. (Massingham & Herrington, 2006, p. 97)

The other learning approach in this study is taking on leadership roles in the course project. The results in Fig. 6.25 show that team leaders achieve much higher marks. All three differences have *p*-values of 0.0000, so H_0 is rejected and H_A is accepted.

Clearly, attendance and project leadership are learning approaches that effectively support the student expectation that he/she will achieve higher marks. Furthermore, with the magnitude of marks achievement they have demonstrated, attendance and project leadership may be put into practice as deep learning approaches.

Blended Learning Evokes Better Performance

The next sections address the three fine-grained research questions posed in the beginning of the chapter with the data set divided into the two instructional design classifications, and the situational awareness of the students altered by the operation of a new and innovational learning context. The statistical techniques for these sections are ‘count’, ‘summarize’, ‘t-test’, ‘pairwise correlation’, Wilcoxon (Mann-Whitney), and ‘linear regression’.

This section discusses the test results for the first research question, “do students exhibit higher academic performance in blended learning?”, with marks being the accepted indicators of academic performance. So, for the research question,

- H_0 is “students achieve marks in the blended learning that are the same as in the traditional lecturing”; and

- H_A is "students achieve marks in the blended learning that are higher than in the traditional lecturing".

where "marks" in H_0 and H_A refers to the 'final' marks. The H_A of "achieving marks that are lower than traditional lecturing" is addressed in the next section. The other five mark categories may provide supplemental explanation or reinforcement of the test results.

Blended Learning Outcomes

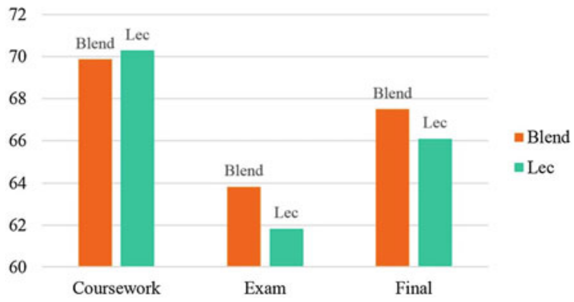
The analysis of this section begins with marks irrespective of prior experience and learning approach, shown in Fig. 6.26. The primary indicator, final, and the vital indicator of individual learning, exam, are both higher for blended learning, plus their differences with traditional lecturing are statistically significant. The blended learning coursework is marginally lower than traditional lecturing, however it is not statistically significant.

Coursework is predominantly teamwork, while exams are an individual effort. In review, the examination is crafted to promote deep learning by the students. Though personality traits do negatively affect some students' performances in exams (Chamorro-Premuzic, & Furnham, 2003) and Asia students are particularly susceptible to examination pressure (Ramburuth & McCormick, 2001; Peng, 2006), the examination is considered an accurate gauge of the student's learning. As exams originate the higher marks, evidently it is the individual's learning that the blended learning is most impacting. This is a stupendous denouement!

The results with the teacher's QAP marks (Fig. 6.27) are consistent with the increase in individual learning. Expectedly, quiz performance is very high in blended learning. This increase in individual learning ameliorates the project mark. Also, all differences are statistically significant.

The active learning component's performance of the being lower in blended learning is due to non-equivalence of the variable's data for the two instructional

Fig. 6.26 Comparison of CEF marks by instructional design



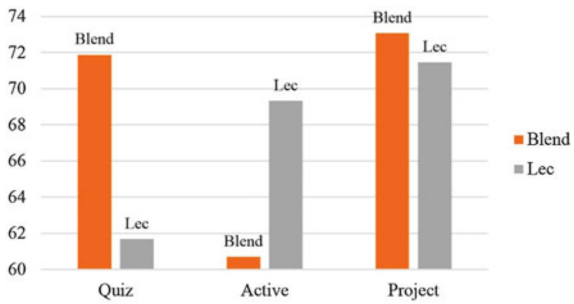


Fig. 6.27 Comparison of QAP marks by instructional design

designs. The students in the traditional lecturing perceive an active learning component as an anomaly, and therefore the teacher compensates by being generous with the marks allocation. In the blended learning, the active learning marks are generated by the eLearning component, which is marked to a stricter standard in order to motive the students to performance at a higher standard. In actuality, the workload and difficulty is much greater in the eLearning, so for it to be equivalent to the easier active learning in the lecturing, the marks should have been equalized through the application of a weighting scheme. Not correcting the data during the data set preparation is a regrettable oversight.

Blended Learning Outcomes by Prior Experience

When the marks are classified by instructional design (Table 6.14), the differences noted in the University data set for N7 become more pronounced. The marks differences between the highest and lowest values in each category are nearly doubled: "5.7" in coursework, "8.5" in exam, and "4.4" in final. Now, the t-tests for these three differences are statistically significant.

Table 6.14 Means of CEF marks for N7 in blended learning

Nationality	Freq	Coursework	Exam	Final
China	90	68.555556	60.288889	65.3
India	83	66.46988	62.421687	64.891566
Indonesia	12	70.25	68.75	69.583333
Malaysia	12	70.583333	64.166667	68.083333
Singapore	313	71.220447	64.977636	68.782748
Singapore PR	19	72.210526	65.736842	69.684211
Vietnam	40	68.275	64.25	66.675

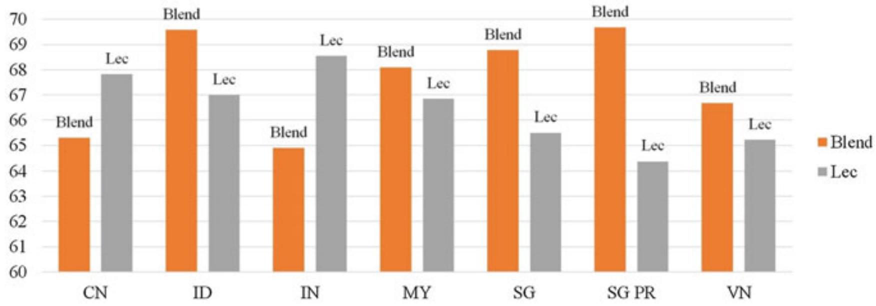


Fig. 6.28 Comparison of final mark for N7 by instructional design

A comparison of CEF and QAP marks achieved in the two contrasting instructional designs by students in each of the N7 members—per Tables H1-7 in Appendix H—reveals that all students attained higher marks in blended learning except those in {CN, IN}. Of the 42 t-tests on the differences between traditional lecturing and blended learning, 17 are statistically significant. Better still, there are two or more significant *p*-values in the tests for {IN, ID, SG, SG PR, VN}. Contrast this proportion of significance, 40%, with the proportion in the population-level analysis (26%). To highlight the achievement differences between the two instructional designs, a column chart (Fig. 6.28) compares side-by-side the final marks (extracted from Table H1) for each instructional design. Clearly, {CN, IN} have higher traditional lecturing, however, the difference is not significant, so H_0 is accepted. For the remainder of N7, only {SG, SG PR} have differences between the contrasting instructional designs that are statistically significant. In other words, the performance of prior experience in aiding the achievement of higher marks in a blended learning context is inconclusive, except for SG including PR. There is reasonable evidence to suggest that SG students achieve higher marks in blended learning.

In Appendix H Figures H8-9, 'not school' students evidently have higher marks in traditional lecturing; this condition is discussed in the next section

Blended Learning Outcomes by Learning Approaches

Next after the prior experience variables are the learning approaches, beginning with attendance. It is clear from the data that the linear and positive correlation between F2F attendance and the final marks in the University population continues in blended learning as shown in Fig. 6.29. Furthermore, the linear equation suggested by the regression test for final marks and F2F attendance in blended learning is as follows,

$$\text{final} = 17.32 + (0.14 * \text{lecA}) + (0.113 * \text{tutA}) + (0.28 * \text{exmA}) + \text{error}$$

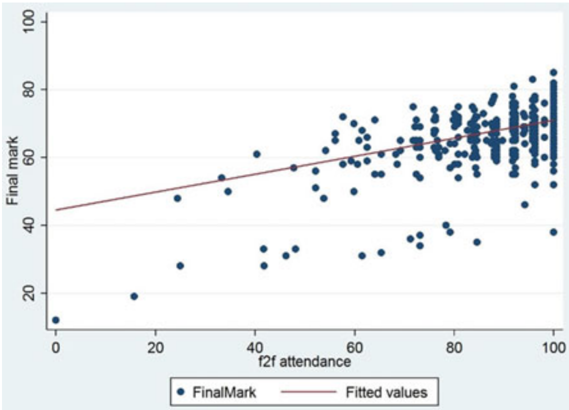


Fig. 6.29 Scatterplot of final and F2F in blended learning with best fit line

and nearly identical to the regression equation for the University population, i.e.,

$$[\text{ final } = 22.67 + (0.08 * \text{ lecA}) + (0.108 * \text{ tutA}) + (0.29 * \text{ exmA}) + \text{ error }]$$

A comparison of CEF and QAP marks for project leadership in the two instructional designs (Tables H10-11 in Appendix H) reveals that team leaders achieve higher marks in both traditional lecturing and blended learning all countries attain higher marks in the blended learning except CN and IN. Again, to highlight the achievement differences between the two instructional designs, a column chart (Fig. 6.30) compares side-by-side the final marks (extracted from Table H6) for each instructional design by school affiliation. The difference for 'not leader' is statistically significant (p-value = 0.0419), but not for leader (p-value = 0.0970). As discovered in the impact analysis section, marks for leaders are high overall, so a significant difference just because of instructional design is unlikely.

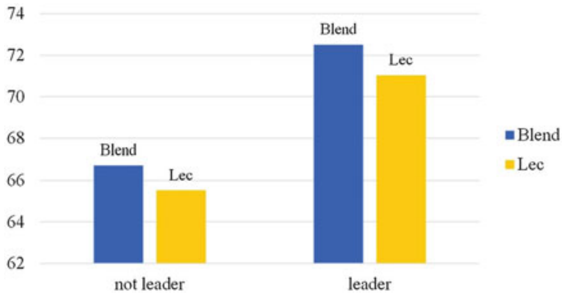


Fig. 6.30 Comparison of final mark for leadership by instructional design

Choosing Learning Approaches in Blended Learning

Figure 6.31 shows that lecture and tutorial attendance in blended learning is substantially greater than in traditional lecturing; exam is almost the same in the two instructional designs. As expected with differences of such magnitude, they are statistically significant. Conversely, the exam attendance difference is negligible and also not statistically significant.

Analysis of attendance employment according to the prior experience variables, Nationality and SchoolAffiliation, confirmed that it is consistent with the overall trend of being higher in blended learning than traditional lecturing. Figure 6.32 shows that F2F attendance in blended learning is substantially higher than in traditional lecturing for all N7 members. Wilcoxon (Mann-Whitney) tests indicated that all differences except for MY are statistically significant.

The relationship of school affiliation and attendance according to instructional design is more complicated. It is inversely proportional (Fig. 6.33). In traditional lecturing, School students have low attendance and 'not School' students have very high attendance. In blended learning, School students are high attenders and 'not

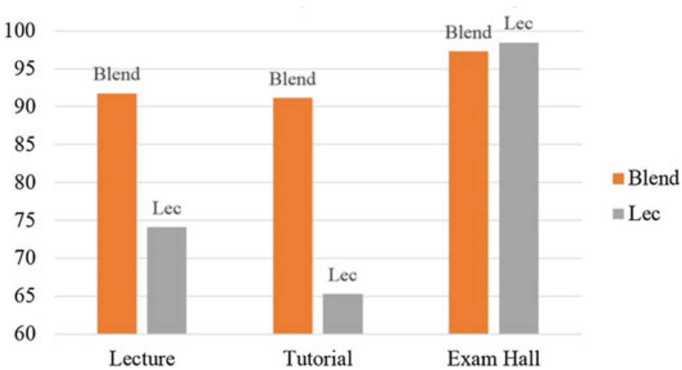


Fig. 6.31 Comparison of LTE attendance by instructional design

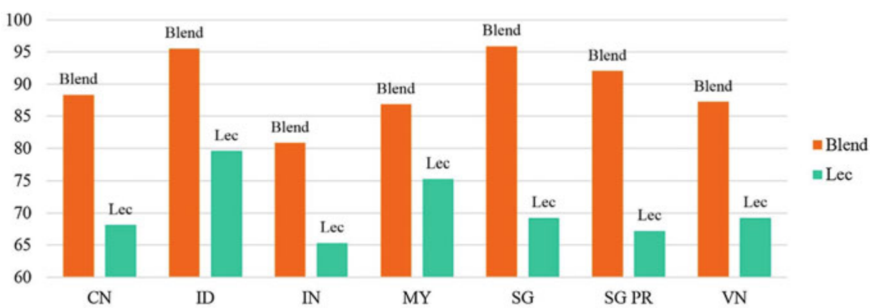


Fig. 6.32 Comparison of F2F attendance for N7 by instructional design

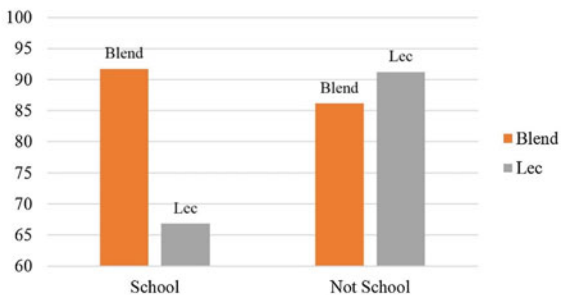


Fig. 6.33 Comparison of F2F attendance for school affiliation by instructional design

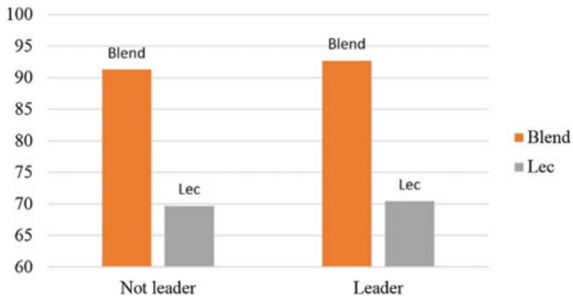


Fig. 6.34 Comparison of F2F attendance for leadership by instructional design

School' students are lower attenders. However, the magnitude of the opposing differences in attendance is not equivalent: it is "24" in traditional lecturing, and only "6" in blended learning. Using the Wilcoxon (Mann-Whitney) test, all differences between School and 'not School' in opposing instructional design classifications or in the same are significant.

The attendance of leaders versus non-leaders in each instructional design is nearly identical (Fig. 6.34), and the *p*-values unequivocally accept the H_0 of no difference between leader and 'not leader'. This indicates that the leaders' higher than 'not leader' achievements are not the consequence of higher attendance; the leaders follow a deep learning approach that is unique to their group.

Blended Learning Disadvantages Select Groups

This section discusses the test results for the second research question, "do students exhibit lower academic performance in blended learning?", with respect to coherent groups of nationality and school affiliation. So, for the research question, there is a $\{H_0, H_A\}$ tuple for each variable.

- For Nationality:

  - H_0 is "students belonging to a nationality achieve marks in the blended learning that are the same as they achieve in traditional lecturing"; and
  - H_A is "students belonging to a nationality achieve marks in the blended learning that are lower than they achieve in traditional lecturing"; and

- For SchoolAffiliation:
  - H_0 is "students from a school achieve marks in the blended learning that are the same as they achieve in traditional lecturing"; and
  - H_A is "students from a school achieve marks in the blended learning that are lower than they achieve in traditional lecturing".

Blended Learning Impact on Nationality

The tables and charts of the marks means and *p*-values for N7 contained in Appendix H show higher blended learning CEF marks for most of N7, though only the marks differences for {SG, SG PR} are statistically significant. Even those nationalities with higher traditional lecturing marks do not have statistically significant marks differences. Therefore, it seems that the determination whether blended learning is "detrimental marks-wise to students from a particular nationality" cannot be decided as a simple {yes, no}. Instead, it must be an adjudicated probability of {likely, unlikely, no}. Table 6.15 shows that completed assessment of detrimental probability for all of N7; it is entered into the last column on the right.

The adjudication weighs three factors:

1. To which instructional design, {traditional lecturing (trad lec), blended learning (blend)}, do the highest CEF marks belong?
2. Is the difference between CEF marks in each instructional design above or below, {+, −}, the mean difference calculated for all N7; and
3. Which hypothesis, {H_0, H_A}, is accepted in the t-test?

Blended learning is 'likely' detrimental if most or all of the CEF marks are higher in traditional lecturing, if the marks difference is mostly "−", and if mostly H_0 is accepted. Blended learning is 'no' detriment when all CEF marks are higher

Table 6.15 Probability that blended learning is detrimental by nationality

Nation	Higher Crsework	Hypo accept	Higher Exam	Hypo accept	Higher Final	Hypo accept	BL detrimental
CN	trad lec(-)	H_0	trad lec(+)	H_0	trad lec(-)	H_0	likely
ID	blend(+)	H_0	blend(+)	H_0	blend(+)	H_0	unlikely
IN	trad lec(-)	H_A	trad lec(-)	H_0	trad lec(-)	H_0	likely
MY	blend(-)	H_0	blend(-)	H_0	blend(-)	H_0	unlikely
SG	blend(-)	H_0	blend(+)	H_A	blend(+)	H_A	no
SG PR	blend(+)	H_0	blend(+)	H_A	blend(+)	H_A	no
VN	trad lec(+)	H_A	blend(+)	H_0	blend(-)	H_0	unlikely

in blended learning, most marks differences are "+", and mostly H_A is accepted. 'Unlikely' is in between 'likely' and 'no'.

The two nationalities shown in Table 6.15 for whom blended learning is 'likely' detrimental, {CN, IN}, are analysed to determine if the cause for detriment is from either adopting ineffective learning approaches, or a defect in the instructional design itself. (This is according to the learning model in Chap. 4 where the learning situation is, strongly influenced by the learning context and informed by the learning approach.) The analysis begins with learning approaches, namely attendance and team leader.

The analysis is intended to reveal in comparison to their compatriots, what kind of attenders the {CN, IN} students are and to what degree did their attendance grow in the blended learning. For this part of the analysis, exam attendance is ignored because it is in practicality a constant, with a mean across the 11 semesters of 97.26, maximum deviations of +5.5 and −2.7, and a mean deviation of ±2.3. Thus, only the F2F attendance is analysed. Figure 6.31 shows students from {CN, IN} generally exhibiting low F2F attendance in both instructional designs. Table 6.16 shows the ranking of all N7 according to those attendance values in Fig. 6.31, and establishes that IN students are the lowest attenders while CN students are moderate attenders.

The growth in attendance is the increase in mean attendance exhibited by the students for N7 in blended learning; this is shown in Table 6.17. The growth is shown in two forms, quantity (qty) and percentage (%). The quantity of growth is the subtraction of the traditional lecturing and blended learning attendance values. The percentage of growth is the division of the blended learning attendance value by the traditional lecturing attendance value.

Students from IN are tied with those of ID at 5th position in the ranking for attendance growth. CN students are ranked as 3rd in attendance growth. The findings of Tables 6.16 and 6.17 are that IN students start off as the lowest attenders and were

Table 6.16 Ranking of F2F attendance for N7 by instructional design

Rank	CN	ID	IN	MY	SG	SG PR	VN
In trad lec	5	1	7	2	3	6	4
In blended	4	2	7	6	1	3	5

Table 6.17 Growth of F2F attendance for N7

Nationality	Qty growth	% Growth	Rank
China	20.174443	1.2961024	3
Indonesia	15.98332	1.2009639	5
India	15.5411	1.2380618	5
Malaysia	11.553509	1.1535082	7
Singapore	26.67565	1.385404	1
Singapore PR	24.859919	1.3700663	2
Vietnam	18.018889	1.2603468	4

Table 6.18 Ranking of leadership for N7 by instructional design

Rank	CN	ID	IN	MY	SG	SG PR	VN
In trad lec	3	7	2	7	1	5	4
In blended	2	5	3	7	1	6	4

only minimally better attenders in blended learning, whereas CN students were low attenders but became proportionally better attenders in blended learning.

Blended Learning Impact on Team Leader

As revealed in an earlier Table 6.12, students from {CN, IN} are the second largest participators as team leader. Table 6.18 shows the ranking of N7 according to number of team leaders in each instructional design. It establishes that the proportion of team leaders taken up by each nationality in traditional lecturing is equivalent to that taken up in blended learning. In other words, team leader is essentially a constant for all N7 including {CN, IN}, and is unaffected by changing the instructional design.

In summary, IN students have the lowest attendance of any nationality in both instructional designs, and the second lowest growth in attendance for blended learning. CN students have moderate attendance, but exhibited a strong growth, 3rd overall, in attendance for blended learning. However, students of both nationalities assume the 2nd highest proportion of team leader positions in both instructional design. Finally, poor attendance might be a reason for worse marks being achieved by IN students in blended learning. However, there is no reason immediately apparent for the worse marks achieved by CN students in blended learning.

Impact of Global Trend in Development, Education, and Technology

Another dimension of analytics that this study will briefly explore for a possible rationale concerning the low achievement of particular nationalities is global indices in education, information technology, and the human condition. Three respected and widely-cited global indices in these domains are the Human Development Index (HDI), Education Index (EdI), and Network Readiness Index (NRI). Appendix J shows the indices data retrieved from reports by the United Nations Development Programme's Human Development Report (2010; 2013) for the HDI and EdI, and The World Economic Forum's Global Information Technology Report (Dutta, Lanvin, & Paua, 2004; Dutta, Lopez-Claros, & Mia, 2006; Dutta & Mia, 2009) for the NRI.

Figure 6.35 is a comparison of N7 rankings from largest to smallest for each global index. Derivation of the rankings for the indices' raw data, including the different

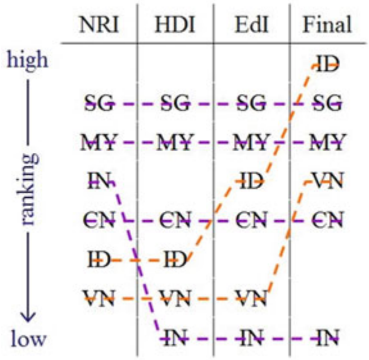


Fig. 6.35 Comparison of N7 rankings in final marks and global indices

directions of sorting values, is shown in Tables J5-7. The nationalities are represented by their two-digit country codes. The dashed lines connect the relative vertical or row positions of all four instances of each member of N7 thus tracing the ranking equivalence of difference from one index to the next.

Figure 6.35 shows consistencies pertaining to nationalities for the three indices, but also shows inconsistencies. Two nationalities, {SG, MY}, are consistently the high performers in all three indices. CN ranking hovers in the middle of N7 at 3rd and 4th, and VN is a consistent low-performer at 6th and 5th. IN ranking drops from 3rd to 6th, and remains as such. Finally, ID rises from 5th through 4th to 3rd. Overall, HDI and EdI exhibit mostly equivalent rankings for N7 with the exception of ID. It is behind CN in the HDI, and then jumps in front of CN in the EdI. The NRI rankings exhibit minor differences with HDI and EdI. Overall, there is no decisive ranking of N7 emerging from the global indices themselves.

When the ranking of N7 final marks are compared with the global indices, there is also both consistencies and inconsistencies. {SG, MY, CN, IN} retain their order relative to each other for the EdI and final marks, but change their position in the ranking. ID ranking rises from 3rd to 1st dropping {SG, MY} to 2nd and 3rd. VN rises from 5th to 4th dropping {CN, IN} to 5th and 6th. Hence, taking into account the inconsistencies of the indices, and the inconclusiveness of comparing them to the final marks, there does not appear to be any definitive rationale for the low achievement of the CN students.

Finally, the notion of a defect in the instructional design itself providing a rationale for the low achievement of the CN students is addressed in the final chapter.

Blended Learning Impact on School Affiliation

Appendix H (Table H4 and Figures H8-9) reveals that the ‘not School’ students in traditional lecturing achieve higher marks in all categories except quizzes, while the School students in blended learning achieve higher marks in in all categories

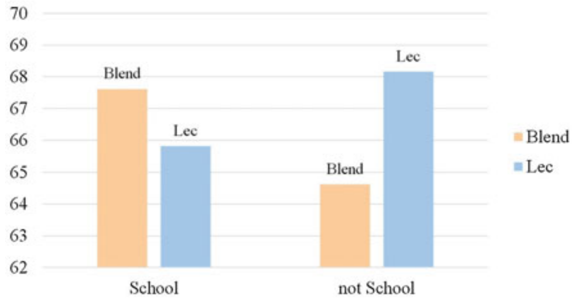


Fig. 6.36 Comparison of final mark for school affiliation by instructional design

except project. Yet again, to highlight the achievement differences between the two instructional designs, a column chart (Fig. 6.36) compares side-by-side the final marks (extracted from Table H6) for each instructional design by school affiliation. The difference for the School is statistically significant (p-value = 0.0032), but not for ‘not School’ (p-value = 0.1073). In the case of ‘not School’ where the magnitude of difference between the contrasting instructional designs is greater than for School, its insignificance is due to the disparate sizes of sub-groups—231–570 for School and 31–24 for ‘not School’—and consequent low degrees of freedom.

Predicting Performance in Blended Learning

This final section discusses the statistical results for the third research question, “can a student’s predilection for higher academic performance in blended learning be predicted?”. Another way of understanding this is, can the student’s potential of achieving the learning outcomes in a blended learning context be derived from the scores in his/her ILS personal report?

The initial design of a prediction mechanism is the ILS profile of high-achievers in blended learning (Fig. 6.37) as a template against which a student’s personal ILS report is contrasted. This is analogous to using a person’s past performance as a predictor of his/her future performance in a similar context. Though the assessment of what constitutes a “similar context” is subjective, nevertheless this approach has universally demonstrated its predictive accuracy. The ILS re-designed report has unequivocally shown, in the “Learning styles” section of this chapter, and in Appendix G, that it is capable of exposing subtle differences that might not be otherwise detected in the learning responses of coherent groups of students. So, upon first inspection this design appears promising as the prediction mechanism.

Upon closer inspection, the ILS report’s intrinsic characteristic of ‘score matching within band’ is a drawback to its predictive accuracy. In Fig. 6.37, a Type I ‘score matching’ condition is clearly present in band four. It conveys an uncertainty in the interpretation of that band, being whether the score matching is indicative of a “must have” condition or it is an authentic phenomenographic (recall Chap. 4) condition.

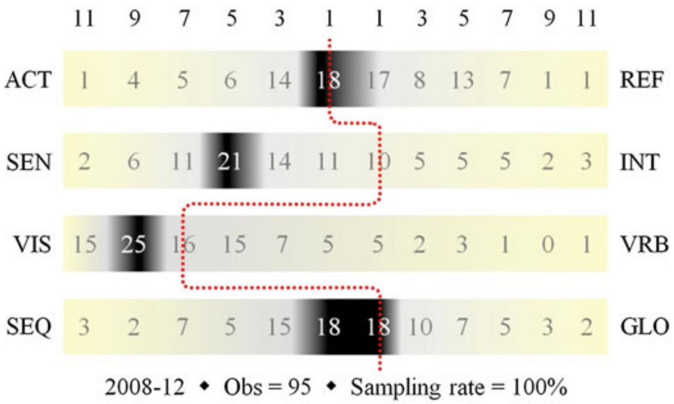


Fig. 6.37 ILS report for high-achievers in blended learning with the 'deep learning curve'

The uncertainty is increased substantively if the 'score matching' is Type II. Definitely, the "spread or spike" representations are useful in a predictive mechanism, but only if there is certainty as to the semantics of the representations. In other words, the problem (in the prediction) is not having multiple peaks (in the representation), but the lack of understanding what that representation exactly means. However, keeping in mind that there are reasonable albeit limited interpretations of the 'score matching' conditions, instead of discarding the ILS report design it is decided to incorporate a second instrument into the prediction mechanism to act as a validator and moderator of the ILS design.

This second instrument is the pairwise correlation of marks (all six categories) to the ILS scores. This mechanism is very simple to operate as the correlation test's capacity of variables in a single run—a test of 288 variable pair's runs in less than a second—is well above the number variables in the data set. However, the magnitude of results from that single run are tedious to analyse; note that half the pairwise test results are duplicates, e.g., "x correlates with y" renders exactly the same coefficient and *p*-values as "y correlates with x", so, only 144 results of 244 tests are analysed. In Appendix G, Table G3 contains the statistically significant results extracted from the 144 total, and Table G4 is a mapping of the variable pairings in Table G3 s onto a 12-column and four-row matrix resembling the ILS report. This resemblance is intended to enhance the visual acuity of the validation-moderation the ILS report in Fig. 6.37. Unexpectedly, 56% of the total correlations are negative, which impedes the desired validation-moderation. The ILS report manifests only the positive condition of summation of frequencies into peaks; it is incongruent to use negative values as validators/moderators. So, Table G4 is transposed without all its negative values into Table 6.19 to uncomplicate and facilitate the validation-moderation.

Unexpectedly, the positive correlations paint a profile of high marks to ILS report scores that significantly contrast with ILS report Fig. 6.37. Especially unexpected is that the correlations entirely exclude the 'sensing', 'visual', and 'sequential' learning responses, and instead include only 'active', 'reflective', 'verbal' and

Table 6.19 Positive correlations of marks and ILS scores

	11	9	7	5	3	1	1	3	5	7	9	11	
Act	p		f, c, z, t					f, e					Ref
Sen											p	t	Int
Vis									f, c			p	vrB
seQ							c				p	e	Glo

Legend final = “f”, exam = “e”, coursework = “c”, quiz = “z”, activelearn = “t”, project = “p”

‘global’ responses. The deviation in the correlations from the deep learning approach in this study is not disconcerting, as ‘active’, ‘intuitive’, and ‘global’ responses conform unequivocally to deep learning. The disconcertion with the correlations is the exclusion of ‘visual’ responses. Every possible student coherent grouping in the data set studied thus far exhibits moderate to strong ‘visual’ responses. Such observations are entirely consistent with the current body of knowledge on the visual proclivity of modern youth.

> The centuries-long domination of texts and words in culture, particularly Western culture, has come to an end. The new “pictorial turn” means that images no longer exist primarily to entertain and illustrate. Rather they are becoming central to communication and meaning-making. (Felten, 2008, p. 60).

The cause of the divergence is posited as a deficiency in the availability of sufficient “visual with high achiever” correlations in the data set, and not a case of inappropriate application of correlation testing. After all, most of the correlations are consistent with deep learning, albeit not the deep learning the teacher had planned and expected. Accordingly, it is decided to incorporate one more instrument into the prediction mechanism to enable a “qualitative triangulation” of the three instruments’ perspectives to subsequently establish a band-wise, not column wise “area of confluence” in the ILS report map; in other words, a ‘score matching within band’.

The linear regression test is chosen as the third instrument due to the linear and positive correlation of the marks with the learning approaches regardless of instructional design (Fig. 6.38). Though it is a powerful test, it has two issues when used with these variables. Firstly, seemingly consistent tests produced inconsistent results. For example, independent variables “x and y” are significant predictors when tested individually with dependent “z”, however “x” ceases to be a predictor when tested together with “y”. The second issue is the excessive number of tests that are necessary to distillate the correct predictors from 54 variables. The tests are run in three stages that progressively eliminate non-predictors when identified from further testing. The first stage comprised 288 tests, the second 103, and the third 18.

The results of the 409 tests are mapped onto another instance of the 12 × 4 matrix that mimics the ILS report (Figure G5 in Appendix G). Included in the mapping are several significant predictors with negative coefficients, though they constitute much less a proportion, only 23.9%, of the total than is the case for the correlations. As with the correlations, and for the same reasons, Table G5 is transposed Table 6.20 with its negative values duly removed.

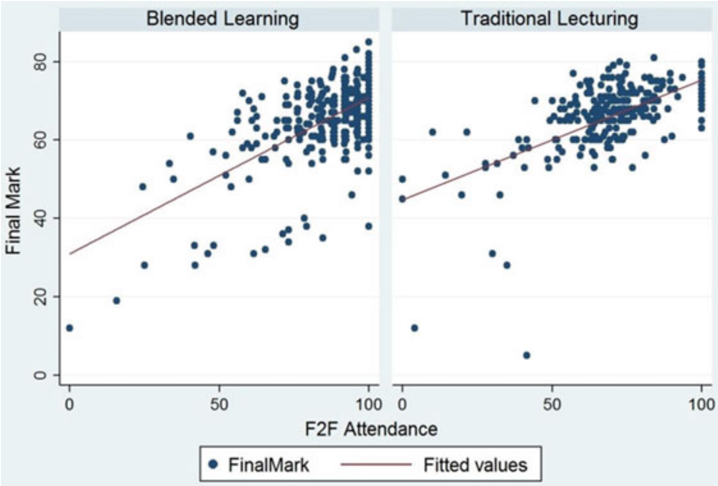


Fig. 6.38 Scatterplot 2-way of final and attendance by instructional design

Table 6.20 Positive linear regressions of marks and ILS scores

	11	9	7	5	3	1	1	3	5	7	9	11	
Act	c, p		f, e, c, z, t		z			f, e			z	c	Ref
Sen	e	c			z					c, p			Int
Vis									f, e, c, z		e, z, p	f, e, c, p	vrB
seQ	f, c		e, z							z	p	e	Glo

Legend final = "f", exam = "e", coursework = "c", quiz = "z", activelearn = "t", project = "p"

Clearly there are more positive regression values than positive correlation values, and more concentrations of sharing regressions values in cells than correlation values. Also, there are regressions contained in the left-sides of bands two and four. However, seven of the 17 occupied cells have identical occupying marks categories, making the layouts of Tables 6.19 and 6.20 appear similar.

The final step in the prediction mechanism is the "qualitative triangulation" of the three instruments. Disappointingly, there are no cell occupation common to all three instruments, and only one common cell occupation of Fig. 6.37 and Table 6.19. (This cell is located in band four, on the "GLO" half in column "1"; this is abbreviated as "g1".) The following lists the common cell (in abbreviated form) occupations of the figure and tables.

$$a11,\ a7,\ r3,\ b5,\ b11,\ g1,\ g9,\ g11$$

The following lists the occupied cells in the figure and the tables that are adjacent; in other words, the 'score matching within bands' that extends across the figure and

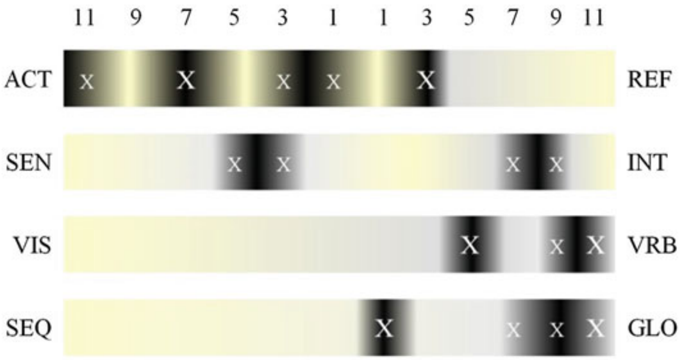


Fig. 6.39 Inceptive prediction mechanism in ILS report form

a table, or across the two tables.

Type II : a11-7
Type I : a3-1, s5-3, i7-9, b9-11, g7-9

These three lists are combined into an inceptive prediction mechanism in the form of the ILS report (Fig. 6.39). However, there are two defects with the mechanism: the values at the ends of the bands, and the excessive 'score matching' in band one.

Table 6.21 shows the variables at the ends of the bands that have frequencies less than 20. By all accounts, such minimal frequencies constitute outliers in the data set, and therefore should be removed from the prediction mechanism, with the exception of 'b5' which constitutes a major concentration of marks categories. The excessive 'score matching' of both Types in band one is entirely uninterpretable, and therefore, should be reduced to the two major concentrations of marks categories. Figure 6.40 shows the removal of the outliers and minor common cell occupations and the establishment of the final version of the prediction mechanism.

The operation of the prediction mechanism with respect to how many of the band values in the students personal ILS report have to conform to the predictor's values has yet to be understood. Testing of the prediction mechanism is the topic of further research.

Table 6.21 Frequency of ILS report band end observations

A11	R11	B5	b7	b9	b11	q11	g11
3	9	11	7	2	1	9	4

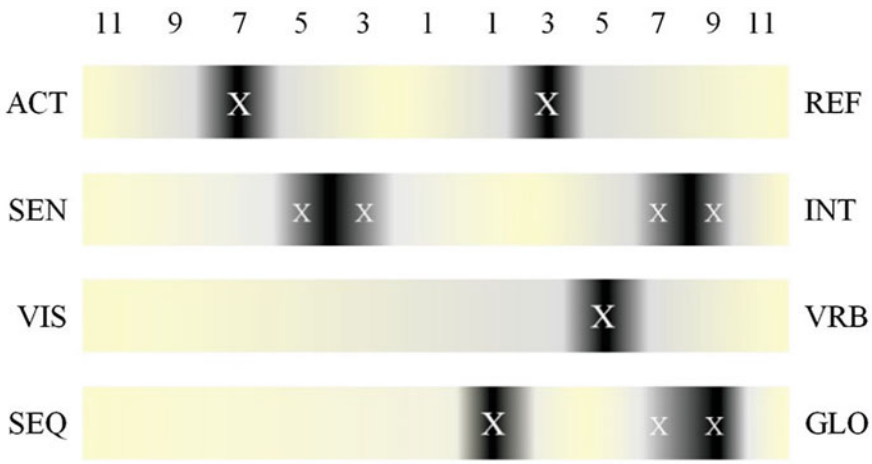


Fig. 6.40 Final prediction mechanism in ILS report form

Validation of Findings via Marks Data Congruity Check

Table 5.5 in Chap. 5 contains the means of marks across all 11 semesters of the experimental period; notably, those in the blended learning semesters appear less uniform than those in the traditional lecturing semesters. With its two dashed horizontal lines indicating the mean mark across semesters for traditional lecturing, {07S1, 07S2; "tradlec"}, and for blended learning, {08S1-11S2; "blended"}, Fig. 6.41 showcases this condition.

For the purpose of this validation, the semester 07ST marks are excluded because of their non-relevance. The CM degree program students that comprise the entirety of semester 07ST students are a concentration of high achievers from schools in the University excluding the School. In contrast, the remaining ten semesters are

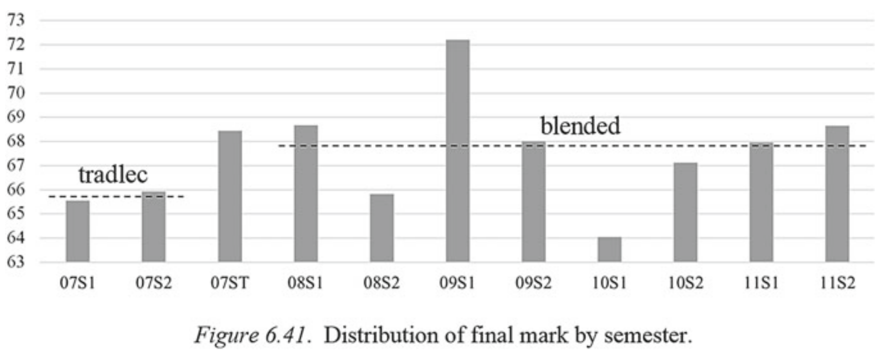


Fig. 6.41 Distribution of final mark by semester

Table 6.22 Change of CEF marks variance in blended learning semesters

Mark	Mean	09S1	10S1	Above	Below
Final	67.495	4.71093	−3.4533	4.7	−3.5
	67.50586	Removed		1.2	−1.7
Exam	63.8249	5.9692	−5.8666	6.0	−5.9
	63.97852	Removed		1.9	−1.8
Coursework	69.862	3.81452	−1.9453	3.8	−2.0
	69.79102	Removed		3.0	−1.8

comprised of over 96% CE students, with academic achievements that span well into the failure range. (The lowest mark in the CM program is 58. The lowest in CE is 5.) The academic difference is evident in Fig. 6.41 where the mark mean for the CM students is much higher than that for the CE students in traditional lecturing and equivalent to the mean for the CE students in blended learning. (Given their academic achievement potential, it is reasonable to posit that CM students would have a higher achievement in blended learning than the CE students; that is a worthwhile candidate for future research.)

It is also evident in Fig. 6.41 that the final mark means in two blended learning semesters, {09S1, 10S1}, are outliers; they have more than double the variance with the "blended" mean than any other semesters' marks. Table 6.22 compares the variance in blended learning CEF marks before and after these two outliers are removed. The upper row in each mark shows the original "blended" mean and the 'before removal' variance. "Above" is the difference between the semester with the highest mean, 09S1, and the "blended" mean, while "Below" is between the lowest, 10S1, and the "blended" mean. The lower row shows the "blended" mean recalculated across six semesters along with the 'after removal' variance.

After removal of the outliers, the variance in exam marks exhibits a significant decrease of over 65%. By contrast, the variance drop for coursework marks is an insignificant 10%. As previously mentioned, exam marks showcase individual learning while coursework marks showcase cooperative learning. Also discussed earlier, the University's recruitment process creates an academic homogeneousness across its student population, so it is expected that in closed, well-established, and cooperative activities like those in coursework, the marks would exhibit a higher degree of uniformity, not just across the blended learning semesters but across all semesters. Table H1 and its corresponding Fig. 6.26 show that coursework is the same in both instructional designs (only 0.4 difference), and that difference is not significant as per Table H2. The coursework mark's uniformity may also be due to the project, which contributes the largest proportion of the mark, remaining the same throughout the entire 11 semesters. To summarize, changes in final marks variance are manifested almost exclusively from the exam marks.

It is concluded in Chap. 3 that the semester-on-semester difference in marks originates primarily from the students themselves. Additionally, it is posited that the circumstances of the students most likely to impact their academic achievement in

Table 6.23 Proportion means of key data across eight semesters of blended learning

Data	Hold-back	Attendance		Team Ldr	eLrn fail
		F2F	Exam		
Means	3.734	91.66	97.33	14.49	15.80

blended learning are: repeating the examination, coursework, or both, nil prior exposure to innovative instructional design, resolute anchorage to traditional lecturing, and nonproficiency in digital learning environments (DLE). To validate the data set semester-on-semester, this study will analyse the outliers for their relation to the posited impactful circumstances of the students; if several significant relations are found, then the data set may be considered to be validated.

Student Circumstances Impacting Blended Learning Achievements

Data is drawn from several tables in this chapter and Appendices H and I to establish a baseline of means for select variables across the blended learning's eight semesters. This baseline is contained in Table 6.23. The second column, "Hold-back", concerns the circumstance of repeating the examination, and is explained in the next section.

Repeating the Examination, Coursework, or Both

An identical Student value appearing in different semesters is not a case of an error in the data, but an instance of a student repeating his/her semester. The data set is thoroughly checked for the existence of spurious duplicates of student entries, and none are present. So, all duplicate students existing in the data are there because the students deferred completing the Software Engineering in one semester. In fact, there are several variations of such deferment, collectively referred to by the term "hold-back".

Naturally, "hold back" does not define students who complete the course in the semester that they initially undertake it, nor does not refer to students informally dropping out—ceasing all participation in the course without notifying the School or the teacher that they are withdrawing—of the course. Though it results in outright failure of the course with no appeal, informal dropout is carried out by an average of 3.4% of the students, all in traditional lecturing. A serendipitous outcome of blended learning is the elimination of informal dropout, a results from the close tracking of attendance on a weekly basis afforded by any eLearning. There is no analogous attendance tracking in traditional lecturing, except for the laboratory project. However, the student's participation record in the laboratory is compiled only at the close of the semester, which is too late for any remedial action to be taken.

Table 6.24 Summary of hold-back students in Software Engineering course

Type	Total	In 09S1	In 10S1
HB1	5	0	0
HB2	10	0	2
HB3	8	0	2

Three “hold-back” scenarios are recorded in both instructional designs. All begin with the student completing the coursework in the initial semester, but absenting him/herself from the examination and subsequently re-registering in a following semester, usually the next in sequence. The first scenario is where the student carries over his/her coursework mark from the previous semester and undertakes only the examination in the current one. The second scenario is where the student repeats the coursework plus the examination in the current semester. The third scenario is where the student absents him/herself from the examination in the second semester and subsequently re-registers in a third semester. In this study, the three scenarios are referenced as HB1, 2, and 3 respectively. Table I20 in Appendix I shows the frequency of the three kinds of hold-back students in the data set. Table 6.24 is a summary of the total hold-backs plus the specific quantities for the outlier semesters, {09S1, 10S1}.

The majority of hold-back students are mediocre achievers at best who lack confidence in the new instructional design. Worse still, some hold-back students generate a gloomier outlook for the course that affects the performance of some of his/her peers. Therefore, a higher proportion of hold-back (or repeating) students acts to decrease the semester’s mark mean. The data in the outlier semesters bears this out: the over-achieving semester, 09S1, has zero hold-backs, and the underachieving semester, 10S1, has 8.33% hold-backs. In comparison to the “blended” mean for hold-back, semester 09S1 is 3.7 below and semester 10S1 is 4.6 above. This supports the prediction of the hold-back effect, therefore, the first relation between the posited impactful circumstances and the data’s non-uniformity is confirmed.

Nil Prior Exposure to Innovative Instructional Design

In terms of Chap. 5 learning model, this circumstance is most appropriately associated with the PriorExperience Class. However, Nationality and SchoolAffiliation, the variables in the data set matched with PriorExperience are not adequate for signifying exposure to innovative instructional design, for two reasons.

First, the University does not keep data on its students’ prior exposures to innovative instructional design as it does for nationality. What is known is that very few Asian secondary and tertiary education institutions operate innovative instructional designs at the time of the experiment, thus it is incorrect to equivocate belonging to a nationality with having been exposed to innovative instructional designs. For example, only one institution in Singapore, Republic Polytechnic, officially conducts PBL, an innovative instructional design, for its diploma courses. From common knowledge of the backgrounds of the students in the School, it is believed that on average under 10% of its Singaporean recruits are graduates of Republic Polytechnic. Given that Singapore appears to be one of the more progressive of Asian nations with respect to education, it is reasonable to presume the percentage of international students exposed to innovative instructional designs would be considerably less than 10%. If this is correct, then the frequency of such students would be in the magnitude of the 'not School' data, around 50. As seen in earlier analysis in the chapter, such a small-sized sample cannot be parsed and sub-categorized without defeating the significance of any findings.

Second, SchoolAffiliation all but entirely precludes exposure to innovative instructional design because the practice of traditional lecturing is so prominent in the University that ostensibly it is the only instructional design in operation. While it is possible that there exists isolated pockets of innovative instructional design that a few individuals of the 'not School' in the data set have experienced before coming to the School's CM program, nevertheless it is certain that no CE students experienced innovative instructional design before joining the Software Engineering course. Finally, even if the international-by-origin proportion of 'not School' students were all exposed to innovative learning prior to joining the Software Engineering course, only one such student exists in the outlier semesters, and thus is insignificant.

Clearly, exposure to innovative instructional design needs to be surveyed to determine if it has a measurable effect on the data variance in general and the outlier semesters in particular. In using this technique it must be taken into account that the surveyed persons may not recognise an innovative instructional design when they undertake it. So, it is likely that the survey should be qualitative, inquiring on the nature of the instructional design innovation, rather than quantitative, such as a binary "yes/no" response to the question.

Resolute Anchorage to Traditional Lecturing

This circumstance is realised by the choices in learning approach made by the students. It is found earlier in the chapter that high attendance (F2F and exam) and undertaking the team leader role both exert a positive influence on academic achievement. Thus, the proportion of students with high attendance and that are team leaders should be larger in the over-achieving outlier semester and smaller in the under-achieving one. Table 6.25 shows the attendance and team leader means for the outlier semesters {09S1, 10S1}.

Table 6.25 Means of learning approach practice in outlier semesters

Approach	09S1	10S1
F2F attendance	96.72647	83.589584
Exam attendance	100	91.666667
Team leader	23.529412	14.583333

The difference between the semester means is striking. The values for semester 09S1 are significantly higher for both approaches than those in 10S1. Even more telling is the variance of the values in Table 6.25 to the means for blended learning in Table 6.23. For semester 09S1, F2F and exam attendance are above the corresponding "blended" means by 5.1 and 2.7 respectively, and team leader is above its corresponding "blended" mean by 9.04. For semester 10S1, F2F and exam attendance are below the corresponding "blended" means by −8.1 and −5.7 respectively, and team leader is equivalent to its corresponding "blended" mean. This follows the prediction and confirms the second relation between the posited impactful circumstances and the data's non-uniformity.

Nonproficiency in DLE

This circumstance is most appropriately associated with the ActiveLearning marks variable, with eLearning being its largest activity. Since eLearning is a bonafide digital learning activity, the student's performance therein is an unequivocal indication of how proficient he/she is in a DLE. Accordingly, the analysis in this section focuses on students who exhibit the highest degree of nonproficiency in a DLE, that being those who fail the eLearning. Table 6.26 shows the proportions of eLearning failures in the outlier semesters, {09S1, 10S1}.

Once more, the difference between the semester means is striking. The failures in semester 10S1 are almost five times the magnitude of 09S1. When they are compared individually to the eLearning failure mean for blended learning in Table 6.23, they clearly fit the predicted outcome of degree and direction of variance. Semester 09S1's mean is −9.92 "below" the 'blended' value (almost twice its own magnitude), while 10S1's is 13.37 "above". All this follows the prediction and confirms the third relation between the posited impactful circumstances and the data's non-uniformity.

A brief side note on veracity of inference that is drawn here from a fail mark. It is generally accepted in the community of teachers that a student's learning of new knowledge is more effective when resulting from his/her application of physical and cognitive exertion in pursuit of the learned artefact. In other words, an active student is a learning student. When a student fails in an active activity like eLearning while others succeed—recall that the students recruited by the University are normalized in their potential to achieve academically—it must be due to something other than the content and workload, such as nonparticipation and incompletion. Recall also that the adjudicator monitors the eLearning performance of every student every week, and in near real-time detects those students who have not started or completed the eLearning. Some of these are technical issues, some of these are unfamiliarity with the software,

Table 6.26 Means of eLearning failures in outlier semesters

Data	09S1	10S1
eLearning fail	5.88235	29.16667

and the rest are not engaged. With early intervention and good teaching praxis, some of these students can be assisted and encouraged to the complete the eLearning released in the remaining weeks. Those that don't respond to the intervention proceed to their inevitable fail in the eLearning.

Whether it is lack of engagement or technical unfamiliarity, they are all manifestations of DLE nonproficiency, because proficiency includes mastery of the process and responsibilities innate in the object to which mastery is intentioned. Teacher-lead learning environments offer the realization of real engagement through physical presence, body language, and sometimes peering directly at a student to grab his/her attention. On the other hand, DLE offers only a second rate similitude of that level of engagement, such as videos, scripted narrations, and written words of encouragement. Despite the impotency of these instruments of engagement, those that are proficient in DLE lucidly understand that they have to substitute the real F2F engagement with internalized goal setting, dedication, and tenacity. In the terms of the learning model, these internalizations are crucial ingredients in the construction of a new situational awareness by the student for this and any novel instructional design. Therefore, it is inarguable that DLE nonproficiency manifests a fail mark, that in turn demonstrates the student's incapability of creating the new situational awareness appropriate for the DLE.

In summary, three significant relations are found between the semesters {09S1, 10S1} to statistically substantiate their propriety as outliers against the "blended" mean: repeating the examination, coursework, or both, resolute anchorage to traditional lecturing, and nonproficiency in DLE. The fourth, nil prior exposure to innovative instructional design, cannot be analysed due to the absence of appropriate variables comprising the data set. Nevertheless, the three are more than sufficient to validate the data set semester-on-semester, and remove any uncertainty of the incongruity of the data set and its statistical analysis.

The distillation and rationalization of the statistical analysis results into conclusions accounting for the higher education performance in and of the blended learning design are presented in the next chapter.

Chapter 7
Contributions, Limitations, and Further Research

This chapter puts forward all the conclusions drawn from the statistical analysis findings detailed in the preceding chapter, and adds to the body of knowledge about the operation of blended learning in the classroom comprising higher education learners from Asia.

This study is framed by three overarching conditions of the experimental conduct. First, the research methodology is design-based, whereby the researcher has not established a priori a set of hypotheses pertaining to the veracity of a theoretical model. Instead, the methodology has testing of a trial design with an intention to highlight observations of some effect; hence, the research is more an exploration and less an explanation. Expectedly, the conclusions rendered by the experiment are broad in content and context.

Second, the data is from higher education students of whom over 99% belong to 17 nationalities in Asia, with Singapore contributing the greatest share of these students. Intentionally, this study constitutes a case study of learning by Asian students in an Asian university. Nevertheless, this study is not ethnographic in its methodology or purpose. Instead, it merely offers a few insights pertaining to higher education students of select nationalities in Asia insofar as they are represented in the inferred population in accordance with the institutional context of the participating University and School. If anything more were attempted, the study would encounter some justifiable scepticism over its pronouncements concerning the learning capability of populations of hundreds of millions, with a plethora of different circumstances of formal and informal learning, drawn from sample sets of only hundreds.

Third, the experiment is a single instance of learning and teaching that is both prominent and isolated by its divergence from the standard practice in the School and the University which is traditional lecturing. So, replacing lecturing in the Software Engineering course with blended learning for the entire 13 weeks in the semester, is as prominent an event in the undergraduate's experience as any, particularly if it is his/her first exposure to another instructional design besides traditional lecturing. The isolation is occasioned by the instructional design replacement occurring in only one of the five courses that each cohort of students normally takes in the semester. The

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divergence may in turn give rise to two disruptions of the experiment, one being the "Hawthorne effect"[1] and another being "reluctance to accept non-authentic learning environment" (Herrington, Oliver, & Reeves, 2002).

There being one and the same teacher for the entire 11 semesters of the experiment is a key factor in normalizing the potentially disruptive Hawthorne and non-authentic learning effects. That is, with the teaching done by the same person in the same characteristic manner to the same degree and with a unified purpose in mind, the semester-on-semester and year-on-year mitigation experienced by the students is consistent. An orientation for the students is held at the beginning of each semester with the new instructional design. Plus, the students are individually apprised of the details of the conduct of the experiment through their endorsement of the 'informed consent' instrument. (The consent acknowledges the experiment conduct and gives permission for the researcher to collect, process, and safeguard the student's academic records from unauthorized access; see Appendix J.) Thus, if the 'Hawthorne effect' were to be experienced by the test subjects, its impact is expected to be normalized for the entirety of each cohort.

The "reluctance to accept non-authentic learning environment" is not harboured in every student, but it is nevertheless a condition that cannot be left unaddressed in those few whom it affects.

> "For some students, there appears to be some misapprehension about the approach, because it is so different from the more academic approaches with which they are familiar. Many students initially perceive authentic environments to be non-academic, non-rigorous, time wasting and unnecessary to efficient learning. It is often only when the suspension of disbelief occurs that these students see the complexity and the value of the learning environment." (Herrington, Oliver, & Reeves, 2002, p. 2)

The (one and the same) teacher addresses this issue at the levels of the cohort and the individual. For the cohort, the teacher reinforces the authenticity of blended learning through the orientation, occasional or "in-response-to-student-query" postings of accessible papers and research conclusions, and weekly learning progress feedback reports for the cohort. During the semester, the teacher holds informal chats with students to determine if they might be the ones harbouring a deep-seated reluctance, and tries to persuade them through dialog to adopt another perspective concerning the new instructional design. In summary, the assurance of authenticity is given to the entire cohort first and then reinforced through personal dialog with specific students that seem to warrant such persuasion.

The pronouncements in this chapter are based mostly on the findings from the statistical analysis of the data set in Chap. 6. However, a few pronouncements are educed from data gathered and preserved by the University, such as student feedback

[1]The "Hawthorne effect" is a person modifying his/her behavior when he/she is aware of being observed. The effect's name and alias, "observer effect", come from research conducted in the Hawthorne Works, an electrical product manufacturer in the USA, during 1924–32 on in-plant lighting levels and worker's productivity. In the context of education, the effect was first explored by Cook in 1962 and 1967. It was followed by "A fresh examination" (Diaper, 1990) and "Was there a Hawthorne effect?" (Jones, 1992).

and post-project debriefs and reports, and from the teacher's own written and cognitive recollections. Such exceptional occasions are clearly announced in the pertinent sections of this chapter where they occur.

Conclusions

Since the content and context of the conclusions are broad, they are extraneously classified in this section under headings based on the didactic triangle of formal education (Kansanen & Meri, 1999) which is the opening reference in this study's literature search. This technique is intended as a cognitive aid for the reader to provide a meaningful though informal context for the broad conclusions, and also a literary aid to give the study a sense of coming full circle back to its beginning.

The first heading in the section, "student and learning", encloses conclusions pertaining to approach and outcomes attributable to the choices and efforts of the students in their learning. "Teacher and teaching" holds conclusions pertaining to techniques and industry of the teachers within their sphere of influence. Finally, "curriculum and organization" refers to conclusions pertaining to responsibilities and mechanisms that are the purview of either the University or the School. Nevertheless, it must be kept in view that all conclusions are related directly or indirectly to the replacement of traditional lecturing with blended learning. Table 7.1 shows the 11 conclusions discussed in this section.

Students and Learning

1. Higher academic performance in blended learning is authentic.

The statistical analysis revealed a statistically significant increase in the final mark of 1.4 points or 2.12%. Though the magnitude of the effect is minute, it is the fact that the increase originates in the examination that makes it noteworthy. Examination is one of the most definitive indicators of personal learning, so its increase of 2 points or 3.24% is indicative of significant personal learning.

In an academic environment mandated and manipulated by the University, differences in nationality and school affiliation are normalized by its student candidacy acceptance mechanisms; consequently, they are not sources for the marks increase. Also, the teacher is the same in both instructional designs so the increase of marks cannot be directly attributed to any difference in teaching acumen. Finally, the analysis shows that students do have equal opportunities for employing the deep learning approaches of attendance and project leadership in both the traditional lecturing and blended learning semesters. The lower F2F attendance in the traditional lecturing is by choice not construction. In other words, there is no experimental indicator whose

Table 7.1 Summary of conclusions

Didactic	Conclusion
Student and learning	Higher academic performance in blended learning is authentic
	Traditional lecturing is nonessential for higher education
	Undertaking a team leader role in a course project is an effective learning approach that transcends instructional design
	Attendance is deep learning approach in blended learning
	'Visual' is not a predictor of higher performance in blended learning because it is an innate trait of the University students
Teacher and teaching	Bloom's taxonomy is an eminently capable tool for managing learning outcomes in blended learning
	The teacher must promote effective learning approaches for a new instructional design
	The roles of teacher and researcher should be separately realized
Curriculum and organization	Student candidacy into the School must take into account 'digital divide' and international programming competition experience if it is going to offer courses with a high digital constitution
	School affiliation is not reliable predictor of performance in blended learning
	STF does decrease with a new and innovative instructional design being used in the classroom

imbalance between the traditional lecturing or blended learning could account for the increase in academic performance.

Moving beyond earlier studies that stated inconclusive results, recent studies now confirm blended learning effectiveness. In a well-cited—1266 by Google Scholar's count—meta-analysis in 2004 by Bernard, Abrami, Lou, Borokhovski, Wade, Wozney, Wallet, Fixet, and Huang, the findings of 232 research studies from 1985 to 2002 rendered no conclusive evidence for or against the effectiveness of distance learning compared to traditional lecturing. (The relevance of distance learning to this study is that it is a foundational component of blended learning.) However, five years later in an updated meta-analysis of 1132 studies comparing online and F2F learning (Means, Toyama, Murphy, Bakia, & Jones, 2009; having 1586 citations by google scholar count), the conclusion is that blended learning does indeed render significantly higher academic performance over traditional lecturing as follows.

> "*Instruction combining online and face-to-face elements had a larger advantage relative to purely face-to-face instruction than did purely online instruction.* [emphasis in original] The mean effect size in studies comparing blended with face-to-face instruction was +0.35, $p < 0.001$. This effect size is larger than that for studies comparing purely online and purely face-to-face conditions, which had an average effect size of +0.05, $p = 0.46$." (Means et al., 2009, p. xv)

2. Traditional lecturing is nonessential for higher education.

Colleagues and management in the University doubt that higher education learning can occur without lectures; this sentiment is best exemplified by a discussion between the first author and the Dean.[2] Opposition by faculty may arise from the barriers to change involving new technology to which the faculty are vulnerable (Ertmer, 1999); in other words, new technology challenges "traditional classroom culture as well as teachers' beliefs about the teaching–learning process" (p. 48).

The student's "reluctance to accept non-authentic learning environment" alluded to earlier would include opposition to the cessation of lectures because of years of prior experience that have conditioned the student to believe lecturing is the one and only authentic learning in formal education. Also, traditional lecturing is the norm for the University, and since its student population is selected to fit its academic norms, the students would "almost to a man" perceive lecturing as the authentic learning of the University. Finally, opposition to the cessation of lectures may also be ethnographic in origin. To paraphrase Ziguras (2001), students from South East Asian countries are observably less comfortable with innovative learning practices than with traditional ones such as lecturing.

Once blended learning is operating as the instructional design for the course, it is possible that the cessation of traditional lecturing could lead to a degeneration of the classroom management and prompt the students to complain en masse about inadequate learning and teaching to the School management. However, these scenarios never materialized, as most of the students seemed to accept the replacement learning activities in the new instructional design, with attendance climbing significantly, and marks increasing albeit more modestly.

However, this most fortuitous outcome of the experiment as a whole does not mean that there are no complaints. In the post project accounting for the research conduct and conclusions from the perspective of the TEF grant (Jones, 2012a), it is reported that a small percentage of students in each blended learning cohort, 5–10%, are intransigently opposed to learning in any new way, even when shown that the new instructional design is more effective in learning and teaching. An important task of the teacher is to manage these individuals to preclude their discontent from spreading to other students.

3. Undertaking a team leader role in a course project is an effective learning approach that transcends instructional design.

Team leaders are significantly higher achievers than 'not leaders' in both instructional designs, although the difference between leader and 'not leader' is slightly greater in blended learning, 5.8%, than in traditional lecturing, 5.53%. The role of team leader carries a much heavier workload than that of the team members. Each

[2]During a Dean's Mixer Party for Tea/Coffee on 28 November 2008, an informal event for the College of Engineeringfaculty in different schools to share ideas and socialize, I discussed my proposal for a blended learning format in my subject. Although supportive in principle, the Dean emphasized that the delivery could not be all eLearning. He stated that a key aspect of the university experience was the traditional F2F discourse between the professor and the student, and in the management's opinion, it is absolutely essential for NTU to retain that for some part of the four years of the degree process.

team leader is individually responsible for the output of his/her own sub-system development team, plus the crop of team leaders for the semester are responsible for the effective integration of the entire software system. Despite what could be an overwhelming workload, it seems that when they acquire this role, the majority of team leaders are able to “rise to the occasion” and manage all these responsibilities effectively while attaining a higher level of performances in learning outcomes.

The statistical analysis did not uncover any aspect of situational awareness or learning approach that might explain why team leaders are so capable. The three largest proportions of nationalities comprising the team leaders are 43% SG, and 17.8% for each of {CN, IN}. While SG students are high achievers, {CN, IN} are the lowest. If nationality were a causal factor of the leader’s achievement, then it should average out to be only moderate—an average of high of SG students and the low of {CN, IN} students—and not high as presently observed. Hence, nationality is discounted as such a causal factor. In the aspect of school affiliation, team leaders are almost exclusively, 96.3%, from the School. However, School students’ achievements are low in traditional lecturing and higher in blended learning, in stark contrast to the constantly high achievement exhibited by team leaders. Therefore school affiliation does not fit as a causal factor in team leader’s achievement. Finally, F2F attendance of leaders and ‘not leaders’ is nearly identical. Thus, team leaders must attain a situational awareness and evoke a deep learning approach that is unique to them and emerging from as yet an undetermined source.

4. Attendance is deep learning approach in blended learning.

The statistical analysis highlighted the very strong positive correlation between final mark and F2F attendance. This finding is consistent with other recent studies listed in Chap. 6. However, statistical correlation alone is not necessarily proof of causation; there needs to be a conjunctive influence to support any claims of causation. In this study, the conjunctive influence is the new instructional design.

It is well-known that some students in the study equivocate learning with gathering information (Jones, 2012b). Traditional lectures are practiced by many faculty as information “coverage” sessions (this point is driven home most eloquently in a seminal short paper by Gibbs in 1981). Most students quickly pick up on the faculty’s implicit purpose, and respond commensurately by acting as information consumers and not learners: “They seem far more pre-occupied with figuring out what “they need to know” and getting my notes, than reading independently or synthesising material themselves” (Ditcher & Hunter, 2001, p. 5). This, coupled with the recorded lecture sessions distributed to the cohort by streaming video, give the information gathering students ample justification to not attend F2F learning sessions.

Additionally, faculty may unwittingly facilitate or further encourage the students’ non-attendance by such legitimate actions as disseminating lecture notes to them prior to the lecture, and reducing the difficulty of the end-of-course examination. Though having the lecture notes before the lecture is a straightforward means of enabling the student’s preparation for the session, it may otherwise become in the student’s mind the definitive source for the course information, and as such, supercede the information disseminated in the traditional lectures. This supposition by the student may be reinforced if the notes are written comprehensively as in a precise and not in 'bullet-point' form as in a presentation slide. While reducing the examination difficulty raises the cohort's grade average, conversely it downgrades its learning outcomes to an all-too-likely emphasis on 'remembering'. So, with the examinable content aggregated into a personal notebook and assessment instruments necessitating only "regurgitation" of factual information, there is really no need for the student to attend any of the F2F learning sessions.

One of the drivers underpinning blended learning is the intension to change the students from information consumers into learners by completely eliminating the deleterious factors and conditions from the learning situation. Lectures are ceased entirely from the F2F learning sessions, and replaced with reviews, quizzes, and student-conducted presentations. Lecture notes are not distributed to the students. Instead, they are posted alongside other learning resources such as published papers and journals, videos, and images in each eLearning session, and are only available to the students when they undertake the session; they are not freely distributed. Finally, assessment of the students is effected both weekly and at the end of the course, with the end-course examination constituting 40%[3] of the final mark. The performance bar for the examination is raised from 'remembering' to 'applying' and 'analysing' (Anderson et al., 2000). The overall effect of these changes is to oblige the student to consider attendance as a means of achieving the learning outcomes of the course.

The final consideration for the teacher is establishing some mechanism to help the students break out of the mind-set conditioned by years of non-attendance in F2F learning sessions, other than resorting to making attendance in the course learning activities mandatory. The mechanism eventually adopted is the award of participation marks counting for about 3% of the final mark, a concept endorsed by the University and well understood and accepted by the students. The data for the participation mark is gathered by an audience response technology by Turning Technologies© (2016) called "clickers". It has a reputable install base, an unblemished track record, and exhibits high reliability and operability in any classroom on the campus.

5. 'Visual' is not a predictor of higher performance in blended learning because it is an innate trait of the University students.

The statistical analysis did not promote the 'visual' response in the ILS report as a predictor of higher performance in blended learning outcomes. Felten (2008) explained that images are replacing the domination of texts and words "particularly in Western culture". However, the domination of imagery and its concordant 'visual' learning response is prevalent in more than just Western culture; for instance, it is entrenched in the student population of the University. Every ILS report compiled in the statistical analysis and the compendium ILS Reports (Appendix G) without

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[3] During the period 2008–2012, the average proportion of the final mark allotted to the examination was 65%. In addition, no course except Software Engineering had less than a 50% weighting for the examination in the final mark. The 40% weighting required University management approval.

exception specifies that the students in the University all possess the strong 'visual' learning responsiveness characteristic. So, by virtue of it being an apparently innate and universal trait of the University students, the 'visual' learning response is a vacuous marker upon which to predict the students' achievements.

Teachers and Teaching

6. Bloom's taxonomy is an eminently capable tool for managing learning outcomes in blended learning.

In reiteration, a learning outcome is a demonstration of capability in some activity or work product that infers an acquisition of learning. Being a long standing—over 60 years since its inceptive publication—tool for managing learning outcomes, Bloom's taxonomy is the sole tool of its kind used for the entire 11 semesters.

Ultimately, the assessment of learning has to be compatible with the theories of learning, otherwise the assessment will not cover all aspects of the theory's implementation. In his instruction theory, Robert Gagné incorporated Bloom's taxonomy; compatibility between the two is thus entrenched. Furthermore, with Gagné's nine steps of instruction being the primary framework for designing the weekly learning activities, by association Bloom's taxonomy is the most appropriate tool to apply to those activities involving the creation and assessment of the learning outcomes. Further still, Bloom's taxonomy has been found to neatly map to NTU's grading scheme (see Table 5.4), thus maintaining the integrity and correctness of the marks submissions.

In addition to the forementioned compatibility with instruction theory, Bloom's taxonomy proved to have other advantages:

- There is a preponderance of support available for understanding and using it. Literally hundreds of taxonomic instruments providing expansions and extensions to the learning outcome lexicon are freely available online. These supplements greatly enhance the taxonomy's flexibility and adaptability for a variety of assessment activities and numerous diverse subjects and courses;
- Though not the simplest of tools with its six learning outcome categories—for example, SOLO has five intervals—it is simple enough for any first time user to quickly and appropriately write and assess the learning outcomes for the intended level of learning;
- It is scalable from small classes of 30 students to large classes of over 200, however, it seems justifiable to extend this finding and posit that there is no practical limit to its scalability; and
- It provides several dimensions of data for statistical analysis, such as concentrations in any category and performance variance or spread across higher categories.

Two weaknesses in Bloom's taxonomy are noted. First, the difficulty of the activity or work product being demonstrated in the learning outcome is not specified. In other words, the learning outcomes for a course may not be all require the same level of effort and learning to achieve. This is mitigated by applying a weighting factor to the learning outcomes, such that the easier outcomes figure numerically less in the final tally of marks. Second, an application of either surface or deep learning in the learning outcome is not captured in the six-point scale of learning outcome. For whatever reason, if the depth of learning (surface or deep) is to be included in with the learning outcome assessment, then the teacher has to formulate his/her own mapping of learning outcome category and depth. For example, a teacher might trace "evaluation" to "deep" learning, and "knowledge" to "surface" learning. However, the teacher in this study found such mapping too subjective as well as possibly not accurate generally to have merit in the adjudication process, and so is eliminated from consideration.

In summary, the teacher found Bloom's taxonomy far more advantageous than disadvantageous. One of its two weaknesses was ignored without any observed ill-effects on the grading of the students. The advantages are that Bloom's taxonomy is flexible, adaptable, scalable, and user-friendly. It is an eminently capable tool for the management of learning outcomes.

7. The teacher must promote effective learning approaches for a new instructional design.

As discussed in the Chap. 4 learning model, Prosser and Trigwell reveal in their 1999 book that many teachers prefer that their students make their own selections of learning approaches, even if they are known by the teacher to be ineffective. Prosser and Trigwell take a contrary position, asserting that teachers should promote the learning approaches that are the most effective for the particular learning outcomes. The conclusion of this study is consistent with that assertion, and also expands the direction slightly: the teacher should promote to his/her students the effective learning approaches for a new instructional design.

This conclusion emerges from an earlier discussion concerning the finding in the statistical analysis that the prior experience of sophomore students has negligible effect upon their marks. The finding is reasoned to occur because the student population becomes academically homogenous by virtue of higher education institution recruiting the kind of students that conform to its standards of academic expectations. Since the instructional design promoted by the University for its F2F learning sessions is traditional lecturing, it stands to reason that the student population would be calibrated to that mode of instruction. So, the advent of an innovative instructional design such as blended learning would leave the University student bereft of plausible ideas for learning approaches that would support his/her expectation of achieving the learning outcomes belonging to that learning context. In fact, promoting suitable learning approaches to the University students would be a critical success factor in the operation of the new instructional design. By induction, this conclusion is generalized to any replacement of an existing instructional design with a new one.

The promotion may be conducted in several ways. The most straightforward and direct way is to provide the students with an online help channel advising them how to "survive" the new instructional design. The information therein would assume the character of a reference guide, and include explanation of the learning context, user guidance for various recommended learning approaches, detailed explanations of learning outcomes, and even a commentary about the research and discipline of learning science. Armed with this information, the students are relied upon to adopt the learning approaches as presented or with their own personalization.

Another way is to incentivize students into making appropriate learning approach choices without making this intention explicit. The technique with a great deal of flexibility for the teacher is the application of 'bonus marks'—these are extra to the normal marks that a student earns by completing coursework and assessments—counting towards the students' final grades. Importantly, these bonus marks must appear to be equally accessible to all students, and be earned for behaviour that is consistent with the expected countenance of an authentic learning activity. One very successful exemplar of this is highlighted in the previous conclusion concerning attendance: students are encouraged to undertake the deep learning approach of attending F2F sessions with the award of "participation marks". This technique is also applied to the eLearning component of the blended learning with the same high degree of success.

The final way is to conduct orientation briefings at the commencement of the course. Admittedly, briefings are only partially successful at transmitting detailed and complex information to its passive audience, especially with respect to procedural topics such as learning approaches. However, they do afford the teacher an opportunity to exert his/her personal influence and persuasive power to heighten the student's receptiveness towards adopting learning approaches that are otherwise unfamiliar.

8. The roles of teacher and researcher should be separately realized.

In the experiment, the roles of teacher and researcher are undertaken by one person. Although this situation could be managed and the experiment seemed to the test subjects to be operating correctly, in reality it was barely manageable. In addition to the onerous workload continuing for most of the five year period of the experiment, there were several lapses that could be attributable to the two-roles-one-person-realization and that entailed correction and even rhetoric to hide from being noticed. In hindsight, the overall conduct of the experiment would have been improved if the designer and implementer roles had been realized by two persons.

The issue with the two-roles-one-person-realization is productivity. The speed at which the structures for the new instructional design are developed from conception to deployment is greatly reduced. Not only is blended learning a new instructional design for the course, but it also is the first of its kind in the School. Without any precedent course to draw ideas and constructs from, every one of the blended learning constructs has to be designed and implemented from scratch. In addition to the initial development effort, there is also the follow-on effort of maintenance. In the majority of deployments of a new instructional design, or even deployments a new learning activity, it is inevitable that some aspects of the new material, sessions, and software will require repair and/or enhancement. Putting these conditions all together, the conduct of the experiment follows a strict sequencing of the conception-to-construction tasks, that is coupled with the substantially greater workload involved in the development and maintenance efforts due to the newness and unprecedented inception of blended learning in the School.

For the first two semesters of the blended learning deployment in 2008, the initial weight of developing and deploying the new software for the eLearning and assessment instruments is alleviated with the hiring of education technology implementers courtesy of the TEF grant. However, once those funds were expended, it fell to the teacher to take on the instructional designer and implementer roles. Repairs are first priority and always completed, leaving enhancements as second priority. Although some enhancements were developed, others never got past the drawing board, for example, the eLearning advanced stream. The deployed version of this enhancement is only minimally realized: a limited number of superficial additions to the content, but no changes to the assessments and practices. Finally, the skills and knowledge pertaining to each role are factors in the workload. During the early period when the teacher is learning his skills and knowledge on-the-job, several inconvenient and time-wasting errors were committed that increased the workload, such as creating inoperative files and losing others.

In the end, the workload of undertaking both designer and implementer roles is one of the considerations in ending the experiment. The diminishing returns of more experimental data to increase the veracity of the results are weighed against the mountain of work required to upkeep the new instructional design. After five years, the workload consideration eclipsed that of results veracity. Ultimately, in long-term design-based research in learning and teaching, realizing the two roles of instructional designer and implementer with one person is not sustainable.

Curriculum and Institution

9. Student candidacy into the School must take into account ‘digital divide’ and international programming competition experience if it is going to offer courses with a high digital constitution.

The statistical analysis uncovered that in blended learning, students from {CN, IN} experience a detrimental effect on their learning outcomes while students from {ID, MY, SG, SG PR, VN} enjoy higher not lower achievement. Yet, all the students in the University are reasoned to be an academically homogenous group calibrated to the learning context of traditional lecturing. So, the fact that a subset of N7 exhibits a lower level of learning outcome achievement than the remainder merits exploring. It is possible that poor attendance is the reason for worse marks being achieved by IN students in blended learning, but it is unlikely to apply to the CN students who are moderately good attenders in blended learning. The second deep learning approach, team leader, is shown not to be a detriment for {CN, IN} students as they constitute the 2nd largest proportion of leaders in the N7, and the nationalities with lesser percentage of team leaders do not exhibit low marks. Finally, a brief exploration of global indices for education, information technology, and the human condition, did not provide a rationale for the low achievement of the CN students in blended learning.

The notion of a defect in blended learning precipitating the low achievement of the CN students is raised in the statistical analysis, and then deferred to this final chapter to be addressed. Accordingly, there is no mention in the instructional design literature of a characteristic of blended learning that is detrimental to particular nationalities. The blended learning instance used in this research is thoughtfully crafted to be true to the tenets of seminal educational theorists and technologists such as Robert Gagne, Charles Bonk, and Randy Garrison. Moreover, if blended learning were defective, more students than just those from {CN, IN} would have experienced lower marks. So, it is facile to posit that blended learning has a defect targeting particular nationalities.

The key to unlocking this puzzle is the relation of global indices and final marks and movements of the {ID, IN, VN} rankings in Fig. 6.35. IN drops from 3rd in the NRI to 6th in the HDI-EdI, while {ID, VN} climb respectively from 5 and 6th to 1st and 4th. In those movements, IN takes the last spot in the ranking and CN is relegated to second last position. It is posited that two computer-related phenomena, ‘digital divide’ and International Olympiad of Informatics (IOI), explain these observations.

‘Digital divide’ is the difference in access and utilization measured at the national level between persons or groups in respect to information and communication technologies (ICT) and knowledge literacy (Organisation for Economic Co-Operation and Development, 2001). As described in Chapter 3, blended learning uses the digital medium extensively for the distribution of content, collection and exchange of information, adjudication of learning outcomes, and expanding synchronous and asynchronous communication between teacher and students, and between students.

Sharma and Mokhtar (2008) report that CN is bridging its ‘digital divide’ by “outfitting of ICT infrastructure in schools followed by the training of students to be information literate so that they would be able to collect and analyze information, as well as communicate and express it” (p. 26). However, the ‘digital divide’ in IN is greater, and so it is embarking on a modest effort just to “equip every child and adult with the basic ability to read and write, with the goal of attaining a sustainable 75% literacy” (p. 27). Compare this with MY’s “multi-media super corridor …, Smart Schools, and Computer-Aided Instruction Programme for Mathematics and Science programs”, and SG’s hundreds of millions of dollars commitment “to train at least 10% of the population to become adept at using ICT applications … helping Singaporeans enhance their employability in the digital environment mainly through learning how to use computers and the Internet effectively, so that their quality of life can be improved and any digital divide within the island nation bridged” (p. 26).

Considering the extensive digital medium in blended learning and the nascent digital penetration in {CN, IN} as compared to {MY, SG}, it seems highly plausible that a nation's 'digital divide' does disadvantage its students in an extensive digital learning environment like blended learning. Such a premise is consistent with the observations. Students from {CN, IN} with a large 'digital divide' achieve worse marks in blended learning, while students from {MY, SG} with negligible 'digital divide' achieve high marks in the same learning context.

Notwithstanding, the upward movement {ID, VN} seems be an anomaly to this. Paraphrasing Sharma and Mokhtar (2008): ID and VN are lower income countries with lower network readiness that contributes to them having a much greater 'digital divide'. Somehow the 'digital divide' effect is being offset by another; that other is posited to be the IOI. A sizeable proportion of the {ID, VN} students recruited by the School are competitors in the IOI, and after recruitment, they immediately join the University's teams to further their competition experience at the collegiate-level; this next level is the International Collegiate Programming Competition (ICPC). In fact, most of these students join the University because of its reputation for always sending teams to compete in the ICPC. There is a direct correlation between the student being an IOI competitor and he/she achieving high marks in blended learning.

The IOI is open to all nationalities, and it is common knowledge that {CN, IN} students comprise a large proportion of the competitors. Yet, they are not picked up in the School's recruitment process. If they were, then like the students from {ID, VN}, they certainly would achieve far better marks in blended learning than they do presently. The School also does not recruit {SG, MY} students that have competed in IOI, and they are not disadvantaged in blended learning because of the high digital proficiency of their nations.

In summary, a student's aptitude and capability in a digital medium does facilitate the achievement of learning outcomes in blended learning. Either coming from a nation without a 'digital divide' or being a competitor in the IOI, both provide the student with an effective prior experience with which to excel in blended learning. To this end, the School's instruments for acceptance of student candidates must take into account 'digital divide' and IOI experience if it offers courses in the future with a high digital constitution.

10. School affiliation is not reliable predictor of academic performance in blended learning.

The statistical analysis revealed that students from the School achieved higher marks in blended learning, and students from 'not School' achieved higher marks in traditional lecturing. There is no bias introduced by the same {CN, IN} student pool that is the subject of the previous conclusion because the composition of {CN, IN} in 'not School' for blended learning is only 8.33% each. Hence, any coincident effect of lower achievement from these two nationalities is considered negligible.

The proportion of other nationalities comprising 'not School' for blended learning is {HK, SE, US} 4.17% each, {CA, FR} 8.33% each, and KZ at 54.17%. So, academic performance in blended learning is largely a consequence of the capability of the KZ students. {CA, FR, HK, SE, US} rank very high in the global indices, while KZ ranks below {CN, IN} (see Fig. 7.1). Evidently, KZ has a greater 'digital divide' than IN.

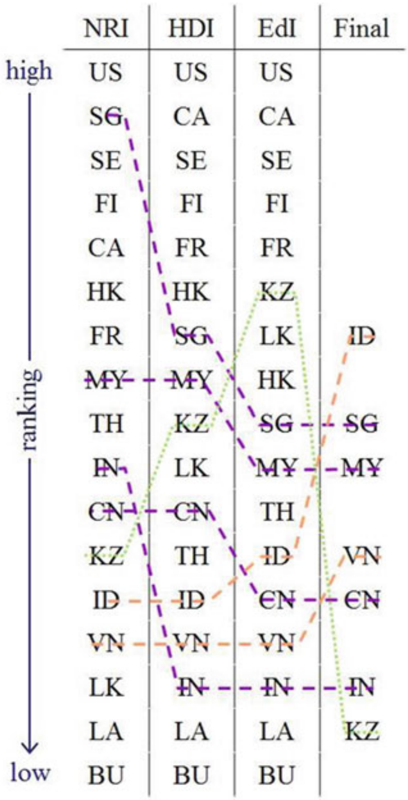

Fig. 7.1 Comparison of all nationality rankings in final marks and global indices

From the School's ICPC records, KZ is in the league of {CN, IN} in IOI participation; only one of 13 or 7.7% students from KZ participated in IOI. KZ students ranked lower in their marks in blended learning than IN students. It is highly likely that a large digital divide and absence of IOI participation factor strongly into the findings for 'not School'.

The statistical analysis also shows that attendance of 'not School' students is higher than those in the School. However, only three (12.5%) 'not School' students took up team leader duties. So, while there is positive reinforcement from one of the two learning approaches, there is nil reinforcement from the other. If both learning approaches are not employed, then the low achievement would be expected. But, in the present circumstances, the correlation of learning approach and low achievement in blended learning is inconclusive.

The statistical analysis pointed out that CM students—they are in the higher percentiles of learning performance in their own schools—comprise 93.5% of the 'not School' students in the traditional lecturing. So, it is expected that the marks in traditional lecturing would be high. Unfortunately, CM students are not subsequently enrolled in the blended learning, so any comparison between traditional lecturing with almost all CM students and blended learning with nil CM students is incommensurate.

Table 7.2 Reduction of STF by instructional design

Year	Activity	Size	Index	Average
2007–08	Lecture	50	88.11	87.66
	Tutorial	23	86.69	
2011–12	Conspectus Pt2	31	84.43	84.79
	Seminar	18	85.43	

Therefore, the finding that 'not School' students are lower performers in blended learning is inconclusive and likely incorrect because of the lack of commensurate data and the accidental domination in the data of one nationality that has very low digital proficiency in blended learning. In other words, due to inadequate data, school affiliation does not emerge as a reliable predictor of high marks achievement in blended learning.

11. STF does decrease with a new and innovative instructional design being used in the classroom.

Table 7.2 shows a depreciation of the teacher's SFT[4] of 2.87 or 3.27%, from the last semester of the traditional lecturing to the last semester of blended learning. The SFT is always voluntary, but the regulation of participation changed during the five year period of the experiment. In the initial years of the experiment, the level of F2F attendance dictates the degree of students participation in the STF—as per the statistical analysis, this goes from 66 to 92%—plus the physicality of the process imposes a slight degree of restraint and deeper reckoning onto the students' scoring. However, once the input process is conducted online, the level of participation is significantly less with only the most vocal students airing their opinions, leading to more visceral and specious scorings, and more distortion from extreme and outlier scorings. Even worse, it is alleged that some students give feedback having never attended the teaching at all; instead, they base their feedback on the recorded lectures or hearsay from their peers. Presently, the level of participation is typically less than one-third of the cohort, and the responses constitute a polarization instead of a continuum, as exemplified by these two learner statements: "Never in my life have I been engaged in such a course …I'm really grateful"; and "Self-directed until lost".

Under these conditions, the findings of the STF are likely to be a commentary more on the teacher's popularity than his/her teaching acumen (Smith, 2003). In Jones (2012), the observation is that about 5–10% of the students in the study harbour sufficient resentment to disparage the teacher directly on student teaching feedback.

[4]STF is a University initiative circa 1990s for the students to biannually evaluate the effectiveness of the faculty's teaching for each course. In the first years of the program, the student inputs are collected on OCR forms handed out at the start of the F2F session. From 2010 onwards, the student data is collected online via a campus-wide website. Following the data collection, the School collates and analyses the feedback scores for school-level descriptive statistics such as mean and deviation, and then reports these statistics to the University and individual faculty member. The data shown in this study is from the teacher's records.

Ditcher and Hunter (2001) found that the faculty of another university believe that 24% of their students expect "to pass the course regardless of the amount of work done" (p. 3), inferring that up to a quarter of the students would give the faculty a poor STF score if they didn't get the mark they thought they deserved. Biggs, in a superlative (and inexplicably little cited) 1994 article, suggests that there may even be an ethnographic component to contend with: students in Confusion-heritage cultures—specifically China, Hong Kong, Korea, Singapore, and Taiwan—may be devastated if they feel the learning situation is beyond their ability to do well. Given how the STF scoring could easily become an outpouring of student acrimony, ill-will, and resentment, it is a certainty that these perceptions are worsened when the learning situation is transformed to something unfamiliar and seemingly non-authentic.

The teacher in this study is experienced and competent, and still suffered a 3.27% drop in the STF score; it could easily be a lot worse for new teachers. On top of the ignominy of experiencing a decline of STF score, there is the unpleasant attention that it brings from the School management along with the downgrading of performance ratings. Such unwelcome consequences of a decline however slight of the STF score is enough to deter a lot of the faculty from experimenting with innovative learning and teaching methods.

Contributions to Extant Knowledge

The following are the contributions from this study to the body of knowledge about the operation of blended learning in the classroom comprising higher education learners from Asia (see Table 7.3 for a summary).

#1. Blended learning in Asia. The majority of the blended learning literature is situated in non-Asian contexts. Due to this, the meme from educationalists and policy makers in Asia is that "the blended learning research" is not congruent with the reality of Asian—or more concretely Confusion-heritage cultures'—circumstances. This sentiment is backed up by eminent authors, such as Biggs who claims "misperception across cultures, a situation made more complicated by the application of Western conceptions of teaching and learning to an Eastern context" (Biggs, 1994, p. 60). This

Table 7.3 Summary of contributions

Blended learning in Asia
Higher education teaching without lecturing
Linking learning achievement with nationality and 'digital divide'
New design for ILS report
Design of inceptive ILS-based prediction mechanism of academic performance
Inceptive report on attendance and normalized marks of different schools in the University, and a technical template for innovative teaching

study is the first case study of blended learning in a core course in the University and probably in any higher education institutions in Singapore.

#2. Higher education teaching without lecturing. In the School and most of the University, faculty conflate contact hours with lecturing. This is a dogmatism; it is not grounded in any reality of a dearth of suitable replacement instructional designs. There are almost "as many learning activities as one can imagine" that a teacher may conduct during higher education F2F sessions that are far removed from and just as effective as lecturing. This study provides ample substantiation, that removing lecturing from the F2F learning sessions not only is bereft of a systemic meltdown, but it is also can have the students employing deep learning approaches and experiencing higher achievement in the learning outcomes (the magnitude depending on the replacement instructional design).

#3. Linking learning achievement with nationality and 'digital divide'. The finding in the statistical analysis that students of two nationalities appeared to experience a detrimental effect from in blended learning is noteworthy in itself. But it is eclipsed by the conclusion in this chapter that the 'digital divide' of a nationality may be linked to learning achievement in blended learning. This is most serendipitous because it opens a new domain of discourse in the operation of blended learning in higher education and in the analysis of the effectiveness of new instructional designs.

#4. New design for ILS report. It is remarkable that since 1988 when Felder and Silverman published their seminal paper on learning styles, through all the updates to the body knowledge including by Felder himself (1996; 2005), and for all the critiques, comparisons, and other analyses of the Felder learning styles, for example, Graf, Viola, and Kinshuk (2007), and Graf and Liu (2009), there was no concerted enhancement to the presentation format of the ILS report for large-scale data. The new design proposed in this study increases the readability and user friendliness of the ILS report for a large population of test subjects, and coincidently may foster a new wave of appreciation for the Felder and Silverman model.

#5. Design of inceptive ILS-based prediction mechanism of academic performance. It is also remarkable that there is not more literature concerning the application of ILS reporting in learning and teaching research. To the author of this study, an understanding of the student's observed achievement in learning is enhanced by an appreciation of his/her innate ability to learn. The Felder and Silverman model of learning styles provides such an appreciation of learning ability. To paraphrase a recent comparative study of learning style instruments by Hawk and Shah (2007), propositions for using learning styles include determining what learning activities might be harmonious with the learners and hence maximize their academic performance. This study is the first in Singapore and may be the first in Asia to follow the proposition of Hawk and Shah in using the ILS report for attempting to predict the effectiveness of learning stemming from an instructional design.

#6. Inceptive report on attendance and normalized marks of different schools in the University, and a technical template for innovative teaching. The University is now embarking on two programs, the "Technology-Enabled Learning" (TEL) and "*Outcomes*-based Teaching and *Learning*", to improve the state of its learning and teaching. Besides being widely dismissed and inconsistently applied, the enactment of these initiatives is seemingly without quantitative evidence of exactly what

learning and teaching shortcomings need improvement. The University has never engaged in community discourse on learning and teaching, or circulated any statistics on even just two of the most significant indicators of learning performance, attendance and normalized marks. This makes the findings of our study the first of its kind, in particular those that elucidate the performance of the students from different schools. For receptive officialdom, the methodology and analysis in this study are an exemplification for conducting such investigations of the cohorts in the future. Moreover, our research platform turns out to be the technical template for the instructional design used in the TEL program.

Limitations

The following are the limitations imposed on this study according to its context, conditions, and resources (see Table 7.4 for a summary).

#1. Undesired reduction of test subjects. When the research began, the average size of the yearly intake of students in the course was 230. So, the expected number of observations for a five year run of the experiment would be of magnitude 1150. However, with the introduction of the Computer Science degree in 2008, the intake immediately dropped 25.8%. Over the three years that followed to the experiment's end, the intake dropped 32.2%, 42.5%, and 44.6% respectively, leading to the overall actual observations being only 856 (a much lower figure than expected). Although the quantity of actual observations is prodigious, there is no knowing what findings might have emerged from there being further observations.

#2. Incongruent scheduling of learning sessions. This pertains to the students' weekly timetables produced by the University. As mentioned in Chapter Three, the weekly timetable contains three kinds of learning periods, lecture, tutorial, and laboratory, with their unique groupings of students—cohorts are subdivided into groups, each having a different tutorial and laboratory—and matching learning spaces such as lecture theatres, tutorial rooms, and labs. Inappropriately, every course's periods are scheduled in the week with disregard to any pedagogy and interrelationship. Exacerbated by the disinclination of the University and School to change the learning periods, especially with lectures no longer existing, the viable work-around is replace the learning activities within each allocated time slot in the week with blended learning compliant ones. Nevertheless, the inherent pedagogical discontinuity from the incongruent scheduling remained, and in some small but real way, undermined the learning progress of select students.

Table 7.4 Summary of limitations

Undesired reduction of test subjects
Incongruent scheduling of learning sessions
No provision of teaching assistant
No moratorium on STF during the experiment
No promotion to the cohort of the research being mainstream

#3. No provision of teaching assistant. Teaching assistants are a welcome relief for some of the teacher's workload; in the School, however, they are a limited resource that is not available to all teachers. Teaching assistance is not an obligation in the terms of the postgraduate candidacy, so while supervisors can assign their postgraduate students to do teaching assistance duty for them, teachers without postgraduate students cannot. As alluded to in an earlier conclusion concerning the realization of instructional designer and implementer roles, the implementation and evolution of the blended learning is a tremendous amount of work. Unfortunately, despite numerous requests, the School did not make special provision of a teaching assistant to the teacher in the conduct of the experiment until the 10th semester. The unavailability of such assistance undoubtedly contributed to the experiment ending due to the exhaustion of the teacher.

#4. No moratorium on STF during the experiment. Despite numerous requests, the School did not support the teacher and make the case to the University to cease the conduct of STF for the period of the experiment. As stated in the earlier conclusion about STF, the teacher experienced a drop of 3.27% in his score. Subsequently, the teacher conducting the experiment received negative fallout from the University on his STF drop. While leaving the teacher more wary about taking up such research in the future, the effect that the STF drop had on his colleagues is more pronounced, to the degree that some, although completely convinced of lecturing's ineffectiveness, nevertheless refuse to adopt new learning activities of any sort into their classrooms. In a final word on the events concerning the research (Jones, 2012), the teacher that a moratorium on STF be approved for any research involving student learning, and allow instead the researcher to gather his/her own feedback that is more appropriate and useful.

#5. No promotion to the cohort of the research being mainstream. The School is well aware of blended learning and the plan to realize it in the Software Engineering course because it reviewed and formally accepted the proposal for such. Disappointingly, after formally accepting it, the School declined to subsequently promote the experiment to the faculty and the students as a mainstream and concerted effort. Particularly significant is the non-inclusion of the experiment and its association to the trend of increasing learning innovation, at the annual briefing to the second year cohort. Similar to the limitation of scheduling incongruity, the absence of overt support for the research may have in some small but real way, diminished the authenticity of blended learning for some students, and possibly even undermined their achievement in the learning outcomes.

Agenda for Further Research

The following are suggestions for areas of further research in the operation of blended learning in the classroom comprising higher education learners from Asia (see Table 7.5 for a summary).

Table 7.5 Summary of further research

Test and verify the ILS-based prediction mechanism
Study the relationship of engagement and academic performance
Convert more courses to blended learning
Study the impact of prior experience
Analyse the dependency of the ILS report's bands

1. Test and verify the ILS-based prediction mechanism. This study proposes using a particular set of scores in the ILS report score as a prediction mechanism for the potential of high achievement in blended learning. Naturally, further research should be conducted to determine the predictive power and accuracy of that mechanism. Possibly the first concerns that such research could address are the dependence or independence of the bands' scores as predictors, and the relation of the ILS report to difference courses still within the same degree program, and those in a different degree program.

2. Study the relationship of engagement and academic performance. This study has shown that relationship of attendance and academic performance is far more complex than is presently perceived by the University and the School. Clearly, attendance does affect academic performance, viewing recorded lectures in lieu of attending the live session does not enhance or even maintain academic performance, and attendance is not merely a visceral response by students to poor teaching acumen. Further research should be conducted to determine all the factors in prior experience and learning situation that may affect attendance, and then establish the direct and indirect relations between attendance and academic performance.

3. Convert more higher education courses to blended learning. The experiment involves only one course with one teacher with a cohort from one school, and thus have prompted colleagues to call into question the veracity of the findings. Further research should be conducted with blended learning realized by different teachers with different content and from different schools to establish a broader perspective and deeper understanding of the effect of an innovative instructional design on learning and teaching in an Asian university.

4. Study the impact of prior experience. This study suggests that prior experience such as nationality and school not only normalizes the student cohort's academic performance in the instructional design promoted by the University, but also determines the cohort's performance in another instructional design. Further research should be conducted to determine to how prior experience correlates to academic performance in various instructional designs.

5. Analyse the dependency of the ILS report's bands. An unexpected finding of the statistical analysis is that some bands in the ILS report appear to be inter-dependent. In other words, a score in one band is typically coincident with a score in another. The literature on the learning styles and the ILS report make no mention of an inbuilt consistency-checking between bands. If anything, the specification of the learning style model infers that the bands are independent. Therefore, further research should be conducted to explore the extent of this observed condition and determine its cause and meaning. In keeping with the genesis of the learning style model being a joint effort by an engineer and psychologist, this further research into the characteristics of the model should adopt the same multi-disciplinary approach.

This chapter put forward 11 conclusions drawn from the statistical analysis findings, and posits 16 additions to the body of knowledge about the operation of blended learning in the classroom comprising higher education learners from Asia.

In a final statement, an epilogue, this monograph stands as an academic exploration of learning and teaching in higher education spanning seven intense yet rewarding years of effort. It is offered as both a chronicling of events in one corner of a technology-oriented university, and a sharing of growth of aptitude in and appreciation for one of the most honourable and challenging professions in society.

Buried under the mountain of work encompassed in the research, and surrounded by naysayer colleagues and management, it was almost impossible to envision a future where blended learning would be the norm for undergraduates, and lecturing would become a superbly-crafted specialty rather than a careless, robotic chore. Yet, a scant three years following the end of the experiment, the findings of this research are echoed in the collective response of most universities across the globe to the Covid-19 pandemic. An overwhelming number have mandated to convert 50% of all their courses to blended learning within five years. Many of these conversions are designed around a significant eLearning component that effects the majority of foundational learning in the course, and embraces the reduction and even elimination of lecturing in its F2F sessions. In fact, blended learning has taken a new life and meaning (cf. Jones & Sharma, 2020a, b). It refers to both teachers and students having the option (they deem fit) of simulcast, face-to-face or online (live or pre-recorded) interactions for lectures and other learning activities. There could not be a better endorsement of the findings reported in this monograph, than a legacy manifested by a major instructional design program, pushing the universities into the "brave new world" of twenty-first century learning and teaching.

Appendix A
Class Attendance Website

(https://wish.wis.ntu.edu.sg/webexe/owa/aus_class_attendance.main?p1=)

This appendix shows the source website and sample output of the University data.

Figure B.1 is the secure website in the University's campus intranet that supplies the data on request.

The course code for the Software Engineering was "CPE207". However, this code does not exist now as it was retired after a reorganization of all the courses to better differentiate the topic allocations for the two degree programs, Computer Engineering and Software Science.

The email address option is useful in contacting select students.

Both the student photo and attendance box options are not working (Fig. A.1).

Figure B.2 is an extract of a sample output generated by the website upon clicking the "Load Class Attendance List" button.

Note that the student identities in the output are masked.

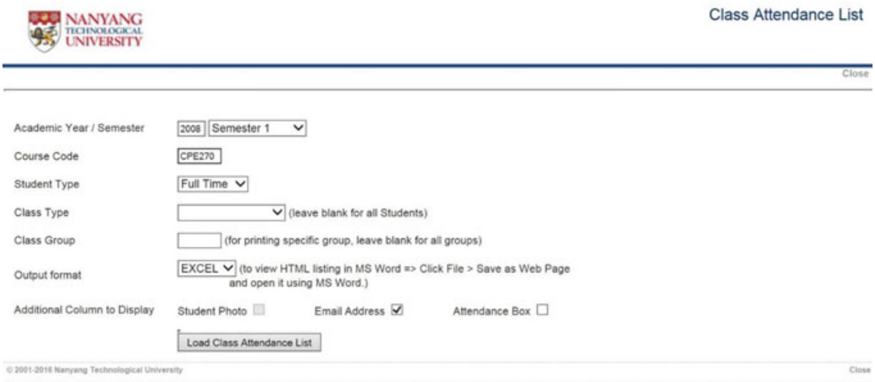

Fig. A.1 Screenprint of class attendance secure website

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	A	B	C	D	E	F	G	H	I
1		Class Attendance List: 2007, 1 Date: 01-AUG-2007 11:19							
2		Course: CE Full-Time							
3		Subject: CPE207 4AU							
4		Class Type: TUT							
5									
6		Class Group: SEA1							
7		Day-Time: Mon 0930 To: 1030 Wk1-13							
8		Venue: TR8							
9		NORTH,LEVEL 5, BETWEEN MPE AND SCE							
10									
11	No.	Name	Prog/ Yr/ Course Type/ Nationality/ VMS Acc						
12	1	STUDENT1	CE2	C	SG	CAIR0002			
13	2	STUDENT2	CE2	C	CN	CHEN0331			
14	3	STUDENT3	CE2	C	CN	GONG0005			
15	4	STUDENT4	CE2	C	VN	HA0001NH			
16	5	STUDENT5	CE2	C	CN	HELU0001			
17	6	STUDENT6	CE2	C	CN	LENG0010			
18	7	STUDENT7	CE1	C	SG	LEON0076			
19	8	STUDENT8	CE2	C	CN	LIUY0029			
20	9	STUDENT9	CE1	C	CN	LOOK0006			
21	10	STUDENT10	CE2	C	SG	ONGW0033			
22	11	STUDENT11	CE2	C	VN	POKW0001			
23	12	STUDENT12	CE2	C	SG	QUXI0001			
24	13	STUDENT13	CE2	C	SG	TANC0121			
25	14	STUDENT14	CE2	C	CN	TANK0046			
26	15	STUDENT15	CE2	C	ID	XI0001EN			

class attendance

Fig. A.2 Screenprint of Excel file output from the class attendance website

Although "CE2" is placed in the Prog/Yr column, it is actually an abridged designation of the cohort that shows only the degree program "CE" but not the year of enrolment. The digit "2" indicates that the student is in his/her second year of attendance in the degree program (Fig. A.2).

"C" is the course type abbreviation for "core" that is a mandatory course that all students in the CE cohorts must complete in order to qualify for the degree.

The nationality data is the next column.

The final column is the email user designation that is retired after the student graduates or leaves NTU.

Appendix B
Learning Style Online Questionnaire and Report

(https://www.engr.ncsu.edu/learningstyles/ilsweb.html)

This appendix shows the questionnaire website and sample report of the student ILS data.

Figure A.1 (across four pages) is the 44 binary choice questions in the instrument created by Soloman and Felder to gather the learning condition choices that reveal a person's learning style. It takes in the range of 15–20 min to complete and submit (Fig. B.1).

Figure B.2 is a sample report returned to the participant of his/her learning style. It takes approximately one minute for the report to be rendered in the participant's monitor.

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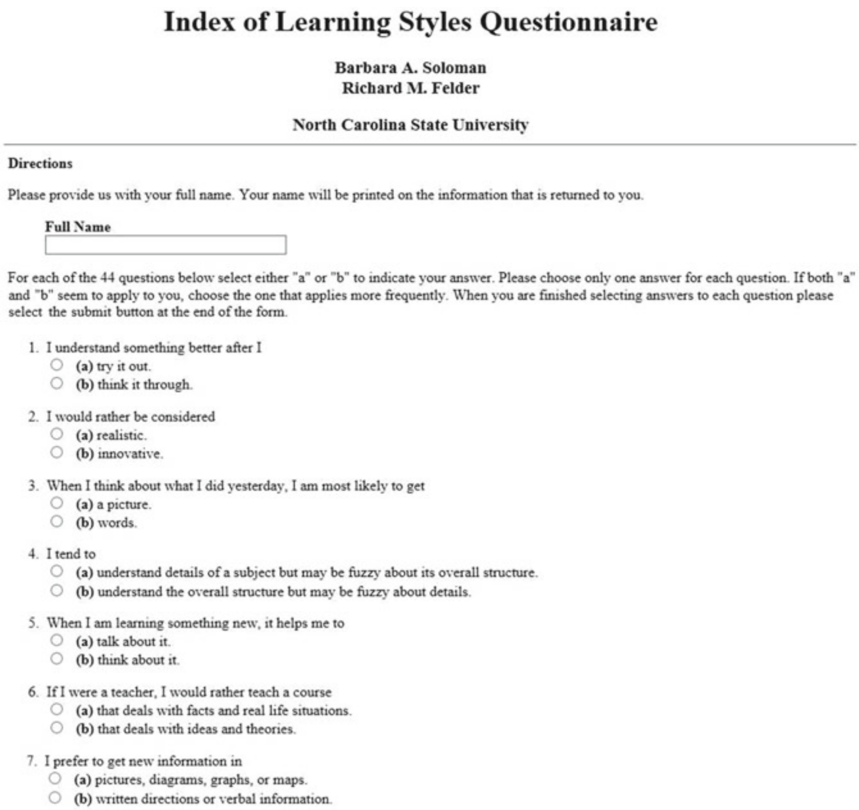

Index of Learning Styles Questionnaire

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Richard M. Felder

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Directions

Please provide us with your full name. Your name will be printed on the information that is returned to you.

Full Name

For each of the 44 questions below select either "a" or "b" to indicate your answer. Please choose only one answer for each question. If both "a" and "b" seem to apply to you, choose the one that applies more frequently. When you are finished selecting answers to each question please select the submit button at the end of the form.

1. I understand something better after I
   - **(a)** try it out.
   - **(b)** think it through.
2. I would rather be considered
   - **(a)** realistic.
   - **(b)** innovative.
3. When I think about what I did yesterday, I am most likely to get
   - **(a)** a picture.
   - **(b)** words.
4. I tend to
   - **(a)** understand details of a subject but may be fuzzy about its overall structure.
   - **(b)** understand the overall structure but may be fuzzy about details.
5. When I am learning something new, it helps me to
   - **(a)** talk about it.
   - **(b)** think about it.
6. If I were a teacher, I would rather teach a course
   - **(a)** that deals with facts and real life situations.
   - **(b)** that deals with ideas and theories.
7. I prefer to get new information in
   - **(a)** pictures, diagrams, graphs, or maps.
   - **(b)** written directions or verbal information.

Fig. B.1 Screenprint of ILS questionnaire website

8. Once I understand
   - (a) all the parts, I understand the whole thing.
   - (b) the whole thing, I see how the parts fit.

9. In a study group working on difficult material, I am more likely to
   - (a) jump in and contribute ideas.
   - (b) sit back and listen.

10. I find it easier
   - (a) to learn facts.
   - (b) to learn concepts.

11. In a book with lots of pictures and charts, I am likely to
   - (a) look over the pictures and charts carefully.
   - (b) focus on the written text.

12. When I solve math problems
   - (a) I usually work my way to the solutions one step at a time.
   - (b) I often just see the solutions but then have to struggle to figure out the steps to get to them.

13. In classes I have taken
   - (a) I have usually gotten to know many of the students.
   - (b) I have rarely gotten to know many of the students.

14. In reading nonfiction, I prefer
   - (a) something that teaches me new facts or tells me how to do something.
   - (b) something that gives me new ideas to think about.

15. I like teachers
   - (a) who put a lot of diagrams on the board.
   - (b) who spend a lot of time explaining.

16. When I'm analyzing a story or a novel
   - (a) I think of the incidents and try to put them together to figure out the themes.
   - (b) I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.

17. When I start a homework problem, I am more likely to
   - (a) start working on the solution immediately.
   - (b) try to fully understand the problem first.

18. I prefer the idea of
   - (a) certainty.
   - (b) theory.

19. I remember best
   - (a) what I see.
   - (b) what I hear.

20. It is more important to me that an instructor
   - (a) lay out the material in clear sequential steps.
   - (b) give me an overall picture and relate the material to other subjects.

21. I prefer to study
   - (a) in a study group.
   - (b) alone.

22. I am more likely to be considered
   - (a) careful about the details of my work.
   - (b) creative about how to do my work.

23. When I get directions to a new place, I prefer
   - (a) a map.
   - (b) written instructions.

Fig. B.1 (continued)

24. I learn
   - (a) at a fairly regular pace. If I study hard, I'll "get it."
   - (b) in fits and starts. I'll be totally confused and then suddenly it all "clicks."

25. I would rather first
   - (a) try things out.
   - (b) think about how I'm going to do it.

26. When I am reading for enjoyment, I like writers to
   - (a) clearly say what they mean.
   - (b) say things in creative, interesting ways.

27. When I see a diagram or sketch in class, I am most likely to remember
   - (a) the picture.
   - (b) what the instructor said about it.

28. When considering a body of information, I am more likely to
   - (a) focus on details and miss the big picture.
   - (b) try to understand the big picture before getting into the details.

29. I more easily remember
   - (a) something I have done.
   - (b) something I have thought a lot about.

30. When I have to perform a task, I prefer to
   - (a) master one way of doing it.
   - (b) come up with new ways of doing it.

31. When someone is showing me data, I prefer
   - (a) charts or graphs.
   - (b) text summarizing the results.

32. When writing a paper, I am more likely to
   - (a) work on (think about or write) the beginning of the paper and progress forward.
   - (b) work on (think about or write) different parts of the paper and then order them.

33. When I have to work on a group project, I first want to
   - (a) have "group brainstorming" where everyone contributes ideas.
   - (b) brainstorm individually and then come together as a group to compare ideas.

34. I consider it higher praise to call someone
   - (a) sensible.
   - (b) imaginative.

35. When I meet people at a party, I am more likely to remember
   - (a) what they looked like.
   - (b) what they said about themselves.

36. When I am learning a new subject, I prefer to
   - (a) stay focused on that subject, learning as much about it as I can.
   - (b) try to make connections between that subject and related subjects.

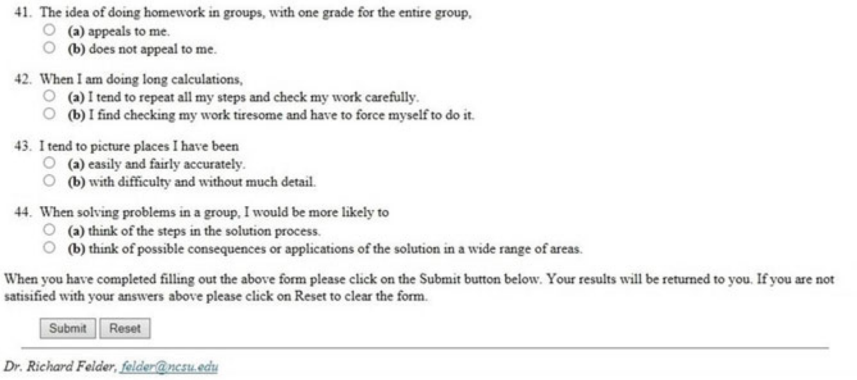
37. I am more likely to be considered
   - (a) outgoing.
   - (b) reserved.

38. I prefer courses that emphasize
   - (a) concrete material (facts, data).
   - (b) abstract material (concepts, theories).

39. For entertainment, I would rather
   - (a) watch television.
   - (b) read a book.

40. Some teachers start their lectures with an outline of what they will cover. Such outlines are
   - (a) somewhat helpful to me.
   - (b) very helpful to me.

Fig. B.1 (continued)



41. The idea of doing homework in groups, with one grade for the entire group,
   - (a) appeals to me.
   - (b) does not appeal to me.

42. When I am doing long calculations,
   - (a) I tend to repeat all my steps and check my work carefully.
   - (b) I find checking my work tiresome and have to force myself to do it.

43. I tend to picture places I have been
   - (a) easily and fairly accurately.
   - (b) with difficulty and without much detail.

44. When solving problems in a group, I would be more likely to
   - (a) think of the steps in the solution process.
   - (b) think of possible consequences or applications of the solution in a wide range of areas.

When you have completed filling out the above form please click on the Submit button below. Your results will be returned to you. If you are not satisified with your answers above please click on Reset to clear the form.

Submit Reset

Dr. Richard Felder, felder@ncsu.edu

Fig. B.1 (continued)

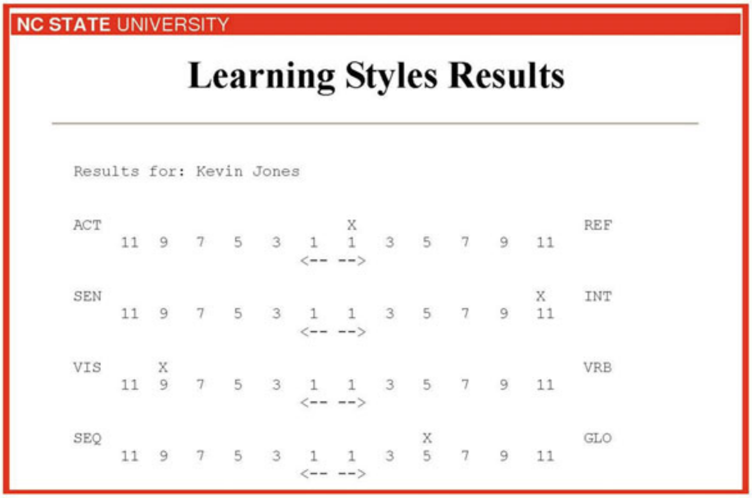


Fig. B.2 Screenprint of ILS report

Appendix C
School's Hardcopy of Marks

This appendix shows an extract of the hardcopy listing of coursework, examination, and final marks held by the University.

Figure C.1 is the first page of the listing showing various descriptive statistics for the marks therein.

Figure C.2 is the second page of the listing showing the three marks, and student names masked.

K. A. Jones and R. S. Sharma, *Higher Education 4.0*,
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Course Total Mark List For CPE207 (Full-Time)
SOFTWARE ENGINEERING
Academic Year : 2008 Semester : 2

Name Order ALL STUDENTS

***NOTE : These statistics DO NOT include Non-graduating, PEB and Postgraduate students.**

COURSE STATISTICS

Total Number of Students	:	117
Total Number of Absentees	:	0
Total Number of IP	:	0
Overall Course Mean	:	65.5
Overall Course Standard Deviation	:	10.1
Coursework Mean	:	68.0
Coursework Standard Deviation	:	7.2
Exam Mean	:	65.3
Exam Standard Deviation	:	9.3

COURSE STATISTICS (Exclude Exam Absentees)

Total Number of Students	:	110
Total Number of Absentees	:	0
Total Number of IP	:	0
Overall Course Mean	:	67.5
Overall Course Standard Deviation	:	6.3
Coursework Mean	:	67.9
Coursework Standard Deviation	:	7.2
Exam Mean	:	65.3
Exam Standard Deviation	:	9.3

GRADE DISTRIBUTION

GRADE	Mark Range	NUMBER OF STUDENTS	NUMBER OF STUDENTS BY %
A+	85 - 100		0.00
A	80 - 84	2	1.71
A-	75 - 79	14	11.97
B+	70 - 74	30	25.64
B	65 - 69	35	29.91
B-	60 - 64	19	16.24
C+	55 - 59	6	5.13
C	50 - 54	3	2.56

COURSE TOTAL MARK DISTRIBUTION

COURSE TOTAL MARKS	NUMBER OF STUDENTS	NUMBER OF STUDENTS BY %	COURSE TOTAL MARKS	NUMBER OF STUDENTS	NUMBER OF STUDENTS BY %
0	0	0.00	51	0	0.00
1	0	0.00	52	2	1.71
2	0	0.00	53	0	0.00
3	0	0.00	54	0	0.00
4	0	0.00	55	2	1.71
5	0	0.00	56	0	0.00
6	0	0.00	57	0	0.00
7	0	0.00	58	3	2.56
8	0	0.00	59	1	0.85
9	0	0.00	60	4	3.42
10	0	0.00	61	2	1.71
11	0	0.00	62	4	3.42
12	0	0.00	63	3	2.56
13	0	0.00	64	6	5.13
14	0	0.00	65	11	9.40
15	0	0.00	66	8	6.84
16	0	0.00	67	9	7.69
17	0	0.00	68	2	1.71
18	0	0.00	69	5	4.27
19	0	0.00	70	8	6.84
20	0	0.00	71	8	6.84
21	0	0.00	72	8	6.84
22	0	0.00	73	4	3.42
23	0	0.00	74	2	1.71
24	0	0.00	75	6	5.13
25	0	0.00	76	3	2.56
26	0	0.00	77	3	2.56
27	0	0.00	78	1	0.85
28	0	0.00	79	1	0.85
29	0	0.00	80	2	1.71
30	0	0.00	81	0	0.00
31	1	0.85	82	0	0.00
32	1	0.85	83	0	0.00
33	0	0.00	84	0	0.00
34	2	1.71	85	0	0.00
35	2	1.71	86	0	0.00
36	0	0.00	87	0	0.00
37	1	0.85	88	0	0.00
38	0	0.00	89	0	0.00
39	0	0.00	90	0	0.00
40	0	0.00	91	0	0.00
41	0	0.00	92	0	0.00
42	0	0.00	93	0	0.00
43	0	0.00	94	0	0.00
44	0	0.00	95	0	0.00
45	0	0.00	96	0	0.00
46	0	0.00	97	0	0.00
47	0	0.00	98	0	0.00
48	1	0.85	99	0	0.00
49	0	0.00	100	0	0.00
50	1	0.85			
			TOTAL :	117	100 %

Fig. C.1 Photocopy of page 1 of marks listing

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DEAN006

Course Total Mark List For CPE207 (Full-Time)
SOFTWARE ENGINEERING
Academic Year : 2008 Semester : 2

Name Order

ALL STUDENTS

PRGM	COURSEWORK (60%)	EXAMINATION (40%)	COURSE TOTAL
CE	69	80	73B+
CE	56	72	62B-
CE	66	46	58C+
CE	71	74	72B+
CE	74	58	68B
CE	*58*	*ABS*	*35F*
CE	59	68	63B-
CE	70	76	72B+
CE	75	87	80A
CE	57	64	60B-
CE	79	73	77A-
CE	67	68	67B
CE	62	53	58C+
CE	71	61	67B
CE	62	37	52C
CE	72	51	64B-
CE	69	73	71B+
CE	72	59	67B
CE	69	77	72B+
CE	*62*	*ABS*	*37F*
CE	70	74	72B+
CE	66	66	66B
CE	74	43	62B-
CE	68	63	66B
CE	70	76	72B+
CE	65	62	64B-
CE	67	47	59C+
CE	77	61	71B+
CE	68	77	72B+
CE	45	57	50C
CE	74	82	77A-
CE	66	62	64B-
CE	74	74	74B+
CE	70	50	62B-
CE	77	75	76A-
CE	70	75	72B+
CE	77	72	75A-
CE	71	69	70B+
CE	63	69	65B
CE	60	59	60B-
CE	79	68	75A-
CE	83	76	80A

s

Page 2

Fig. C.2 Photocopy of page 2 of marks listing

Appendix D
Marks Data Set

This appendix shows the listing of the coursework, examination, and final marks in the data set (Tables D.1, D.2 and D.3).

Table D.1 Coursework marks

Value	Freq	%
85	1	0.12
83	2	0.23
82	4	0.47
81	3	0.35
80	13	1.52
79	19	2.22
78	25	2.92
77	36	4.21
76	36	4.21
75	59	6.89
74	79	9.23
73	67	7.83
72	55	6.43
71	53	6.19
70	57	6.66
69	59	6.89
68	41	4.79
67	56	6.54

(continued)

K. A. Jones and R. S. Sharma, *Higher Education 4.0*,
https://doi.org/10.1007/978-981-33-6683-1

Table D.1 (continued)

Value	Freq	%
66	30	3.5
65	35	4.09
64	24	2.8
63	11	1.29
62	15	1.75
61	14	1.64
60	15	1.75
59	6	0.7
58	6	0.7
57	7	0.82
56	5	0.58
55	6	0.7
54	1	0.12
53	1	0.12
52	5	0.58
47	3	0.35
46	1	0.12
45	2	0.23
32	1	0.12
24	1	0.12
20	1	0.12
9	1	0.12

Table D.2 Exam marks parts 1 and 2

Value	Freq	%
87	2	0.23
86	1	0.12
85	1	0.12
83.5	1	0.12
83	6	0.7
82.5	1	0.12
82	3	0.35
81	11	1.29
80	4	0.47
79.5	1	0.12

(continued)

Table D.2 (continued)

Value	Freq	%
79	6	0.7
78.5	1	0.12
78	6	0.7
77.5	2	0.23
77	18	2.1
76.5	1	0.12
76	21	2.45
75.5	3	0.35
75	22	2.57
74.5	1	0.12
74	30	3.5
73.5	2	0.23
73	24	2.8
72.5	6	0.7
72	32	3.74
71.5	4	0.47
71	24	2.8
70.5	3	0.35
70	34	3.97
69.5	2	0.23
69	30	3.5
68.5	3	0.35
68	44	5.14
67.5	4	0.47
67	32	3.74
66.5	2	0.23
66	35	4.09
65.5	4	0.47
65	34	3.97
64.5	6	0.7
64	29	3.39
63.5	5	0.58
63	24	2.8
62.5	1	0.12
62	33	3.86
61.5	6	0.7

(continued)

Table D.2 (continued)

Value	Freq	%
61	24	2.8
60.5	5	0.58
60	30	3.5
59.5	2	0.23
59	13	1.52
58.5	4	0.47
58	20	2.34
57	18	2.1
56.5	2	0.23
56	13	1.52
55.5	1	0.12
55	20	2.34
54.5	5	0.58
54	14	1.64
53.5	3	0.35
53	10	1.17
52.5	1	0.12
52	7	0.82
51	9	1.05
50.5	3	0.35
50	11	1.29
49	6	0.7
48.5	3	0.35
48	10	1.17
47.5	1	0.12
47	4	0.47
46	3	0.35
45.5	3	0.35
45	3	0.35
44.5	3	0.35
43.5	1	0.12
43	6	0.7
42.5	1	0.12
41	2	0.23
40.5	1	0.12
40	1	0.12
39	1	0.12

(continued)

Table D.2 (continued)

Value	Freq	%
37	3	0.35
35.5	2	0.23
34	1	0.12
29	1	0.12
0	20	2.34

Table D.3 Final marks parts 1 and 2

Value	Freq.	%
85	1	0.12
83	1	0.12
82	1	0.12
81	3	0.35
80	7	0.82
79	8	0.93
78	15	1.75
77	13	1.52
76	28	3.27
75	50	5.84
74	30	3.5
73	35	4.09
72	45	5.26
71	49	5.72
70	108	12.62
69	33	3.86
68	45	5.26
67	51	5.96
66	53	6.19
65	68	7.94
64	18	2.1
63	19	2.22
62	25	2.92
61	24	2.8
60	37	4.32
59	6	0.7

(continued)

Table D.3 (continued)

Value	Freq.	%
58	15	1.75
57	7	0.82
56	6	0.7
55	10	1.17
54	5	0.58
53	6	0.7
52	2	0.23
51	2	0.23
50	4	0.47
48	2	0.23
46	3	0.35
45	1	0.12
40	1	0.12
38	2	0.23
37	1	0.12
36	1	0.12
35	1	0.12
34	1	0.12
33	2	0.23
32	1	0.12
31	3	0.35
28	3	0.35
19	1	0.12
12	2	0.23
5	1	0.12

The following figures show the histograms fitted with the normal distribution curves for the coursework, examination, and final marks in the data set (Figs. D.1, D.2 and D.3).

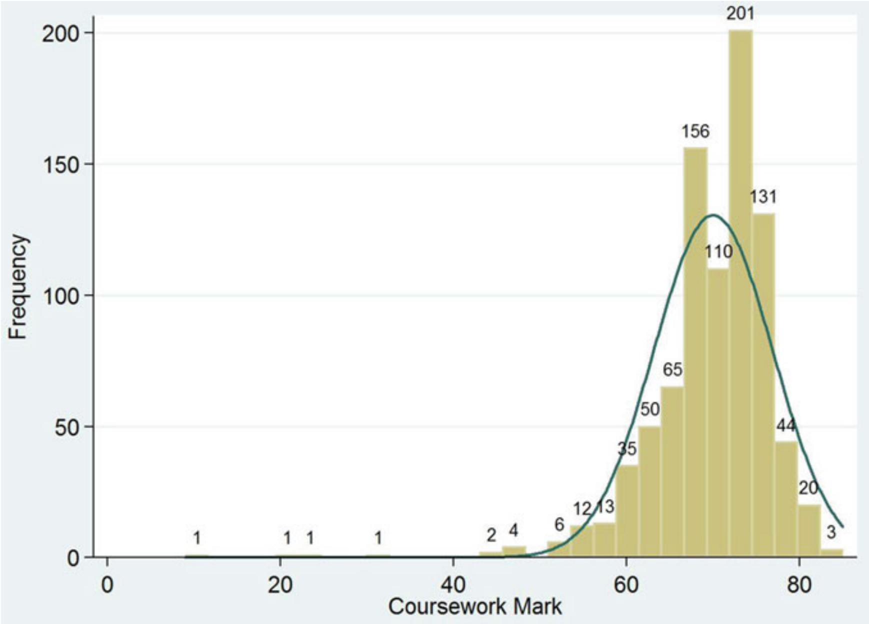

Fig. D.1 Coursework marks histogram with normal curve

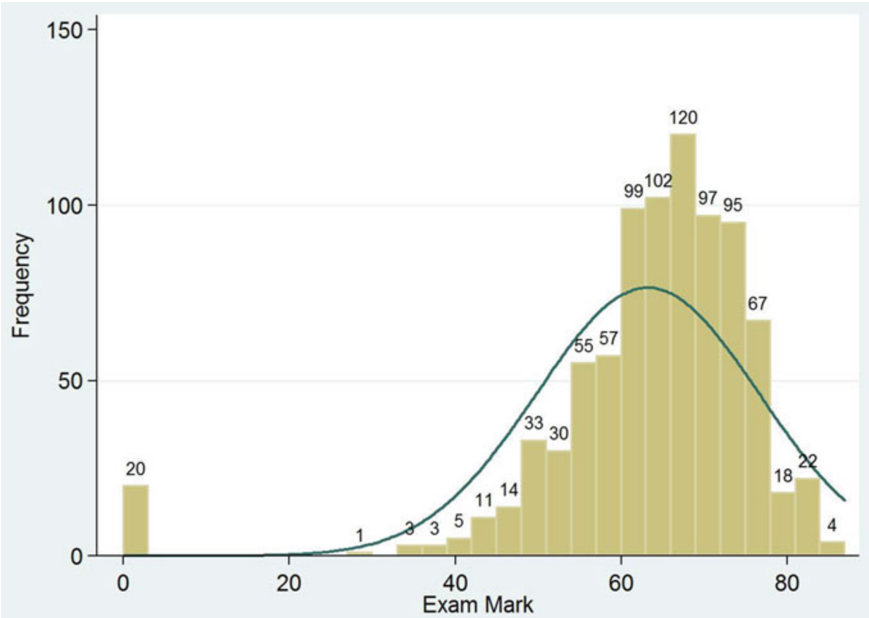

Fig. D.2 Exam marks histogram with normal curve

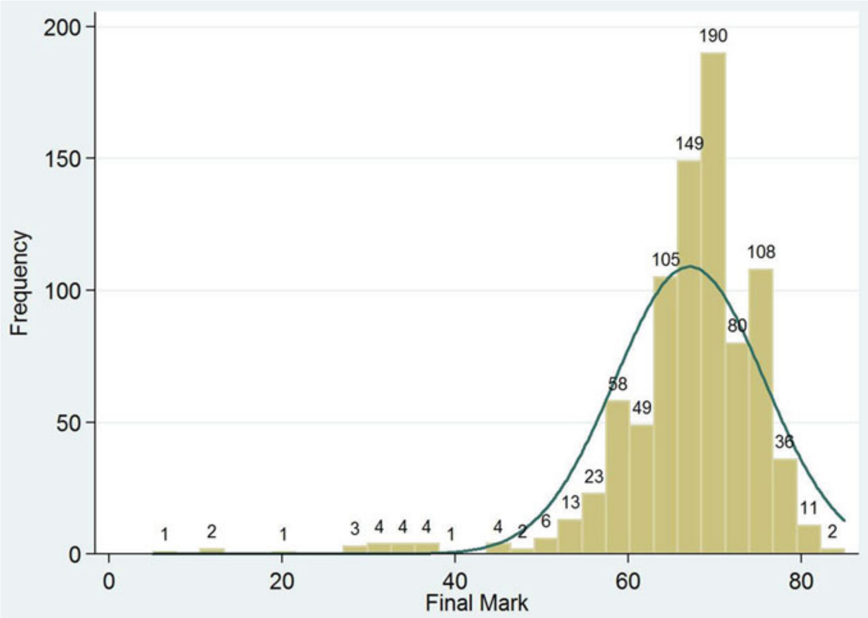

Fig. D.3 Final marks histogram with normal curve

Appendix E
Attendance Data Set

This appendix shows the listing of the lecture, tutorial, and examination attendance in the data set (Tables E.1, E.2 and E.3).

Table E.1 Lecture attendance parts 1 and 2

Value	Freq.	%
100	349	40.77
96.15	10	1.17
95	44	5.14
92.31	69	8.06
91.67	34	3.97
90	1	0.12
88.46	7	0.82
87.5	1	0.12
87.1	36	4.21
84.62	41	4.79
83.33	32	3.74
80.77	2	0.23
80	1	0.12
79.2	20	2.34
76.92	19	2.22
75	9	1.05
73.08	3	0.35
71.3	19	2.22

(continued)

K. A. Jones and R. S. Sharma, *Higher Education 4.0*,
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Table E.1 (continued)

Value	Freq.	%
71.2	4	0.47
70.4	5	0.58
70	1	0.12
69.6	4	0.47
69.23	6	0.7
68	2	0.23
66.67	4	0.47
66.4	4	0.47
65.6	3	0.35
64.8	4	0.47
64	8	0.93
63.3	14	1.64
63.2	4	0.47
62.4	8	0.93
61.6	5	0.58
61.54	5	0.58
60	5	0.58
59.2	4	0.47
58.4	2	0.23
58.33	6	0.7
57.6	2	0.23
56.8	2	0.23
56	1	0.12
55.4	4	0.47
55.2	2	0.23
54.4	3	0.35
53.85	6	0.7
53.6	1	0.12
52.8	3	0.35
52	1	0.12
50.4	1	0.12
50	3	0.35
48	1	0.12
47.5	4	0.47
46.15	4	0.47
45.6	1	0.12
43.2	1	0.12
39.6	2	0.23

(continued)

Table E.1 (continued)

Value	Freq.	%
38.46	1	0.12
37.5	1	0.12
33.33	2	0.23
31.7	2	0.23
30.77	1	0.12
28.8	1	0.12
23.8	1	0.12
23.08	1	0.12
15.8	1	0.12
8.33	1	0.12
7.9	1	0.12
0	6	0.7

Table E.2 Tutorial attendance parts 1 to 3

Value	Freq.	%
100	356	41.59
94	1	0.12
92.31	62	7.24
92	3	0.35
91.67	58	6.78
90.5	2	0.23
89	1	0.12
88.5	1	0.12
87.5	2	0.23
87	1	0.12
86.5	1	0.12
86	1	0.12
85	2	0.23
84.62	33	3.86
84	4	0.47
83.5	2	0.23
83.33	20	2.34
83	4	0.47
82.5	4	0.47
82	6	0.7

(continued)

Table E.2 (continued)

Value	Freq.	%
80.77	1	0.12
80.5	1	0.12
80	2	0.23
79	3	0.35
78.5	1	0.12
78	3	0.35
77.5	4	0.47
77	1	0.12
76.92	24	2.8
76.5	2	0.23
76	3	0.35
75.5	1	0.12
75	13	1.52
74.5	5	0.58
74	6	0.7
73.5	2	0.23
73	3	0.35
72.5	3	0.35
72	3	0.35
71.5	1	0.12
71	6	0.7
70.5	2	0.23
70	1	0.12
69.5	4	0.47
69.23	13	1.52
69	2	0.23
68.5	4	0.47
68	4	0.47
67.5	3	0.35
67	3	0.35
66.67	2	0.23
66.5	4	0.47
66	8	0.93
65.5	2	0.23
65	2	0.23
64.5	4	0.47

(continued)

Table E.2 (continued)

Value	Freq.	%
64	4	0.47
62	1	0.12
61.54	14	1.64
61.5	2	0.23
61	3	0.35
60.5	4	0.47
60	4	0.47
59.5	1	0.12
59	6	0.7
58.5	2	0.23
58.33	2	0.23
58	1	0.12
57.5	2	0.23
57	1	0.12
56	3	0.35
55.5	1	0.12
55	2	0.23
54.5	1	0.12
54	1	0.12
53.85	5	0.58
53.5	2	0.23
53	1	0.12
52	3	0.35
51.5	2	0.23
51	1	0.12
50.5	1	0.12
50	7	0.82
49	1	0.12
48	1	0.12
46.5	1	0.12
46.15	4	0.47
46	4	0.47
45	2	0.23
44.5	1	0.12
43	2	0.23
42.5	1	0.12
42	1	0.12

(continued)

Table E.2 (continued)

Value	Freq.	%
41.67	2	0.23
41.5	1	0.12
41	2	0.23
40.5	1	0.12
40	10	1.17
39.5	2	0.23
38.46	1	0.12
37.5	1	0.12
34.5	1	0.12
34	2	0.23
33	3	0.35
30.77	2	0.23
28	1	0.12
25.5	1	0.12
25	1	0.12
23.5	1	0.12
23.08	1	0.12
23	1	0.12
21	1	0.12
20	1	0.12
16.67	3	0.35
15.8	1	0.12
15.38	1	0.12
0	10	1.17

Table E.3 Examination attendance

Value	Freq	%
100	836	97.66
0	20	2.34

The following figures show the histograms for the lecture, tutorial, and examination attendance in the data set (Figs. E.1, E.2 and E.3).

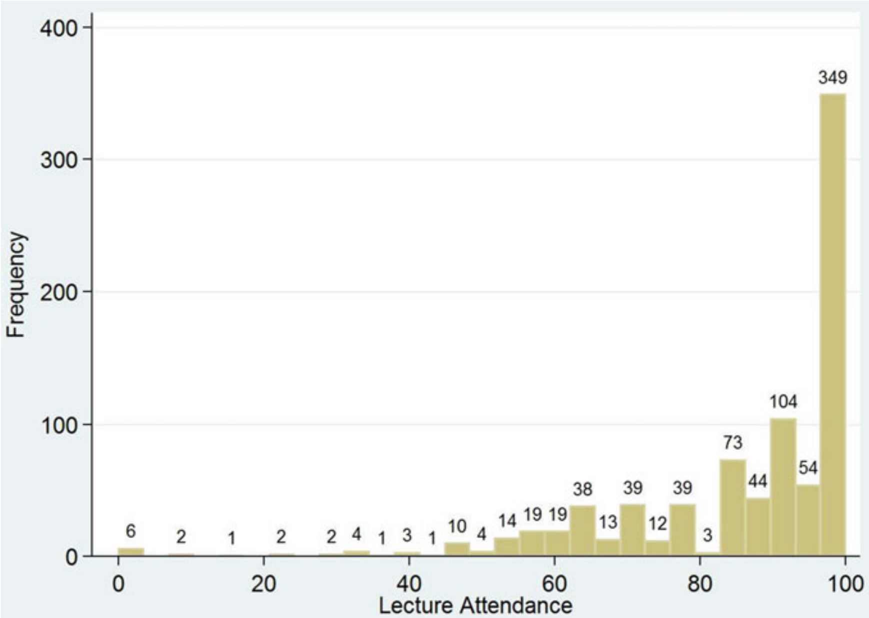


Fig. E.1 Lecture attendance histogram

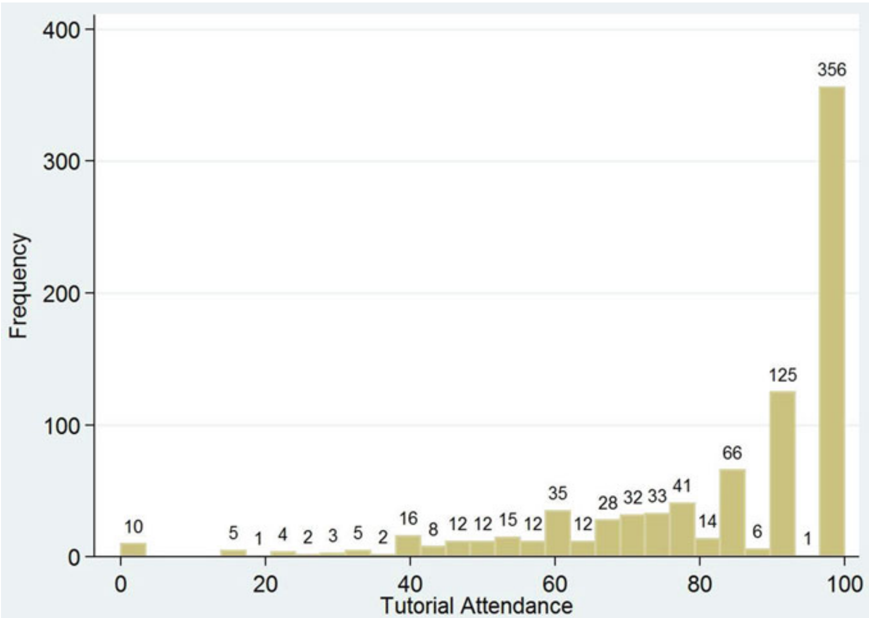


Fig. E.2 Lecture attendance histogram

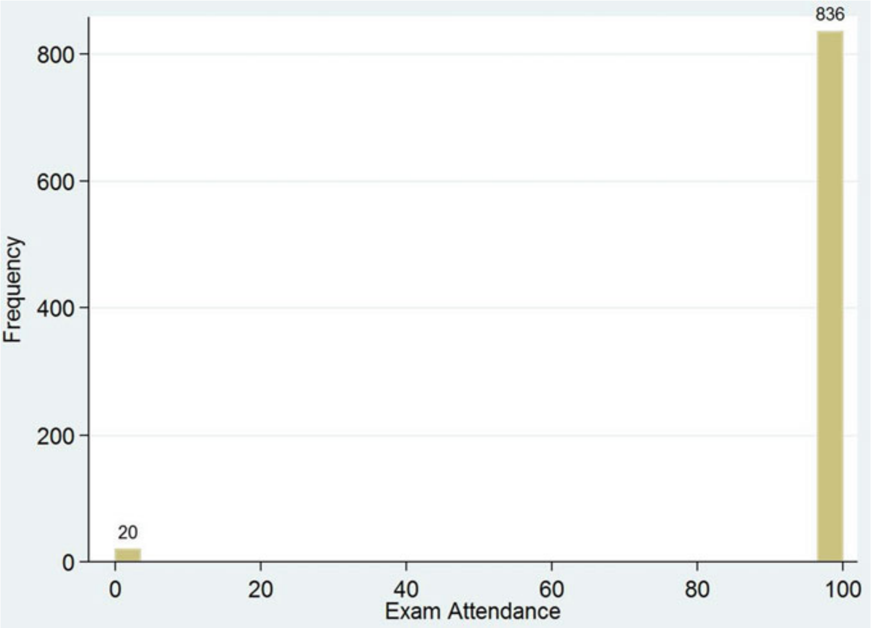


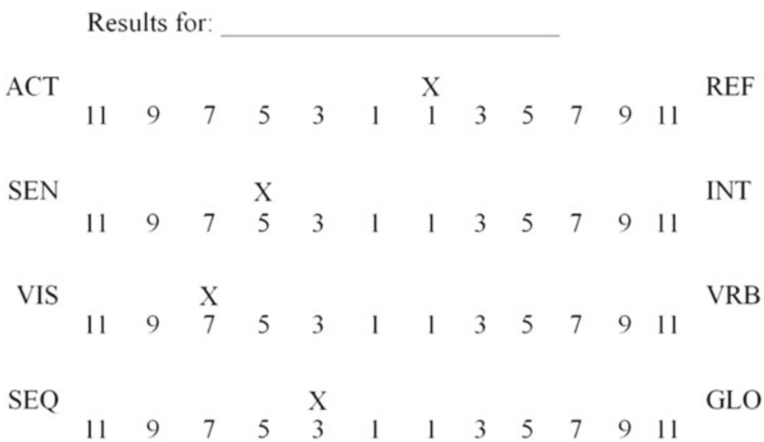
Fig. E.3 Exam attendance histogram

Appendix F
New Design of ILS Report for Many Scores

This appendix explains the evolution of the redesigned Felder-Soloman ILS report used for depicting the summation of many individual ILS scores.

Repetition of the scale for each band in the original format (Fig. F.1) obscures the salient information, “X” that indicates the ILS score in a band, from the viewer. Figure F.2 shows these are replaced by a single scale at the top. Also, information concerning the period of ILS survey, number of observations, and percentage of participation in survey during that period are added at the bottom.

Next the frequencies of the scores for each tuple of, the flanking cognitive responses in abbreviation and the top score scale, are totaled for the test subjects (Fig. F.3). For example three test subjects in the sample are ascribed a score of {active, 11} in their personal ILS report, so the frequency “3” is entered at the end of the row closest to “ACT” and below the column “11”.


Results for: ______________________

ACT							X						REF
	11	9	7	5	3	1	1	3	5	7	9	11	
SEN				X									INT
	11	9	7	5	3	1	1	3	5	7	9	11	
VIS			X										VRB
	11	9	7	5	3	1	1	3	5	7	9	11	
SEQ					X								GLO
	11	9	7	5	3	1	1	3	5	7	9	11	

Fig. F.1 Original format from the ILS report

K. A. Jones and R. S. Sharma, *Higher Education 4.0*,
https://doi.org/10.1007/978-981-33-6683-1

	11	9	7	5	3	1	1	3	5	7	9	11	
ACT							X						REF
SEN				X									INT
VIS			X										VRB
SEQ					X								GLO

Period ◆ # of Obs ◆ ratio of submitted to total

Fig. F.2 Original format refined

	11	9	7	5	3	1	1	3	5	7	9	11	
ACT	3	27	44	72	122	147	**151**	92	83	54	22	9	REF
SEN	22	54	117	**137**	115	119	85	75	48	19	21	14	INT
VIS	108	151	**185**	137	88	62	53	21	11	7	2	1	VRB
SEQ	9	39	59	103	**157**	128	98	110	62	37	20	4	GLO

2007-12 ◆ Obs = 826 ◆ Sampling rate = 96.5%

Fig. F.3 1st draft of new format

However, once completed, the four rows of frequencies visually overwhelm the report, even with the largest frequency bolded in each row. To facilitate an immediate recognition of the four largest frequencies, the rows are highlighted with a neutral (grey) tone that visually separates them and also accentuates the bolded frequency (Fig. F.4).

The 2nd draft of the new format is effective for viewing a single report, however, it is ineffective when several reports are contrasted in a single viewing, again because the largest frequencies in each report do not extrude from the separate reports to allow the immediate condensing of each report's salient information. Figure F.5 illustrates how the 2nd draft ILS reports for the two contrasting instructional design do not

	11	9	7	5	3	1	1	3	5	7	9	11	
ACT	3	27	44	72	122	147	**151**	92	83	54	22	9	REF
SEN	22	54	117	**137**	115	119	85	75	48	19	21	14	INT
VIS	108	151	**185**	137	88	62	53	21	11	7	2	1	VRB
SEQ	9	39	59	103	**157**	128	98	110	62	37	20	4	GLO

2007-12 • Obs = 826 • Sampling rate = 96.5%

Fig. F.4 2nd draft of new format

	11	9	7	5	3	1	1	3	5	7	9	11	
ACT	0	7	13	14	35	**49**	35	35	22	18	5	4	REF
SEN	7	15	**41**	30	34	38	21	20	16	8	7	0	INT
VIS	30	44	**51**	44	25	17	14	4	5	2	1	0	VRB
SEQ	1	12	18	29	**51**	48	30	22	13	9	4	0	GLO

2007-12 • Obs = 237 • Sampling rate = 90.5%

	11	9	7	5	3	1	1	3	5	7	9	11	
ACT	3	20	31	58	87	98	**116**	57	61	36	17	5	REF
SEN	15	39	76	**107**	81	81	64	55	32	11	14	14	INT
VIS	78	107	**134**	93	63	45	39	17	6	5	1	1	VRB
SEQ	8	27	41	74	**106**	80	68	88	49	28	16	4	GLO

2007-12 • Obs = 589 • Sampling rate = 99.2%

Fig. F.5 Two 2nd draft reports side-by-side

accentuate their differences; can you see the two differences between the reports' largest frequencies?

The other shortcoming of the 2nd draft format is that it does not highlight matching or near-matching frequencies in a band's adjacent columns, such as occurs in Fig. F.5 left-hand report's band four {SEQ 3 = "51" and SEQ 1 = "48"}. In review, the ILS scores in a band are not disjoint, so several test subjects who have a common learning style in reality, may receive scores in their ILS reports that are in adjacent columns. This phenomenality emerges immediately in small samples <30, but abates in large groups >100 as a clear centre-most frequency emerges. Notwithstanding, a format is needed to depict this phenomenality if and when it exists. In order to devise a format that would resolve all these issues, the author took his inspiration from three kinds of chart visualizations (Fig. F.6).

The new format (Fig. F.7) sanctioned for utilization in this study combines the readability of the column chart, the recognitive power of the colour intensity gradient of the litmus strip, and the visualization of centre of concentrations of matching frequencies in blot tests.

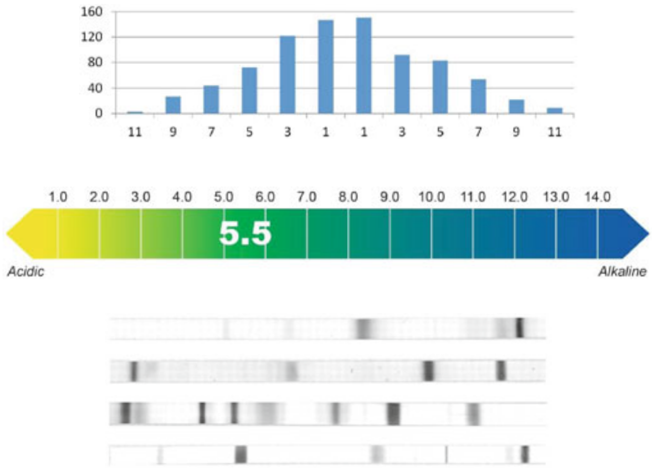


Fig. F.6 (From top to bottom) Column chart, litmus Ph test, and blot test for biometrics

	11	9	7	5	3	1	1	3	5	7	9	11	
ACT	3	27	44	72	122	147	151	92	83	54	22	9	REF
SEN	22	54	117	137	115	119	85	75	48	19	21	14	INT
VIS	108	151	185	137	88	62	53	21	11	7	2	1	VRB
SEQ	9	39	59	103	157	128	98	110	62	37	20	4	GLO

2007-12 ◆ Obs = 826 ◆ Sampling rate = 96.5%

Fig. F.7 Sanctioned new format

The two ILS reports in 2nd draft format in Fig. F.5 are now redisplayed in Fig. F.8 using the new format. Clearly, it is more readable and more expressive; the two differences between the reports' largest frequencies can be recognized very quickly.

Not only does the new format highlight the occurrence of the matching/near-matching in a band's adjacent columns, but it also draws attention to multiple peak scores in non-adjacent columns within the band. In review, a second spike in the band, especially in an opposing half, means the sample is fractured by two near equal-sized internal groups with dichotomous learning styles. These two phenomenality are designated as "score matching within band' type I and II (Fig. F.9).

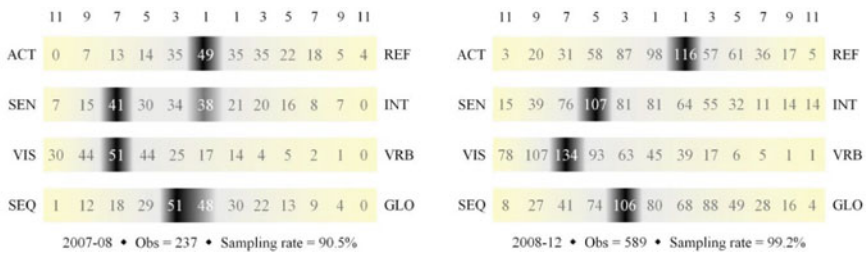


Fig. F.8 Two new format reports side-by-side

Fig. F.9 'Score matching within band' types

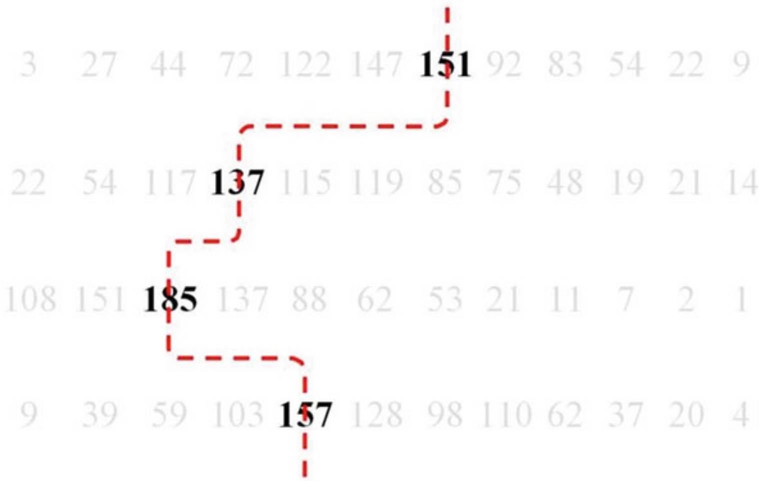


Fig. F.10 Contrast curve

The final aspect that is available in the new format is the capability to emulate an overlay of one ILS report upon another. This is accomplished via a mechanism called a contrast curve. This is contiguous dashed line that traces and joins the largest frequencies of the four bands. Figure F.10 shows the contrast curve drawn from and for the ILS report in Fig. F.7.

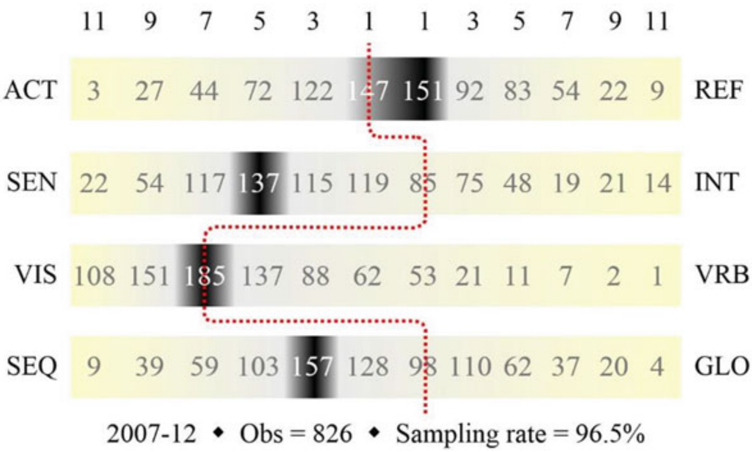


Fig. F.11 New format with contrast curve

Figure F.11 shows the ILS report in Fig. F.7 overlaid with a contrast curve (in square dot form) from another ILS report. It is apparent that the contrast curve does not obscure the underlying report, and the report doesn't overwhelm the curve. So, though the curve is an expedient to simulate an actual overlay, the process of an effective comparison of the two reports is made more effective and informative.

Figure F.11 show just how effectively the comparison can be carried out. Immediately, the reader sees that the two reports coincide in band one (a type I 'score matching within band') and band three, and also vary in the sensing-intuitive (band two) and sequential-global (band four). It is also evident that the variance in band two is more severe than in band four. Such is the recognitive power of the new format and the contrast curve.

Appendix G
Compendium of ILS Reports

This appendix showcases all the ILS reports into one handy reference.

The following figures are the ILS reports for the first three semesters during which the instructional design is traditional lecturing. The students in the first two semesters are primarily CE, whereas they are CM—belonging to schools other than the School—in the third semester (Figs. G.1, G.2 and G.3).

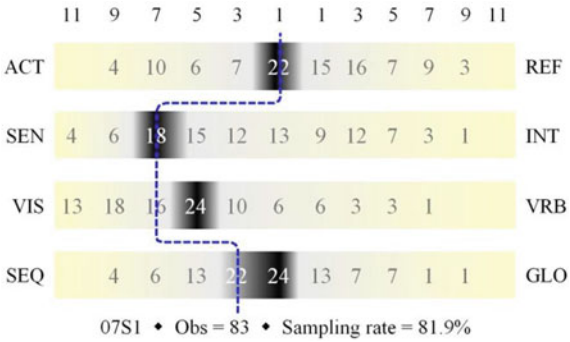


Fig. G.1 ILS report for 07S1 with traditional lecturing curve

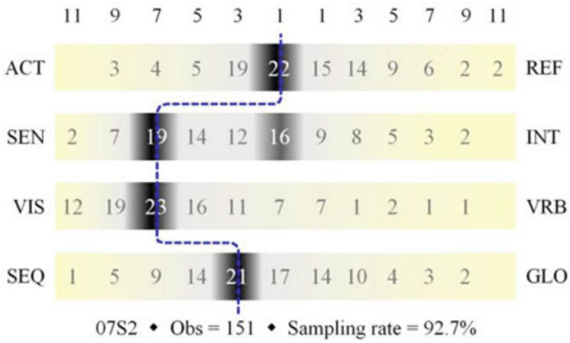


Fig. G.2 ILS report for 07S2 with traditional lecturing curve

K. A. Jones and R. S. Sharma, *Higher Education 4.0*,
https://doi.org/10.1007/978-981-33-6683-1

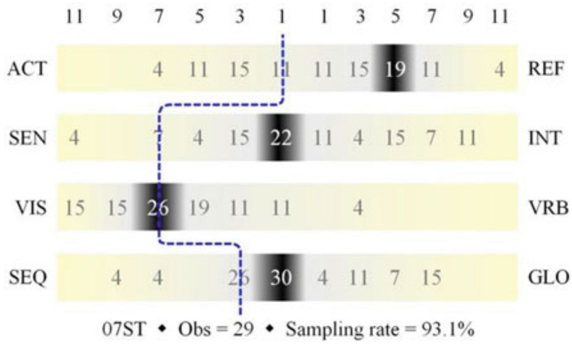


Fig. G.3 ILS report for 07ST with traditional lecturing curve

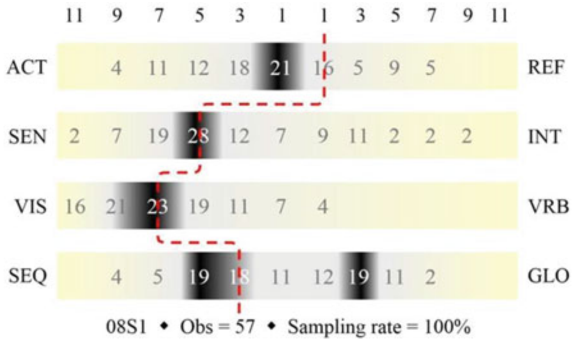


Fig. G.4 ILS report for 08S1 with blended learning curve

Clearly, while the ILS reports of the first two semesters are near identical and commensurate with the traditional lecturing curve, the special semester is significantly atypical, with more reflectiveness, and a balance of ‘sensing’ and ‘intuitive’, and of ‘sequential’ and ‘global’.

The following eight figures are the ILS reports for the remaining semesters; blended learning operated in these. The students in all semesters are primarily CE.

Note the emergence in the reports of ‘score matching within band’ and correspondences to the contrast curve, in this case the Asia curve (recall Fig. 6.16). (The contrast curve concept explained in Appendix F.) Type I score matching is in Figs. G.4, G.6, G.9, G.10, G.11 and Type II in Figs. G.4, G.5, G.7, G.9, G.11. Interestingly, no semesters are equivalent to the Asia curve, and only two, 10S1 and 11S2, have a near equivalence. The incongruity of the remaining semesters with the Asia curve is exacerbated by the Type II matching. Since the sizes of the cohorts in the semesters are not too small, the existence of such variance must be due to another reason as yet unknown. Table G.1 summarizes the matching and curve variances by semester (Fig. G.8).

The following figures are the ILS reports for N7 (see Chap. 6) (Figs. G.12, G.13, G.14, G.15, G.16, G.17 and G.18).

Singapore and Malaysia are identical to the Asia curve, while China and Singapore PR are near equivalent. Every band in the China profile has ‘score matching’, either

Fig. G.5 ILS report for 08S2 with blended learning curve

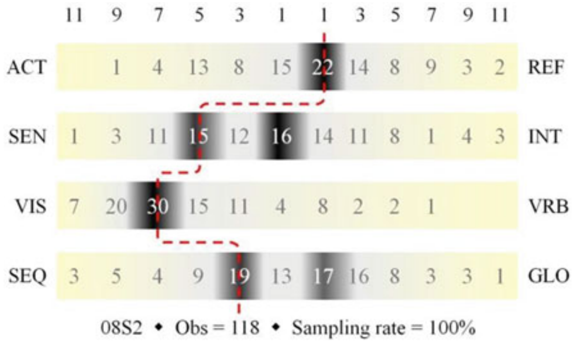


Fig. G.6 ILS report for 09S1 with blended learning curve

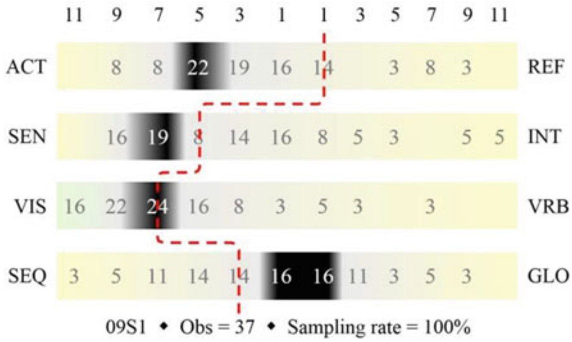
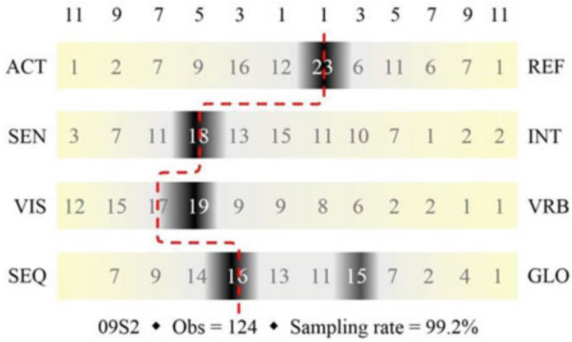


Fig. G.7 ILS report for 09S2 with blended learning curve



Type I or II, phenomenality, while Singapore PR has nil ‘score matching’ in every band. Table G.2 summarizes the report variances by nationality.

The following four figures are the ILS reports for the high-achieving—equivocating to Bloom’s cognitive outcomes of ‘analysing’, ‘evaluating’, and ‘creating’ (recall Table 5.4)—students in traditional lecturing versus high-achieving students in blended learning. The first two figures apply to the traditional lecturing students.

Fig. G.8 ILS report for 10S1 with blended learning curve

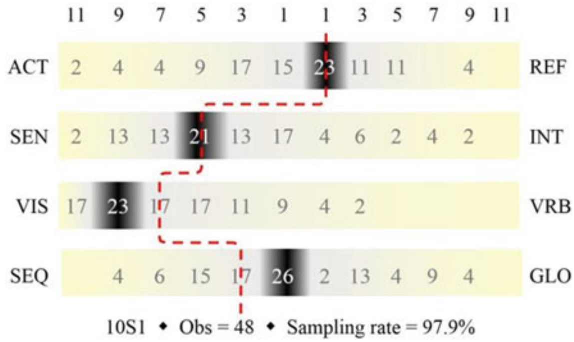


Fig. G.9 ILS report for 10S2 with blended learning curve

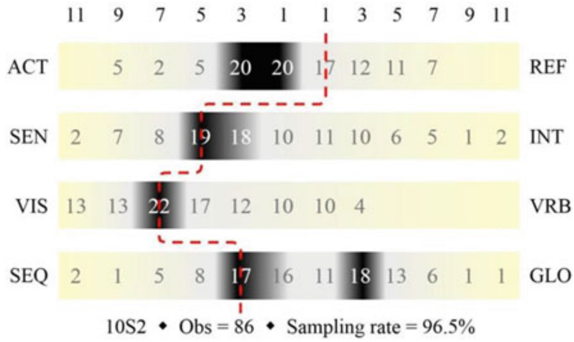
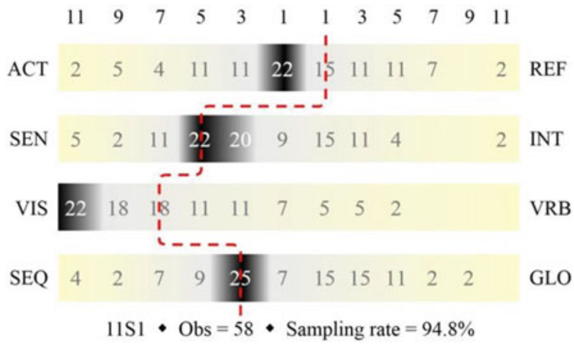


Fig. G.10 ILS report for 11S1 with blended learning curve



The high achieving student group in traditional lecturing is small, and this is probably the source of the excessive ‘score matching within band’ (both Type I and II). When contrasted with the Asia curve in Fig. G.19, the traditional lecturing high-achievers are slightly more ‘reflective’, slightly less visual, and indeterminate for ‘sequential’ and ‘global’ (Type II score matching is very difficult to interpret). When contrasted with the traditional lecturing curve in Fig. G.20, ostensibly representing

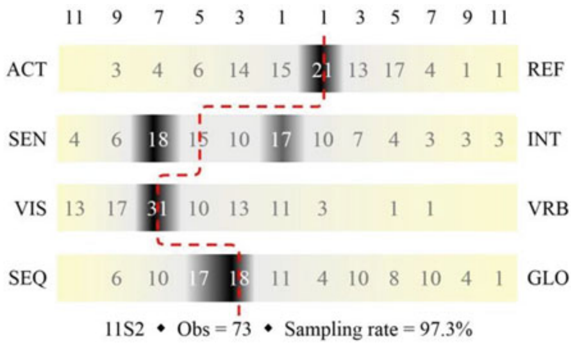


Fig. G.11 ILS report for 11S2 with blended learning curve

Table G.1 ILS report variance between semesters

Band	Score matching within band	Correspondence to blended learning curve
One	In {09S2, 10S2} in ACT half	{08S2, 09S2, 10S1, 11S2} are matching, while {08S1, 09S1, 10S2, 11S1} are more ACT
Two	In {08S2, 10S2, 11S1, 11S2} all in SEN half	All are matching except {09S1, 11S2} which are all more SEN
Three	Nil	All are matching except {10S1, 11S1} which are more VIS
Four	All except {10S1, 11S1} most often one spike in SEQ and another in GLO	All are matching except {09S1, 10S1} which are more GLO

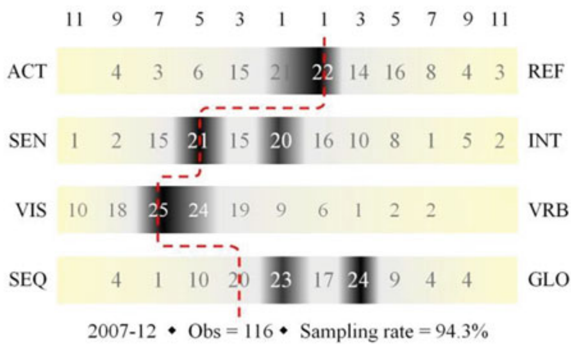


Fig. G.12 ILS report for China with Asia curve

moderate-achievers in their group, the variance in 'reflective' is more pronounced (Figs. G.21 and G.22).

The high achieving student group size in blended learning is a factor of three greater than that of the traditional lecturing, and hence has only one 'score matching within band' (Type I). When contrasted with the blended learning curve—equivalent to Asia, and ostensibly representing moderate-achievers in their group curve—the high-achievers are slightly more 'reflective', slightly more 'visual', and more

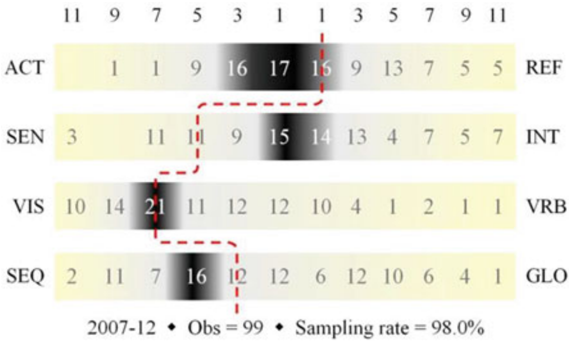


Fig. G.13 ILS report for India with Asia curve

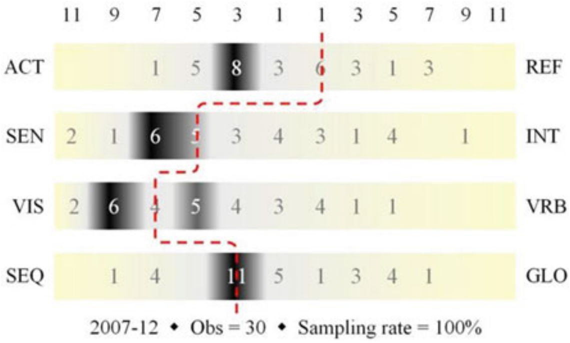


Fig. G.14 ILS report for Indonesia with Asia curve

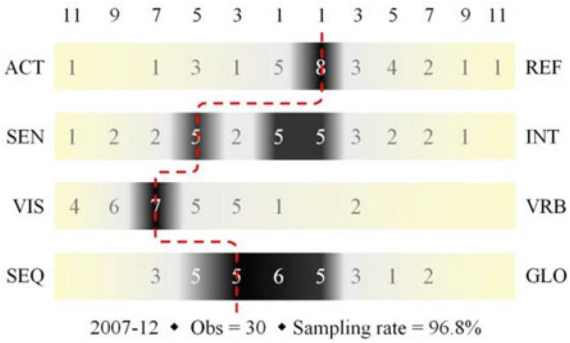


Fig. G.15 ILS report for Malaysia with Asia curve

balanced in 'sequential' and 'global'. When contrasted with the deep lecturing curve, the closer conformance to 'active-reflective' and 'sequential' and 'global' balances is highlighted; these may be the source of their higher degree of achievement than their lower-achieving peers in the blended learning and the students in traditional lecturing. Interesting, the high-achievers in both instructional designs are hampered by having too high 'sensing' response.

Fig. G.16 ILS report for Singapore with Asia curve

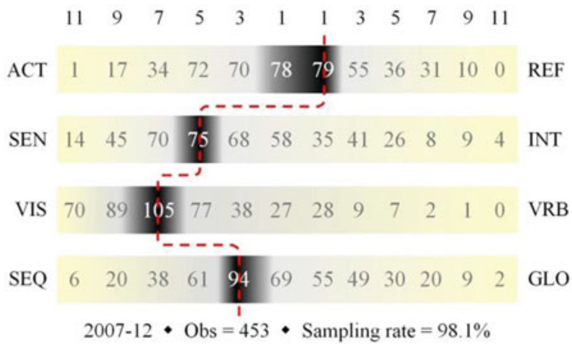


Fig. G.17 ILS report for Singapore PR with Asia curve

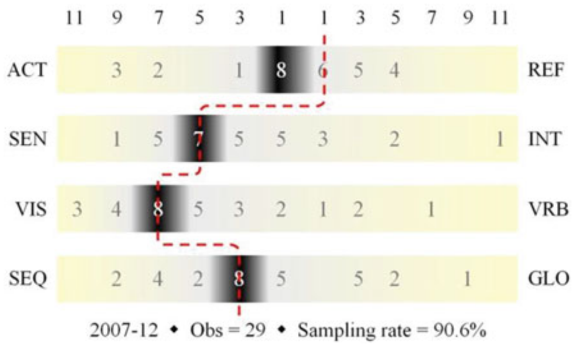
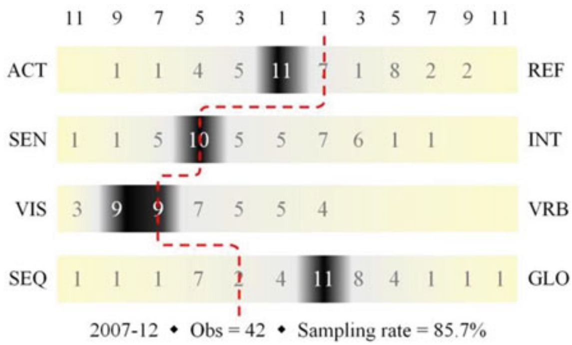


Fig. G.18 ILS report for Vietnam with Asia curve



The following figures are the ILS reports for the students affiliated outside of the School (Figs. G.23 and G.24).

The 'not school' ILS report for traditional lecturing is distinct from that of blended learning; there is contrast in every band. Traditional lecturing is more 'reflective', slightly more 'intuitive', slightly less 'visual', and more 'global'. Also, it has Type II 'score matching within band' for band one, and Type I for band four, whereas blended learning has Type I in bands one and three.

Table G.2 ILS report variance between nationalities

Band	Score matching within band	Correspondence to blended learning curve
One	In {CN, IN, SG} in ACT-INT middle	{CN, IN, MY, SG} are matching, while {ID, SG PR, VN} are all more ACT
Two	In CN in SEN; in {IN, MY} all SEN-INT middle	All are matching except IN which is more INT and ID which is more SEN
Three	In {CN, ID} less VIS; in VN more VIS	All are matching except ID which is more VIS
Four	In {CN, MY} more GLO	{ID, MY, SG, SG PR} are matching, while {CN, VN} are more GLO, and IN more SEQ

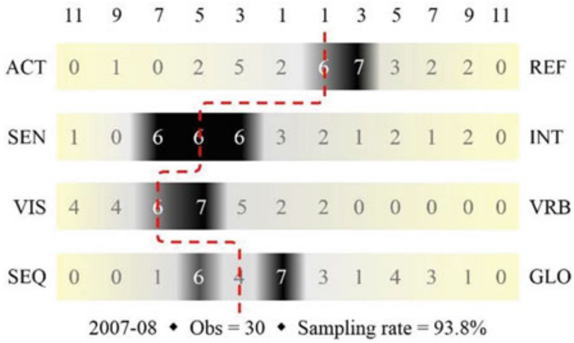


Fig. G.19 High-achieving students in traditional lecturing with Asia curve

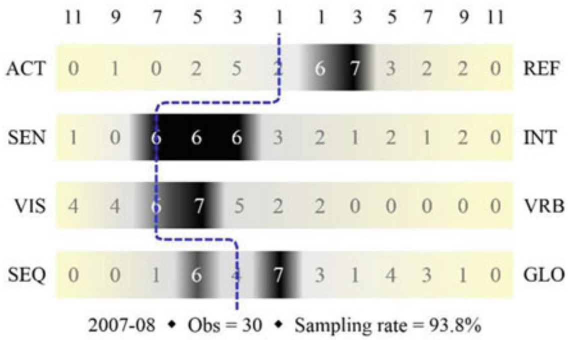


Fig. G.20 High-achieving students in traditional lecturing with traditional lecturing curve

The following figures are the ILS reports for the attendance (Figs. G.25 and G.26). Students with 100% attendance in both instructional designs share equivalent ‘visual’ and ‘sequential’, and both are near equivalent to the contrast curve of their instructional design group. High attenders in traditional lecturing have scores that skew towards ‘reflective’ and ‘intuitive’.

The following figures are the ILS reports for team leader (Figs. G.27 and G.28).

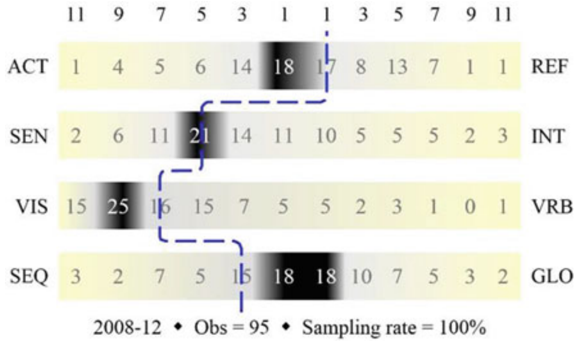


Fig. G.21 High achieving students in blended learning with blended learning curve

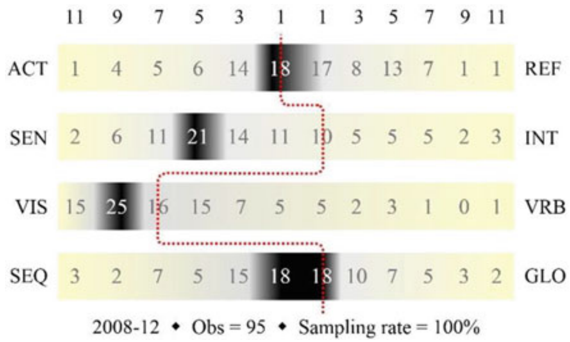


Fig. G.22 High achieving students in blended learning with deep learning curve

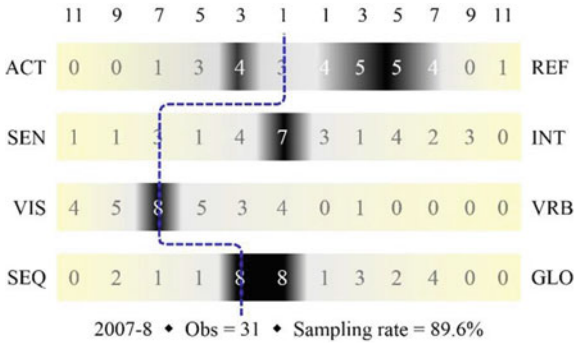


Fig. G.23 'Not school' students in traditional lecturing with traditional lecturing curve

Expectedly, the leader's ILS report is near equivalent for both instructional designs. Also, the both ILS reports are equivalent to the deep learning curve for 'visual' and 'global', and near equivalent for 'active' and 'sensing'.

The following tables show the pairwise correlation of the marks categories to the ILS report scores, and the subsequent plotting of the correlations into a 12-column and four-row matrix mimicking the ILS report structure (Table G.3).

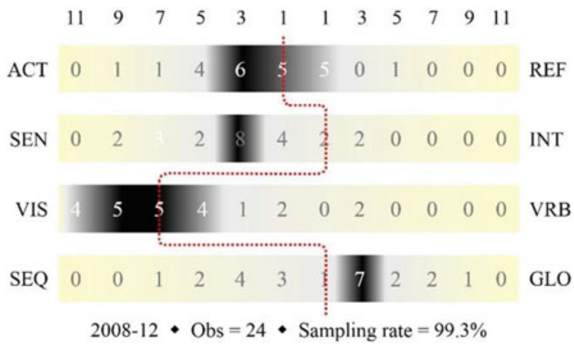


Fig. G.24 'Not school' students in blended learning with deep learning curve

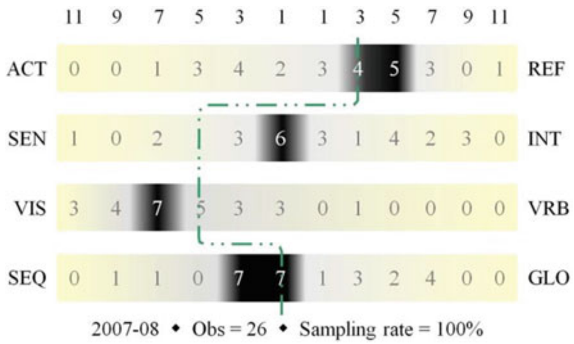


Fig. G.25 100% attendance in traditional lecturing with >74 mark in traditional lecturing curve

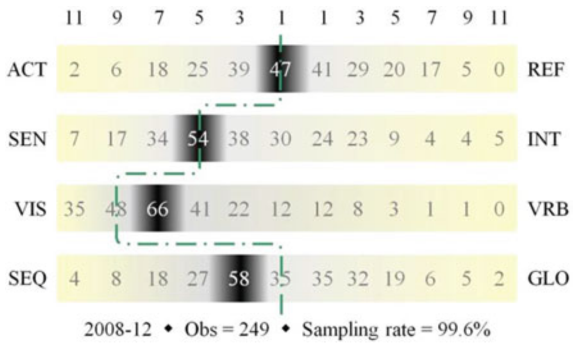


Fig. G.26 100% attendance in blended learning with >74 mark in blended learning curve

Table G.4 reveals interesting insights into the disposition of the mark-ILS correlation.

- There are more negative correlations than positive to the measure of 56.3%. So, the table is specifying more scores for a predictive rejection than for acceptance;
- The left-sides of bands two-to-four have either no correlations at all, or only negative correlations. Only band one's left-side contains correlations; and

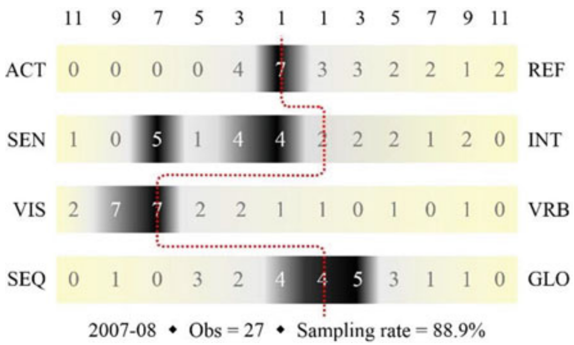


Fig. G.27 Leader in traditional lecturing with deep learning curve

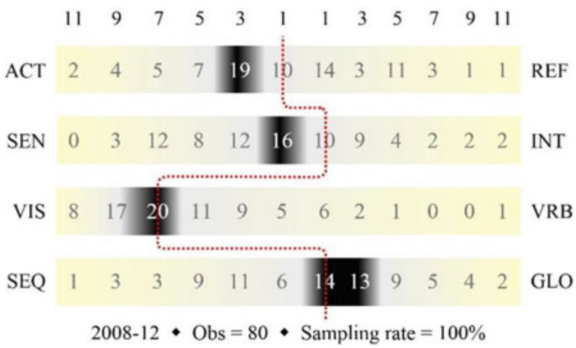


Fig. G.28 Leader in blended learning with deep learning curve

- Seven (30.4%) of the 23 occupied cells are shared by multiple marks categories. Only one of those seven cells (14.3%) is shared by >2 marks categories, indicating there is no clear concentration of correlations. Four of the seven shared cells have one or both of its occupant mark categories being negatively correlated.

The following table show the plotting of the statistically significant linear regression tuples into a similar 12-column and four-row matrix ILS report mimic structure.

At first viewing, Table G.5 appears near identical to Table G.4. But upon further inspection, there are noteworthy distinctions. is distinct from Table G.4 in negative coefficients, left-side results, and shared cells. Table G.5 shows an increase of results in the left-sides of bands two and four, but is unchanged in the band three remains lessening of the insights into the disposition of the mark-ILS correlation.

- There are 46 regressions versus 23 correlations. This suggests there are more regressive relationships in the data set;
- The proportion of negative-to-positive regressions, 23.9%, is much less than that of correlations, 56.3%. So, Table G.5 is mostly specifying scores that are predictive acceptors;

Table G.3 Extract of pairwise correlations with *p*-value near or below α

ILS score	Marks						
	Final	Exam	CW	Quiz	Active	Project	
a11	0.0381	0.0186	0.0529	0.0403	0.0075	0.0634	Coef
	0.2738	0.5933	0.1287	0.2478	0.8295	0.0686	*p*-value
a9	-0.0405	-0.0136	-0.0648	0.0116	-0.0076	-0.0818	Coef
	0.2445	0.6968	0.0628	0.7396	0.8267	0.0188	*p*-value
a7	0.0697	0.0365	0.1043	0.0656	0.1051	0.0439	Coef
	0.0454	0.2946	0.0027	0.0596	0.0025	0.2078	*p*-value
a1	-0.0406	-0.0702	0.0253	0.0074	0.0163	0.0123	Coef
	0.2438	0.0437	0.4686	0.8318	0.6399	0.7245	*p*-value
r1	-0.005	0.0226	-0.0505	0.0017	-0.0693	-0.0084	Coef
	0.8852	0.5158	0.1467	0.9616	0.0466	0.8095	*p*-value
r3	0.0669	0.0689	0.0416	0.0099	0.0467	0.0042	Coef
	0.0547	0.0478	0.232	0.7753	0.1803	0.903	*p*-value
r5	-0.0302	-0.0394	-0.013	-0.093	-0.0115	0.0298	Coef
	0.3854	0.2585	0.7097	0.0075	0.7425	0.3919	*p*-value
r7	-0.0241	-0.0225	-0.0131	0.0022	0.0567	-0.0755	Coef
	0.4898	0.5186	0.7079	0.9497	0.1033	0.0299	*p*-value
r9	-0.021	-0.0113	-0.0379	-0.0551	-0.0682	0.032	Coef
	0.5475	0.745	0.2768	0.1135	0.0501	0.3585	*p*-value
r11	0.0054	0.0359	-0.0323	-0.067	-0.0589	0.014	Coef
	0.8762	0.3031	0.3537	0.0541	0.091	0.688	*p*-value
s7	-0.0029	0.002	-0.012	0.014	0.0416	-0.0618	Coef
	0.9346	0.954	0.7311	0.688	0.2322	0.0757	*p*-value
i3	-0.0468	-0.0209	-0.076	-0.027	-0.0764	-0.0419	Coef
	0.1794	0.5487	0.029	0.4384	0.0282	0.2287	*p*-value
i5	-0.0137	0.0093	-0.0309	-0.0624	-0.0163	-0.0161	Coef
	0.6935	0.7898	0.3751	0.0729	0.6403	0.6449	*p*-value
i9	0.029	0.0277	0.0261	-0.0256	-0.0195	0.0747	Coef
	0.4048	0.4267	0.4541	0.4634	0.5764	0.0317	*p*-value
i11	-0.0331	-0.0101	-0.0623	-0.025	-0.0719	-0.0155	Coef
	0.3418	0.7721	0.0734	0.4735	0.0387	0.6572	*p*-value
b1	-0.0247	-0.018	-0.0242	-0.0176	-0.059	0.0187	Coef
	0.4791	0.6056	0.4878	0.6141	0.0899	0.5907	*p*-value
b5	0.0604	0.0511	0.0622	0.0133	0.054	0.0374	Coef
	0.0827	0.1422	0.0742	0.7037	0.1211	0.2834	*p*-value
b11	0.044	0.0511	0.0253	-0.0039	-0.0478	0.0805	Coef
	0.2065	0.1425	0.4681	0.9109	0.1699	0.0208	*p*-value
q3	0.0001	0.004	-0.0062	0.0245	0.0375	-0.0573	Coef
	0.9967	0.9088	0.8579	0.4823	0.2813	0.0996	*p*-value
g1	0.0468	0.0256	0.0647	0.017	0.0382	0.0374	Coef
	0.1786	0.4632	0.0632	0.6253	0.2723	0.2827	*p*-value
g3	-0.0142	-0.0211	-0.009	0.003	-0.0584	0.0318	Coef
	0.6841	0.5455	0.796	0.9319	0.0933	0.3613	*p*-value
g9	-0.011	-0.0168	0.0009	-0.0672	-0.0345	0.0625	Coef
	0.7513	0.6292	0.9796	0.0536	0.3214	0.0727	*p*-value
g11	0.0509	0.0628	0.0192	0.0043	-0.029	0.0511	Coef
	0.1436	0.0713	0.5808	0.9021	0.4045	0.1421	*p*-value

Table G.4 Plot of mark and ILS score correlations

	11	9	7	5	3	1	1	3	5	7	9	11	
Act	p	-c, -p	f, c, z, t			-e	-t	f, e	-z	-p	-t	-z, -t	Ref
Sen			-p					-c, -t	-z		p	-c, t	Int
Vis							-t		f, c			p	vrB
seQ					-p		c	-t			p	e	Glo

Legend final = “f”, exam = “e”, coursework = “c”, quiz = “z”, active learning = “t”, project = “p”

Table G.5 Plot of mark and ILS score regressions

	11	9	7	5	3	1	1	3	5	7	9	11	
Act	c, p		f, e, c, z, t		z		-t	f, e	-z	-p	z, -t	c, -z	Ref
Sen	e	c			z				-z	c, p			Int
Vis						-t			f, e, c, z		e, -c, z, -t, p	f, e, c, -z, -t, p	vrB
seQ	f, c		e, z							z	p	e	Glo

Legend final = “f”, exam = “e”, coursework = “c”, quiz = “z”, active learning = “t”, project = “p”

- Now, the left-sides of bands two and four have regressions; band three remains value-less. Band one’s left-side continues to contain values; and
- For the same occupancy of cells (23), the scheme of sharing of marks category in cells that emerges for regressions is 46.8% sharing and 36.4% >2. This indicates that there is more sharing and more concentrations in the shared cells for regressions than correlations.

Appendix H
Compendium of Marks Tests and Charts

This appendix showcases the comparisons of marks for N7, school affiliation, and leadership in blended learning versus traditional lecturing in one handy resource.

Tables H.1 and H.2 summarize the CEF and QAP marks means for the nationalities in each of the instructional designs, and the significance of the differences. Table H.1 holds the values charted in Figs. 6.26 and 6.27 comparisons of CEF and QAP marks.

Tables H.3 and H.4 summarize the CEF and QAP marks means for the nationalities in each of the instructional designs.

The following figures are column charts comparing means of marks, CEF on the left and QAP on the right for each nationality in N7. {CN, IN} have higher CEF marks in traditional lecturing, whereas the remainder perform better in blended learning, with one exception Vietnam in coursework. All quizzes and projects have higher achievement in blended learning, and all active learning has higher achievement in traditional lecturing (Figs. H.1, H.2, H.3, H.4, H.5, H.6 and H.7).

Table H.1 Means for CEF and QAP marks by instructional design

InstrDsgn	Crse	Exam	Final	Quiz	Active	Project
trad	70.293893	61.820611	66.083969	61.670229	69.317977	71.456489
bl	69.861953	63.824916	67.494949	71.868619	60.695758	73.069882

Table H.2 *p*-values for CEF and QAP marks by instructional design

Mark category	H_A		
	diff < 0	diff != 0	diff > 0
Final	0.9862	0.0277	0.0138
Exam	0.9781	0.0437	0.0219
Coursework	0.1979	0.3957	0.8021
Quiz	1.0000	0.0000	0.0000
ActiveLearn	0.0000	0.0000	1.0000
Project	0.9994	0.0012	0.0006

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K. A. Jones and R. S. Sharma, *Higher Education 4.0*,
https://doi.org/10.1007/978-981-33-6683-1

Table H.3 Means for CEF marks by nationality

Nationality	Freq	ID	Coursework	Exam	Final
China	33	Trad	70.818182	64.848485	67.818182
	90	Bl	68.555556	60.288889	65.3
India	18	Trad	70.5	66.75	68.555556
	83	Bl	66.46988	62.421687	64.891566
Indonesia	18	Trad	68.444444	65.222222	67
	12	Bl	70.25	68.75	69.583333
Malaysia	19	Trad	69.631579	63.552632	66.842105
	12	Bl	70.583333	64.166667	68.083333
Singapore	149	Trad	70.456376	60.530201	65.496644
	313	Bl	71.220447	64.977636	68.782748
Singapore PR	13	Trad	69.846154	59.038462	64.384615
	19	Bl	72.210526	65.736842	69.684211
Vietnam	9	Trad	72	58.388889	72
	40	Bl	68.275	64.25	66.675

Table H.4 Means for QAP marks by nationality

Nationality	Freq	ID	Quiz	Active Learning	Project
China	33	Trad	64.818182	72.82303	71.363636
	90	Bl	65.964444	58.627111	72.697556
India	18	Trad	60.833333	63.426111	72.611111
	83	Bl	67.236385	49.567591	72.484578
Indonesia	18	Trad	59.111111	70.247222	68.888889
	12	Bl	72.134166	62.553334	72.8525
Malaysia	19	Trad	54.736842	60.883158	73.105263
	12	Bl	70.227499	58.748333	74.865
Singapore	149	Trad	62.798658	70.629262	71.437584
	313	Bl	75.554089	65.694249	72.860319
Singapore PR	13	Trad	53.353846	68.691539	70.646154
	19	Bl	75.792631	66.449999	73.998421
Vietnam	9	Trad	67.333333	63.37	73.666667
	40	Bl	64.458	52.1905	74.699001

The following table summarizes the *p*-values for the results of the H_0 difference formula "diff = mean(bl) − mean(trad) = 0" for all nationalities in each of the instructional designs. If the *p*-value is lower than α for diff > 0, then the students of that nationality have a statistically significantly larger mark mean in blended learning. However, if the *p*-value is lower than α for diff < 0, then the students of that

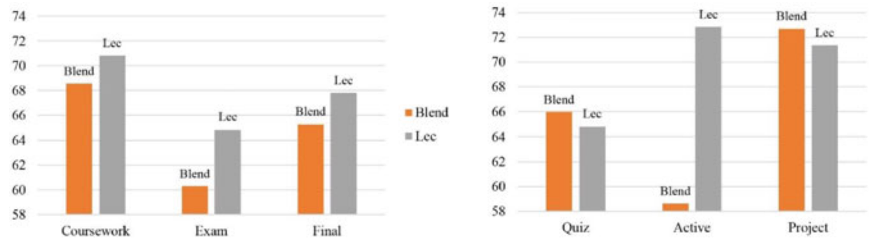

Fig. H.1 **a** China student CEF marks by instructional design. **b** China student QAP marks by instructional design

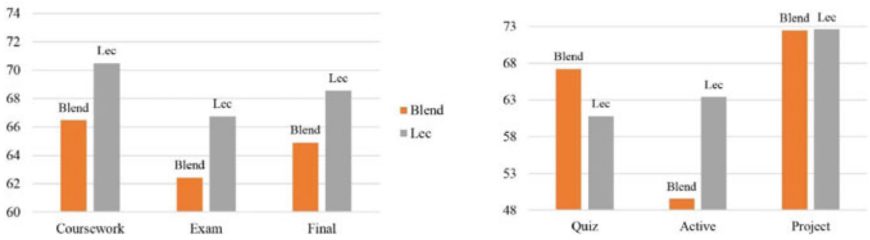

Fig. H.2 **a** India student CEF marks by instructional design. **b** India student QAP marks by instructional design

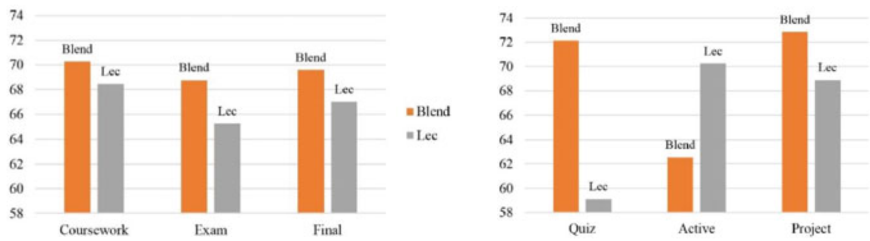

Fig. H.3 **a** Indonesia student CEF marks by instructional design. **b** Indonesia student QAP marks by instructional design

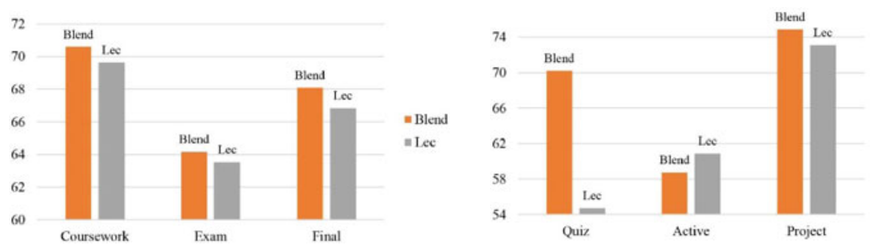

Fig. H.4 **a** Malaysia student CEF marks by instructional design. **b** Malaysia student QAP marks by instructional design

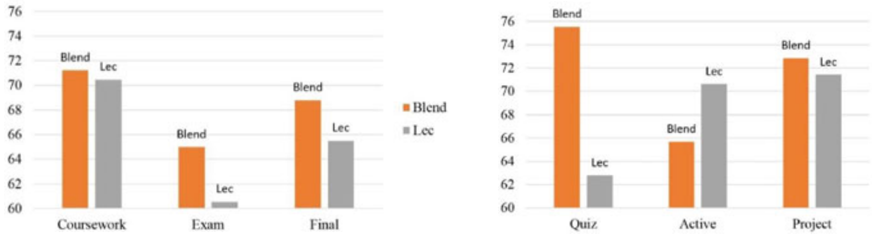

Fig. H.5 **a** Singapore student CEF marks by instructional design. **b** Singapore student QAP marks by instructional design

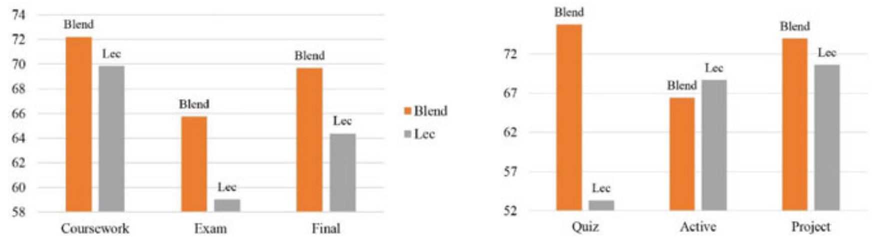

Fig. H.6 **a** Singapore PR student CEF marks by instructional design. **b** Singapore PR student QAP marks by instructional design

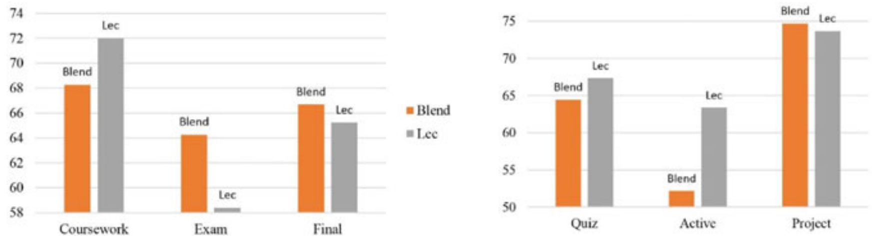

Fig. H.7 **a** Vietnam student CEF marks by instructional design. **b** Vietnam student QAP marks by instructional design

nationality have a statistically significantly larger mark mean in traditional lecturing. Only the differences in SG and SG PR are statistically significant; the differences in the remaining nationalities are predominantly not significant (Tables H.5 and H.6).

The following table summarizes the CEF and QAP marks means for the school affiliation in each of the instructional designs.

The following figures are column charts comparing the means of the marks CEF on the left and QAP on the right for School versus 'not School' in each instructional design. In the traditional lecturing charts, the 'not School' students achieve higher marks in all categories except quizzes. However, in blended learning, it is the School students that achieve higher marks in in all categories except project (Figs. H.8 and H.9).

Table H.5 *p*-values for CEF and QAP marks by nationality

Nationality	Mark category	H_A		
		diff < 0	diff != 0	diff > 0
China	Final	0.1298	0.2595	0.8702
	Exam	0.1050	0.2101	0.8950
	Coursework	0.0795	0.1589	0.9205
	Quiz	0.6204	0.7592	0.3796
	ActiveLearn	0.0000	0.0000	1.0000
	Project	0.7970	0.4061	0.2030
India	Final	0.1036	0.2071	0.8964
	Exam	0.1784	0.3567	0.8216
	Coursework	0.0326	0.0651	0.9674
	Quiz	0.9092	0.1816	0.0908
	ActiveLearn	0.0020	0.0039	0.9980
	Project	0.4731	0.9462	0.5269
Indonesia	Final	0.8484	0.3032	0.1516
	Exam	0.8379	0.3241	0.1621
	Coursework	0.7889	0.4222	0.2111
	Quiz	0.9805	0.0390	0.0195
	ActiveLearn	0.0944	0.1888	0.9056
	Project	0.1050	0.0617	0.0309
Malaysia	Final	0.6837	0.6326	0.3163
	Exam	0.5685	0.8629	0.4315
	Coursework	0.6596	0.6809	0.3404
	Quiz	0.9790	0.0420	0.0210
	ActiveLearn	0.4022	0.8044	0.5978
	Project	0.8836	0.2328	0.1164
Singapore	Final	1.0000	0.0000	0.0000
	Exam	1.0000	0.0001	0.0000
	Coursework	0.8852	0.2295	0.1148
	Quiz	1.0000	0.0000	0.0000
	ActiveLearn	0.0014	0.0028	0.9986
	Project	0.9828	0.0344	0.0172
Singapore PR	Final	0.9948	0.0104	0.0052
	Exam	0.9904	0.0193	0.0096
	Coursework	0.8908	0.2183	0.1092
	Quiz	0.9968	0.0063	0.0032
	ActiveLearn	0.3577	0.7155	0.6423
	Project	0.9529	0.0943	0.0471
Vietnam	Final	0.7157	0.5686	0.2843
	Exam	0.8971	0.2058	0.1029
	Coursework	0.0271	0.0541	0.9729
	Quiz	0.2711	0.5422	0.7289
	ActiveLearn	0.0061	0.0122	0.9939
	Project	0.6980	0.6040	0.3020

Table H.6 Means of CEF marks for school affiliation by instructional design

Instructional design	School affiliation	Mark	Freq	Mean
In traditional lecturing	In school	Final	231	65.805195
		Exam		61.415584
		Coursework		70.212121
		Quiz		62.219048
		ActiveLearn		68.696407
		Project		71.236364
	Not in school	Final	31	68.16129
		Exam		64.83871
		Coursework		70.903226
		Quiz		57.580645
		ActiveLearn		73.949677
		Project		73.096774
In blended learning	In school	Final	570	67.615789
		Exam		63.961404
		Coursework		69.97193
		Quiz		72.076649
		ActiveLearn		61.288386
		Project		73.000965
	Not in school	Final	24	64.625
		Exam		60.583333
		Coursework		67.25
		Quiz		66.927916
		ActiveLearn		46.620833
		Project		74.706666

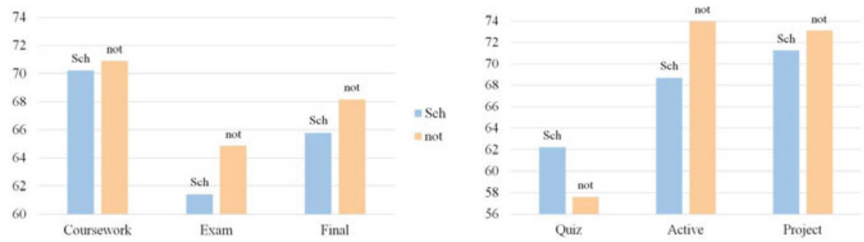

Fig. H.8 **a** CEF marks in traditional lecturing for school versus 'not school'. **b** QAP marks in traditional lecturing for school versus 'not school'

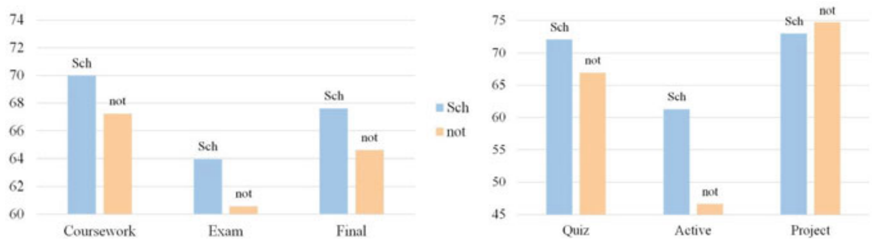

Fig. H.9 **a** CEF marks in blended learning for school versus 'not school'. **b** QAP marks in blended learning for school versus 'not school'

Table H.7 *p*-values for marks for school versus 'not school' by instructional design

Instructional design	Mark category	H_A		
		diff < 0	diff != 0	diff > 0
Traditional lecturing	Final	0.0865	0.1730	0.9135
	Exam	0.0772	0.1545	0.9228
	Coursework	0.3099	0.6197	0.6901
	Quiz	0.8876	0.2248	0.1124
	ActiveLearn	0.0481	0.0961	0.9519
	Project	0.0916	0.1832	0.9084
Blended learning	Final	0.9555	0.0891	0.0445
	Exam	0.8810	0.2379	0.1190
	Coursework	0.9750	0.0500	0.0250
	Quiz	0.9491	0.1019	0.0509
	ActiveLearn	1.0000	0.0001	0.0000
	Project	0.1021	0.2041	0.8979

The following table summarizes the *p*-values for the results of the H_0 difference formula "diff = mean(School) − mean(not School) = 0" in each instructional designs. If the *p*-value is lower than α for diff > 0, then the students affiliated with the School have a statistically significantly larger mark mean than those 'not School'. However, if the *p*-value is lower than α for diff < 0, then the 'not School' students have a statistically significantly larger mark mean. The higher achievement in blended learning is statistically significant for three marks categories; in traditional lecturing only one (Tables H.7 and H.8).

The following table summarizes the CEF and QAP marks means for the team leadership in each of the instructional designs.

The following figures are column charts comparing the means of the marks CEF on the left and QAP on the right for leader versus 'not leader' in each instructional design. Team leaders achieve higher marks in both traditional lecturing and blended learning (Figs. H.10 and H.11).

Table H.8 Means of CEF marks for team leader by instructional design

Instructional design	School affiliation	Mark	Freq	Mean
In traditional lecturing	Not leader	Final	235	65.514894
		Exam		61.348936
		Coursework		69.642553
		Quiz		60.513191
		ActiveLearn		69.229021
		Project		70.798298
	Leader	Final	31	71.037037
		Exam		65.925926
		Coursework		75.962963
		Quiz		71.740741
		ActiveLearn		70.092222
		Project		77.185185
In blended learning	Not leader	Final	570	66.714008
		Exam		62.883268
		Coursework		69.182879
		Quiz		71.59179
		ActiveLearn		60.306226
		Project		72.244202
	Leader	Final	24	72.5125
		Exam		69.875
		Coursework		74.225
		Quiz		73.64725
		ActiveLearn		63.1985
		Project		78.374875

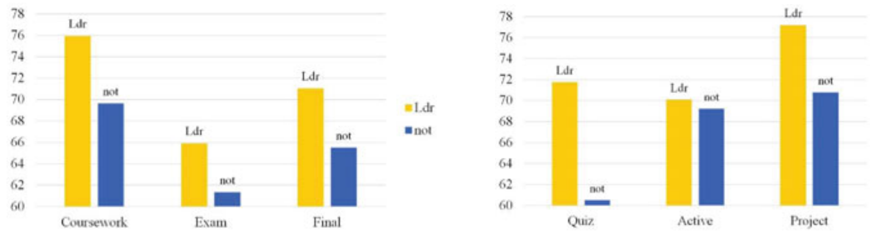

Fig. H.10 **a** CEF marks in traditional lecturing for leader versus 'not leader'. **b** QAP marks in traditional lecturing for leader versus 'not leader'

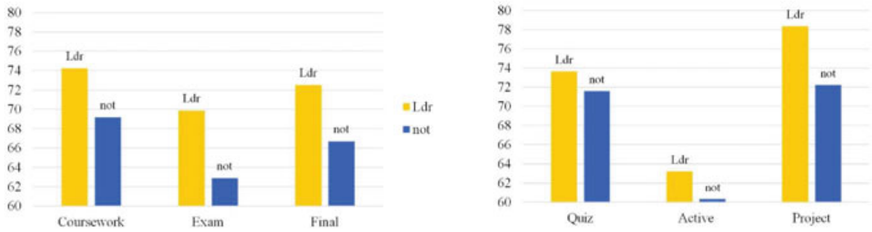

Fig. H.11 **a** CEF marks in blended learning for leader versus 'not leader'. **b** QAP marks in blended learning for leader versus 'not leader'

Table H.9 *p*-values for marks for leader versus 'not leader' by instructional design

Instructional design	Mark category	H_A		
		diff < 0	diff != 0	diff > 0
Traditional lecturing	Final	0.0012	0.0025	0.9988
	Exam	0.0364	0.0728	0.9636
	Coursework	0.0000	0.0000	1.0000
	Quiz	0.0027	0.0054	0.9973
	ActiveLearn	0.3987	0.7974	0.6013
	Project	0.0000	0.0000	1.0000
Blended learning	Final	0.0000	0.0000	1.0000
	Exam	0.0000	0.0000	1.0000
	Coursework	0.0000	0.0000	1.0000
	Quiz	0.1289	0.2578	0.8711
	ActiveLearn	0.0906	0.1812	0.9094
	Project	0.0000	0.0000	1.0000

The following table summarizes the *p*-values for the results of the H_0 difference formula "diff = mean(not leader) − mean(leader) = 0" in each instructional designs. If the *p*-value is lower than α for diff > 0, then the students 'not leader' have a statistically significantly larger mark mean than the leaders. However, if the *p*-value is lower than α for diff < 0, then the leader students have a statistically significantly larger mark mean. Most of the differences—three in traditional lecturing and four in blended learning—are statistically significant (Table H.9).

Appendix I
Compendium of Tables for Charts

This appendix contains all the tables used in create the charts in the descriptive statistics section of Chap. 6 in one handy resource (Table I.1).

This table holds the values charted in “Fig. 6.2. Distribution of SG versus international students in the School by semester” (Table I.2).

This table holds the values charted in “Fig. 6.5. Comparison of CEF marks” (Table I.3).

This table holds the values charted in “Fig. 6.6. Comparison of QAP marks” (Table I.4).

Table I.1 Frequencies and percentages of SG versus ‘not SG’ students

Semester	SG		‘Not SG’	
	Freq	%	Freq	%
07S1	60	72.2891	23	27.71080
07S2	91	60.6667	59	39.33330
07ST	11	37.9318	18	62.0690
08S1	42	76.3636	13	23.6364
08S2	66	55.9322	52	44.0678
09S1	27	79.4118	7	20.5882
09S2	47	37.9032	77	62.0968
10S1	37	77.0833	11	22.9167
10S2	46	53.4884	40	46.51161
11S1	33	57.8947	24	42.1053
11S2	34	47.2222	38	52.7778

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Table I.2 Means of CEF marks

Freq	Coursework	Exam	Final
856	69.99416	63.21145	67.06308

Table I.3 Means of QAP marks

Freq	Quiz	Active learn	Project
856	68.74715	63.3348	72.57606

Table I.4 Frequency of ‘not school’ by nationality and instructional design

‘Not school’	CA	CN	FI	FR	HK	ID	IN	KZ	MY	SE	SG	US
In traditional lecturing	0	1	1	0	0	7	0	0	10	0	11	1
In blended learning	2	2	0	2	1	0	2	13	0	1	0	1

Table I.5 Means of LTE attendance

Freq	Lecture	Tutorial	Exam
856	86.3655	83.2243	97.31308

Table I.6 Means of F2F and exam attendance

Semester	F2F	Exam
07S1	62.707229	98.795181
07S2	69.058667	99.333333
07ST	93.275862	93.103448
08S1	97.749091	98.181818
08S2	92.253389	95.762712
09S1	96.72647	100
09S2	90.520161	98.387097
10S1	83.589584	91.666667
10S2	93.797674	98.837209
11S1	92.777193	100
11S2	85.898611	95.833333

This table holds the values charted in “Fig. 6.8. Distribution of ‘not School’ by nationality and instructional design” (Table I.5).

This table holds the values charted in “Fig. 6.10. Comparison of LTE attendance” (Table I.6).

This table holds the values charted in “Fig. 6.11. Comparison of F2F and exam attendance by semester” (Table I.7).

Table I.7 Means of LTE attendance by school affiliation

School affiliation	Freq	Lecture	Tutorial	Exam
School	801	86.169625	82.864794	97.877653
Not school	55	89.218182	88.46	94.545455

Table I.8 Frequency of team leaders by semester

Semester	Freq
07S1	10
07S2	17
07ST	0
08S1	8
08S2	14
09S1	8
09S2	16
10S1	7
10S2	10
11S1	9
11S2	8

Table I.9 Means of LTE attendance by team leadership

Leadership	Freq	Lecture	Tutorial	Exam
Not leader	749	86.329693	82.619906	97.329773
Leader	107	86.616168	87.455047	100

Table I.10 Means of CEF marks for school affiliation

School affiliation	Freq	Coursework	Exam	Final
School	801	70.041199	63.227216	67.093633
Not school	55	69.309091	62.981818	66.618182

This table holds the values charted in "Fig. 6.12. Comparison of LTE attendance by school affiliation" (Table I.8).

This table holds the values charted in "Fig. 6.13. Distribution of team leaders by semester" (Table I.9)

This table holds the values charted in "Fig. 6.14. Comparison of LTE attendance by team leadership" (Table I.10).

This table holds the values charted in "Fig. 6.23. Comparison of CEF marks for school affiliation" (Table I.11).

Table I.11 Means of CEF marks for leadership

Leadership	Freq	Coursework	Exam	Final
Not leader	749	69.327103	62.401869	66.337784
Leader	107	74.225	68.878505	74.663551

Table I.12 Means of CEF marks by instructional design

CEF marks	Freq	Coursework	Exam	Final
In traditional lecturing	262	70.29389	61.82061	66.08397
In blended learning	594	69.86195	63.83492	67.49495

Table I.13 Means of QAP marks by instructional design

QAP marks	Freq	Quiz	Active	Project
In traditional lecturing	262	61.67023	69.31798	71.45649
In blended learning	594	71.86862	60.69576	73.06988

Table I.14 Means of LTE attendance by instructional design

LTE attendance	Freq	Lecture	Tutorial	Exam
In traditional lecturing	262	61.67023	69.31798	71.45649
In blended learning	594	71.86862	60.69576	73.06988

This table holds the values charted in "Fig. 6.25. Comparison of CEF marks for leadership" (Table I.12).

This table holds the values charted in "Fig. 6.25. Comparison of CEF marks by instructional design" (Table I.13).

This table holds the values charted in "Fig. 6.27. Comparison of QAP marks by instructional design" (Table I.14).

This table holds the values charted in "Fig. 6.30. Comparison of LTE attendance by instructional design" (Table I.15).

This table holds the values charted in "Fig. 6.31. Comparison of F2F attendance for N7 by instructional design" (Table I.16).

This table holds the values charted in "Fig. 6.32. Comparison of F2F attendance for school affiliation by instructional design" (Table I.17).

This table holds the values charted in "Fig. 6.33. Comparison of final mark for leadership by instructional design" (Table I.18).

This table holds the values charted in "Fig. 6.34. Comparison of F2F attendance for leadership by instructional design" (Table I.19).

This table holds the values charted in "Fig. 6.35. Comparison of final mark for school affiliation by instructional design" (Table I.20).

Table I.15 Means of F2F attendance for N7 by instructional design

F2F attendance	Traditional lecturing		Blended learning	
	Freq	Mean	Freq	Mean
CN	33	68.133334	90	88.307777
ID	18	79.533334	12	95.516666
IN	18	65.294444	83	80.838554
MY	19	75.263158	12	86.816667
SG	149	69.214765	313	95.890415
SG PR	13	67.176924	19	92.036843
VN	9	69.211111	40	87.23

Table I.16 Means of F2F attendance for school affiliation by instructional design

F2F attendance	School		'Not school'	
	Freq	Mean	Freq	Mean
In traditional lecturing	231	66.84502	570	91.20323
In blended learning	31	91.68544	24	86.10417

Table I.17 Means of final mark for leadership by instructional design

Final mark	'Not leader'		Leader	
	Freq	Mean	Freq	Mean
In traditional lecturing	235	65.514894	27	71.037037
In blended learning	514	66.714008	80	72.5125

Table I.18 Means of F2F attendance for leadership by instructional design

F2F attendance	'Not leader'		Leader	
	Freq	Mean	Freq	Mean
In traditional lecturing	235	69.646383	27	70.429629
In blended learning	514	91.275486	80	92.645

Table I.19 Means of final mark for school affiliation by instructional design

School affiliation	School		'Not school'	
	Freq	Mean	Freq	Mean
In traditional lecturing	231	65.805195	31	68.16129
In blended learning	570	67.615789	24	64.625

Table I.20 Frequency of hold-back students in the data set

Type	Student masked	Nat	07S2	08S1	08S2	09S2	10S1	10S2	11S2
HB1	LLT	CN		1					
HB1	NDD	VN		1					
HB1	TJYS	SG		1					
HB1	AP	IN			1				
HB1	WJJ	SG			1				
HB2	TKL	SG	1						
HB2	RY	KZ		1					
HB2	DDC	VN			1				
HB2	LYF	CN			1				
HB2	MW	IN			1				
HB2	PTM	SG			1				
HB2	RAK	IN			1				
HB2	KX	CN				1			
HB2	CR	CN					1		
HB2	SDS	IN					1		
HB3	LXGL	CN				1			
HB3	LXGL	CN					1		
HB3	AW	IN					1		
HB3	AW	IN							1
HB3	RW	CN						1	
HB3	RW	CN							1
HB3	RDS	IN							1
HB3	VD	IN							1
		Total	1	4	7	2	4	1	4
		%	0.6667	7.2727	5.9322	1.6129	8.3333	1.1628	5.5556

Appendix J
Global Indices

This appendix shows the global indices data from United Nations Development Programme and World Economic Forum. The source reports cover many nationalities; the tables herein show the values only for the 17 nationalities in this study.

Table J.1 shows the data for the Human Development Index (HDI) compiled in the years 2005 to 2010 and reprinted in the Human Development Report 2010 with

Table J.1 Extracts of human development report 2010, 20th anniversary edition

Nationality	Code	2005	2009	2010	Mean HDI	2010 rank
United States	US	0.895	0.899	0.902	0.89866667	4
Canada	CA	0.88	0.886	0.888	0.88466667	8
Sweden	SE	0.883	0.884	0.885	0.884	9
France	FR	0.856	0.869	0.872	0.86566667	14
Finland	FI	0.863	0.869	0.871	0.86766667	16
Hong Kong (SAR)	HK	0.842	0.857	0.862	0.85366667	21
Singapore	SG	0.826	0.841	0.846	0.83766667	27
Malaysia	MY	0.726	0.739	0.744	0.73633333	57
Kazakhstan	KZ	0.696	0.711	0.714	0.707	66
China	CN	0.616	0.655	0.663	0.64466667	89
Sri Lanka	LK	0.635	0.653	0.658	0.64866667	91
Thailand	TH	0.631	0.648	0.654	0.64433333	92
Indonesia	ID	0.561	0.593	0.6	0.58466667	108
Vietnam	VN	0.54	0.566	0.572	0.55933333	113
India	IN	0.482	0.512	0.519	0.50433333	119
Lao People's Democratic Republic	LA	0.46	0.49	0.497	0.48233333	122
Myanmar	BU	0.406	0.444	0.451	0.43366667	132

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Table J.2 Extracts of education index 2015

Nationality	Code	2005	2006	2006	2007	2009	Mean EdI
United States	US	0.86678489	0.86951488	0.87634351	0.88039436	0.88368347	0.87534422
Canada	CA	0.85316667	0.85259333	0.85202	0.85144667	0.85087333	0.85202
Sweden	SG	0.66722161	0.6838884	0.69777741	0.7144442	0.71544444	0.69575521
France	SE	0.82966667	0.82668889	0.82371111	0.82351111	0.82331111	0.82537778
Finland	HK	0.68294444	0.68982889	0.71338	0.74804222	0.75770444	0.71838
HK SAR	FR	0.78965406	0.7915663	0.79625631	0.79988288	0.80268906	0.79600972
Singapore	FI	0.81156667	0.81560444	0.81408667	0.81534667	0.80827333	0.81297556
Malaysia	MY	0.65074444	0.65470444	0.65866444	0.66262444	0.66658444	0.65866444
Kazakhstan	KZ	0.7553	0.75947111	0.75808667	0.75948	0.75531778	0.75753111
China	LK	0.70948611	0.71514444	0.72080278	0.72646111	0.72899444	0.72017778
Sri Lanka	TH	0.56855572	0.55903112	0.58237577	0.58905376	0.6012873	0.58006073
Thailand	CN	0.5313963	0.54390222	0.56103778	0.57539556	0.58975333	0.56029704
Indonesia	ID	0.55931761	0.56413405	0.56542966	0.56689266	0.58797006	0.56874881
Vietnam	VN	0.47038889	0.47817556	0.48596222	0.49374889	0.50153556	0.48596222
India	IN	0.40895556	0.41961444	0.43027333	0.44162667	0.44464667	0.42902333
Lao PDR	LA	0.38517778	0.39031556	0.39545333	0.40336889	0.41406222	0.39767556
Myanmar	BU	0.3430963	0.35136593	0.35963556	0.36327556	0.36691556	0.35685778

the inclusion of the ranking per the 2010 HDI (UN Development Programme, 2010). The tabulated values are averaged.

HDI is a composite statistic of life expectancy, education, and income per capita indicators, which are used to rank countries into four tiers of human development. A country scores higher HDI when the lifespan is higher, the education level is higher, the GDP per capita is higher, the fertility rate is lower, and the inflation rate is lower. The HDI was developed by the Pakistani economist Mahbub ul Haq working alongside Indian economist Amartya Sen, often framed in terms of whether people are able to “be” and “do” desirable things in their life, and was published by the United Nations Development Programme.

Table J.2 shows the data for Education Index (EdI) compiled in the years 2005 to 2009 and then averaged (UN Development Programme, 2013).

EdI is a component of the HDI and indicates the access that school-aged children have to a complete education. EdI is the average of:

- “expected years of schooling” (number of years a child of school entrance age can expect to spend in a given level of education) indexed by dividing by 18. The maximum, 18, is equivalent to achieving a master’s degree in most countries; and
- “mean years of schooling” (average number of completed years of education of a population 25 years and older) indexed by dividing by 15.

Table J.3 shows the Network Readiness Index (NRI) compiled in the years 2003 to 2009 and then averaged.

Table J.3 Extracts of global information technology reports

Nationality	Code	2003–04	2005–06	2006–07	2007–08	2008–09	Mean NRI
Canada	CA	6	6	11	13	10	9.2
China	CN	51	50	59	57	46	52.6
Finland	FI	3	5	4	6	6	4.8
France	FR	19		23	21	19	20.5
HK SAR	HK	18	11	12	11	12	12.8
India	IN	45	40	44	50	54	46.6
Indonesia	ID	73	68	62	76	83	72.4
Kazakhstan	KZ			73	71	73	72.33333
Lao PDR	LA						109
Malaysia	MY	26	24	26	26	28	26
Myanmar	BU						146
Singapore	SG	2	2	3	5	4	3.2
Sri Lanka	LK	66	83	86	79	72	77.2
Sweden	SE	4	8	2	2	2	3.6
Thailand	TH	38	34	37	40	47	39.2
United States	US	1	1	7	4	3	3.2
Vietnam	VN	68	75	82	73	70	73.6

NRI researched and compiled by The World Economic Forum (WEF) measures the propensity for countries to exploit the opportunities offered by information and communications technology (ICT). It is published in the annual Global Information Technology Report (GITR) in collaboration with INSEAD (Dutta, Lanvin, & Paua, 2004; Dutta, Lopez-Claros, & Mia, 2006; Dutta and Mia, 2009). The GITR is regarded as the most authoritative and comprehensive assessment of how ICT impacts the competitiveness and well-being of nations.

The index was originally developed by the Information Technology Group, which worked at Harvard University's Center for International Development until 2002. It seeks to better understand the impact of ICT on the competitiveness of nations and is a composite of three components:

- Environment such as market, political, regulatory, and infrastructure, for ICT;
- Readiness of the country's key stakeholders, such as individuals, businesses, and governments, to use ICT; and
- Usage of ICT among these stakeholders.

Table J.4 shows the final marks achieved in blended learning by the students from 17 nationalities as per their two-digit country codes. (SG PR is a segment of people taking up long-term residency in SG; it is not a nationality, so it is subtracted from the 18 nationalities for the purpose of the global indices analysis. The final mark for SG PR students is averaged with that of SG students.) The mark values are sorted in

Table J.4 Ranking of final marks in blended learning by nationality

Code	Final
LK	75.5
LA	72
US	71
CA	70
ID	69.583333
SG	69.2334795
FR	68.5
MY	68.083333
VN	66.675
BU	66
CN	65.3
HK	65
IN	64.891566
KZ	64
SE	57
TH	55
FI	53

descending order from largest to the smallest. This constitutes the baseline ranking against which the HDI, EdI, and NRI are compared.

Tables J.5, J.6 and J.7 show the indices average values (extracted from Tables J.1, J.2 and J.3) for their respective 17 nationalities as per their two-digit country codes. Tables J.5, J.6 and J.7 comprises NRI, HDI, and EdI respectively. The indices in each table are ranked in order of magnitude largest to smallest analogous to the final marks ranking, however, the sorting of NRI values is opposite to HDI and EdI. The largest magnitude of NRI is the smallest value, i.e., NRI = "1" is larger in magnitude than NRI = "2". The sorting of HDI and EdI values is largest to smallest.

Table J.5 Ranking of NRI in ascending order

Code	NRI avg
US	3.2
SG	3.2
SE	3.6
FI	4.8
CA	9.2
HK	12.8
FR	20.5
MY	26
TH	39.2
IN	46.6
CN	52.6
KZ	72.3
ID	72.4
VN	73.6
LK	77.2
LA	109
BU	146

Table J.6 Ranking of HDI in descending order

Code	HDI avg
US	0.89866667
CA	0.88466667
SE	0.884
FI	0.86766667
FR	0.86566667
HK	0.85366667
SG	0.83766667
MY	0.73633333
KZ	0.707
LK	0.64866667
CN	0.64466667
TH	0.64433333
ID	0.58466667
VN	0.55933333
IN	0.50433333
LA	0.48233333
BU	0.43366667

Table J.7 Ranking of EdI in descending order

Code	EdI avg
US	0.87534422
CA	0.85202
SE	0.82537778
FI	0.81297556
FR	0.79600972
KZ	0.75753111
LK	0.72017778
HK	0.71838
SG	0.69575521
MY	0.65866444
TH	0.58006073
ID	0.56874881
CN	0.56029704
VN	0.48596222
IN	0.42902333
LA	0.39767556
BU	0.35685778

Appendix K
Consent Form

This appendix shows the two pages of the Consent form MS Word document in print view (Fig. K.1).

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ABOUT THIS RESEARCH AND YOUR PARTICIPATION

This research adheres to the principles of informed consent. Your written consent to participate will be sought, after you have been informed about the purposes and procedures of the research, the risks and benefits associated with the study, and how the information you provide will be handled.

Title of study:
The role of new educational technology (NET) in institutes of higher learning.

Principal Investigator (PI):
Mr. Kevin Anthony Jones

Co-PI:
NA

BACKGROUND

About this research:
This research is studying the role that NET plays in the teaching and learning of syllabus content. The research will determine how the learning objectives of the subject are supported by the use of NET. The results of the research will assist in planning and operating NET in the university classroom in the near future.

Benefits:
There are no direct benefits to the participants. You are helping to contribute to our understanding of NET. The results of the research will be written up in the form of academic journal papers.

Risks:
There are no risks to the participants. You continue with your academic endeavours at NTU without hindrance, intrusion, or distraction; your marks are beyond effect.

ABOUT YOUR PARTICIPATION

What participants are asked to do:
Participants are asked to do nothing, other than give their agreement for the use of the data from select subjects they are taking in NTU. Plus, a few select participants may be asked if they would be interviewed for up to 30 minutes to share their experience with and without the NET.

Fig. K.1 Screen-print of pages one and two of Consent Form

Voluntary participation, your right to withdraw:

Participation is voluntary. You can withdraw your agreement to participate at any time. There are no repercussions for non-participants.

Use of your name:

The study does not need to use your data with your name; your NTU email username is sufficient. Results of the study will not carry any identifying information that could be linked to you.

Confidentiality:

Any information you provide, and any data collected, for this study, will be kept confidential and will be used only by the PI. A database administrator may view parts of the information necessary for the execution of their duties.

QUERIES

Please retain one signed copy of this document, so that you are aware of your rights as a participant in this study. If you have questions at any time, please contact Kevin Jones: askajones@ntu.edu.sg. You may also contact the Institutional Review Board of Nanyang Technological University directly: irb@ntu.edu.sg.

SIGNED CONSENT

I have read this informed consent form and freely agree to participate in the above-specified research. I understand that my data from the below-specified subjects I am taking in NTU will be used in the above-specified research, and I may be asked to be interviewed about my experience with NET. I understand that I can withdraw my agreement to participate at any time.

______________________________ (code, title, sem of subject providing data)

______________________________ (signature)

______________________________ (participant's name; please print)

______________________________ (day month year)

Fig. K.1 (continued)

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