

Examining e-Learning Effectiveness, Outcomes and Learning Style: A Longitudinal Study

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Abstract

The use of information technology (IT) in education has accelerated rapidly. From the learner's perspective, e-learning is self-service and allows an individual great flexibility and control as well as access to hyperlinked interactive multimedia contents while learning at preferred paces and times. Prior information systems (IS) research has investigated different aspects of e-learning; however, the cumulating evidences of its relative effectiveness and outcomes have been largely equivocal. In this study, we conducted a longitudinal quasi field experiment to comparatively examine e-learning and conventional face-to-face learning in the context of English learning. Our evaluative study used relatively comprehensive effectiveness and outcome measurements and involved 507 undergraduate university students. In addition to assessing the effectiveness and outcomes associated with e-learning, we examined the effect of learning style on the effectiveness and outcome improvements resulting from the use of e-learning as opposed to conventional face-to-face learning. Overall, our analysis shows that learning effectiveness (measured objectively and subjectively) associated with e-learning is significantly higher than that observed in the conventional classroom. Subjects supported by e-learning are also more satisfied with the course contents than their conventional classroom counterparts. Personalized learning support appears to be stronger in e-learning than in the conventional classroom setting but the difference is not significant statistically. Anchored using the Learning Style Model by Kolb (1976), our analysis results suggest that the exact magnitude and significance of the differential learning effectiveness and outcomes resulting from e-learning appear to be contingent upon the individual's learning style. In particular, assimilators may benefit more from e-learning than accommodators, whereas e-learning effectiveness and outcomes seem comparable between convergers and divergers.

1. Introduction

The use of information technology in education has accelerated rapidly. In a nutshell, the prevailing e-learning¹ is about creating and utilizing computer-based systems to better support a wide array of learning activities (Rosenberg M. 2001). The Gartner's Group (2004) predicts an annual growth of 16.7 percent between 2003 and 2008 in the revenues generated from business-focused e-learning software. This global market is expected to double in size by 2008, reaching \$619.4 million in new-license revenues. Various forms of e-learning have sprouted around the world and showcase exciting innovations for enhancing individuals' learning (Zhang and Nunamaker 2003).

Increasingly, information technology has become a critical integral in modern education, pervasively and deeply penetrating into the entire spectrum of learning activities that range from common information searches to sophisticated interactive multimedia-based learning support. E-learning is self-service, allowing an individual great flexibility and control as well as access to hyperlinked interactive multimedia contents while learning at preferred paces and times. E-learning can support a virtual community (synchronous or asynchronous) that also enhances individual learning (Bradshaw 2001, Fisher 2002). According to the constructivist perspective, a learner's active processing and application of the newly acquired knowledge/information is critical (Jonassen et al. 1999). E-learning may better support such information (knowledge) processing and applications than conventional face-to-face learning by enhancing intellectual stimulations to the learner, facilitating the accomplishment of learning objectives, and enriching the learning experience. In addition, e-learning may better support interaction with the learning environment (including course contents) and allows the use of strategies effective for acquiring, internalizing, retaining, and retrieving target information or knowledge (Cohen 1984).

Previous information systems (IS) research has investigated different aspects of technology-enabled learning, e.g., Bostrom et al. (1990), Alavi (1994), Alavi et al. (1995), Leidner and Jarvenpaa (1995), and Piccoli et al. (2001). Both the effectiveness and outcomes associated with e-learning have been studied. A review of extant literature suggests the effectiveness (such as

¹ We use technology-enabled learning and e-learning interchangeably but acknowledge the latter has a connotation of using information technology for supporting asynchronous learning by individuals geographically dispersed.

learning achievement) and outcomes (such as satisfaction) of e-learning to be largely equivocal. For instance, Johnson et al. (2000) and Piccoli et al. (2001) reported no significant differences in learning performance (achievement) between students supported by technology-enabled learning and those using the conventional face-to-face classroom. On the other hand, several studies that include Beerman (1996), Andrewartha and Wilmot (2001), and Ladyshewsky (2004) observed considerable improvements in learning achievement and satisfaction resulting from the use of technology-enabled learning.

According to the relevant education psychology literature, learning style is fundamental to learning effectiveness and outcomes and thus offers a logical lens for scrutinizing or reconciling the equivocal findings by previous research. By and large, learning style refers to important characteristic behaviors of a learner that can serve as relatively a stable indicator of how he or she perceives, interacts with, and responds to the learning environment (Keefe 1979). Conceivably, people vary in learning style and therefore demand personalized learning support which is unavoidably constrained in the conventional face-to-face classroom setting. Towards this, Macfarlane (1992) suggested e-learning to be an effective solution to personalized learning by shifting control responsibilities from the instructor to the learner.

The use of e-learning cannot guarantee prominent and significant improvements in learning effectiveness and outcomes. In this light, learning style represents an appealing anchor for identifying the contingent conditions under which the use of e-learning is likely to result in significant, favorable learning effectiveness and/or outcomes. We conducted a longitudinal quasi field experiment to comparatively examine e-learning and conventional face-to-face learning in the context of English learning. We assessed effectiveness using objective learning achievement (performance) and the learning effectiveness perceived by individual learners. We evaluated the respective learning outcomes associated with e-learning and conventional face-to-face learning in terms of learning satisfaction, personalized learning support, and learning community support, overall course learnability, and course content assessment. Our subjects were undergraduate students at a major university in Hong Kong who enrolled in the Freshman English class mandated by the university. We targeted language training because of its importance to the targeted students as well as its relative difficulty to learn. Language training has received limited

attention from previous e-learning research in IS, which predominantly emphasized on topic areas specific to information systems. The value and applicability of e-learning understandably spans across different domains and disciplines and therefore its effectiveness and outcomes need to be examined in different contexts, including language training. According to Hart-Gonzalez and Lindemann (1993), English is a difficult subject for Chinese speakers. Overall, our analysis shows that the learning effectiveness (measured objectively and subjectively) associated with e-learning is significantly higher than that observed with conventional face-to-face learning. Subjects supported by e-learning exhibit more favorable assessments of the course contents than their conventional classroom counterparts. Personalized learning support appears to be stronger in e-learning than in the conventional classroom setting but the difference is not significant statistically. On the other hand, the learning community support by the conventional classroom is significantly higher than that by e-learning. We observe no significant difference between e-learning and conventional face-to-face learning in learning satisfaction, personalized learning support and overall course learnability. Using the Learning Style Model by Kolb (1976), we further examined the effect of learning style on the differential learning effectiveness and outcomes between e-learning and conventional face-to-face learning. Overall, our analysis generates interesting evidences suggesting that the exact magnitude and significance of the improvements in learning effectiveness and outcome resulting from the use of e-learning appear to be contingent upon the individual's learning style.

The organization of the remaining of the paper is as follows. Section 2 reviews relevant previous research and highlights our motivation. Section 3 analyzes learning in general and provides an overview of learning style, with particular focus on Learning Style Model (Kolb 1976). Section 4 describes the e-learning system under examination, discusses the hypotheses to be tested, and details our study design in terms of experimental design, measurements and data collection procedure. Section 5 highlights important analysis results and discusses their implications to e-learning research and practice. Section 6 concludes this paper with a summary of the study and its contributions and limitations, together with some future research directions.

2. Literature Review and Motivation

Technology-enabled learning has been investigated by information systems (IS) researchers and practitioners alike. Leidner and Jarvenpaa (1995) investigated the importance of information technology for enhancing the education in management. Use of collaborative technology to support learning has been a prominent focus. Alavi (1994) studied the use of group decision support system (DGSS) for supporting collaborative learning and reported that subjects using the DGSS learned more effectively, exhibited higher interests in learning, and perceived the course more favorably than their counterparts in the conventional classroom. Leidner and Fuller (1996) tested whether technology-supported collaborative learning was more effective than individual constructive learning in a context of case-based learning. They found subjects who collaborated in small or large groups exhibiting a higher interest in the case material and perceiving to have learned more than those learning individually who nevertheless showed a higher learning performance. Alavi et al. (1995) conducted a quasi-experimental field study to compare two collaborative distributed learning arrangements and reported that individuals using the e-mail technology learned more than those using a more sophisticated Beta system, and that the satisfaction with the learning process was comparable among subjects using the respective technologies.

Use of hyperlinked multimedia also has been examined. Swaak et al. (2004) analyzed hypertext multimedia presentations by testing their effect on individuals' acquisition of definitional and intuitive knowledge germane to discovery learning and expository instruction respectively. Their results showed that the hypertext (i.e., expository instruction) group performed better on the definitional knowledge test than the simulation (i.e., discovery learning) group. In addition, the hypertext group performed better than the simulation group in testing items pertinent to intuitive knowledge but required more time to complete the test. Using a simulated multimedia Intranet, Lim and Benbasat (2002) conducted a controlled experiment to assess the benefits of multimedia presentations over text-based presentations. They reported that individuals using the multimedia system exhibited a higher recall of explanative and descriptive information (knowledge), and that the observed higher inference ability might be attributed to the increased recall of explanative and descriptive information rather than from use of the multimedia system directly. Haseman et al. (2002) compared three multimedia instructional systems which offered high, low, and non-

interactive modes, respectively. Their analysis suggested a positive effect of interactivity on individual attitudes towards learning but showed no significant effect on learning achievement.

The cumulating empirical evidences suggesting desirable impacts of e-learning have been mostly equivocal. Alavi et al. (1995) examined technology-enabled collaborative learning that involved geographically dispersed as well as local student groups, and conventional face-to-face collaborative learning. They observed comparable knowledge acquisition and satisfaction with the learning process by students in the different learning environments studied. Abraham (2002) designed and empirically tested a virtual IS classroom and showed improved feedback to students via an online grade book and email but insignificant differences in the learning outcomes between the conventional face-to-face and the virtual classroom. Piccoli et al. (2001) empirically examined technology-enabled learning and showed learning performance not significantly different between traditional classrooms and virtual learning environments. They also observed lower satisfactions with the learning process by students using technology-enabled learning than those in conventional classrooms. Newby (2002) observed students in open laboratories exhibiting a higher anxiety about learning than those in closed laboratories, thus attributing this observation to the perceived unavailability of instructors in open laboratories.

Bernard et al (2004) performed a meta-analysis of technology-enabled learning and showed its effects on learning achievement or outcomes to be essentially insignificant, a finding consistent with the proposition by Clark (1983), who suggested a limited contribution of the delivery medium to the outcomes of planned instructions. Based on a task-representation fit model, Lim and Benbasat (2000) tested hypotheses concerning the use of multimedia for alleviating the limitations of text-based information for supporting an individual's analysis and use of organizational data in decision-making. They suggested that text-based and multimedia representation was equally effective for reducing perceived equivocality in analyzable tasks, and that multimedia representation was more effective for reducing perceived equivocality in less-analyzable tasks than text-based presentations. In addition, individuals perceived the video-based representation to be more useful than the text-based presentation for supporting their task performance. Taylor and Nikolova (2004) approached the equivocal findings of e-learning in a language context from the perspective of gender as well as academic performance by examining

students' achievements in computer-based Spanish reading. They showed significant differences between high-ability male and average-ability male students as well as much smaller differences between high-ability female and average-ability female students.

The importance of individual learners' characteristics also has been investigated. Martens et al. (2004) considered the impacts of e-learning to be greatly contingent upon individual learners, showing empirical evidence suggesting students with high intrinsic motivation not necessarily learning more but engaging in more explorative study behaviors. The equivocal findings on desirability of e-learning may be scrutinized in light of salient theories or models in educational psychology literature, such as Corno and Snow (1986), Jonassen and Grabowski (1993). Of particular relevance is learning style, which has been examined in the context of designing hypermedia contents, such as MacGregor (1999), McLoughlin (1999), Chiu and Wang (2000), Farrell and Moore (2000-2001), and Chen and Macredie (2002). The relationships between learning (teaching) medium and learning style preferences have been studied. Using the Learning Style Inventory developed by Dunn et al. (1989), Cohen (2001) investigated whether learning medium had an effect on individuals' learning style preferences and suggested that learning medium might lead to different learning preferences. Inconsistent findings were observed by Neuhauser (2002), who reported no significant differences in students' learning styles in an online versus a face-to-face environment. Based on the Learning Modality Preferences Inventory and the Keirsey Temperament Inventory, Neuhauser (2002) found the effect of learning style preferences on learning performance to be insignificant. Aragon et al. (2002) emphasized on learning achievement and suggested students learn as effectively in an online environment as in conventional face-to-face settings, regardless of learning style preference across motivation, task engagement, and cognitive control. A review of prior studies examining the effect of learning style on the learning effectiveness and outcomes associated with e-learning suggests the need for longitudinal investigations based on comprehensive measurements. The current study purports to fill this research gap by examining e-learning in the context of English learning which has received little research attention.

3. Analysis of Learning and Learning Style

The ability to learn is critical to the human specie and has been examined through several fundamentally different lenses. A review of extant education psychology literature suggests the salience of the behavioral, the cognitive, the constructive, and the social learning approach for learning (Schuman 1996). Behaviorists emphasize on reinforcements that bring about learning and thus consider that learning can be shaped and directed through such reinforcement mechanisms as motivational and correctional feedback. In the cognitive paradigm, a central quest is what an individual knows and how an individual acquires knowledge, rather than what he or she does (Wertheimer 1980). In this vein, analysis of individuals' learning focuses on how they develop or organize possesses for perceiving, framing, understanding, analyzing, or problem solving. Constructivists consider the thrust of learning lies in spontaneous and self-regulated learning induced in natural, untutored conceptualization or comprehension, such as Piaget (1977). According to the constructive approach, meaningful learning takes place only when an individual reflects. That is, learning is initiated and sustained by an individual's thoughts and internalization. The social learning approach considers learning a non-trivial behavior that takes place in a complex social setting. Learned behavior by individuals is largely affected by such factors as expectancy (such as cognition) and reinforcement value (such as motivation) that they perceive within the social system.

For both the cognitive and the constructive approaches, knowledge transfer and dissemination is critical; e.g., knowledge acquisition and applications (Wertheimer 1980). In this light, learning involves a process that is directed towards specific objects (such as contents) and has defined or desired outcomes. Mayer (1989) suggests learning outcomes to be direct results of the learning process and singles out the importance of learning material and learner characteristics. By and large, learning outcomes can be measured in different yet complementary dimensions germane to perception, attitude, satisfaction and enjoyment (Gagne 1977, Mayer 1989). Learning achievement (performance) is also essential and can be assessed objectively and subjectively. Bieber et al. (2002) proposed a community knowledge evolution system of which architecture highlighted the importance of evaluating e-learning in terms of satisfaction, use of resources, learning experience enrichment, performance enhancement, organizational memory creation/retention, and collaborative work support. A review of extant literature suggests the

criticality of learning achievement as well as learning outcomes which can be assessed using overall satisfaction, attitude towards learning, course content assessment, personalized learning support, and learning community support.

Individuals vary considerably in learning style which refers to key characteristic behaviors of a learner that can serve as relatively stable indicators of how he or she perceives, interacts with, and responds to the learning environment (Keefe 1979). Learning style underscores the importance of individualized learning which, in turn, demands learning environments and materials tailored to an individual's particular learning style. Kolb (1976) investigated individual characteristics and proposed Learning Style Model, which is built upon concreteness-versus-abstractness and experimentation-versus-reflection delineations. According to this model, individuals inherently vary in their reliance on and use of concrete experience, abstract conceptualization, active experimentation, and reflective observation. Concrete experience emphasized on being involved and primarily dealing with immediate human situations in live experiential fashions. The locus is feeling rather than thinking, with a particular interest in the uniqueness or complexity of the presented reality (such as learning materials) rather than theories or their generalizations. Concrete experience essentially represents an intuitive "artistic" approach to learning and places less value to systematic or scientific means for learning. On the other hand, abstract conceptualization focuses on logics, concepts, intuitions or patterns and highly values thinking (internalization) and shows greater interests in theory building, intuition development, or pattern extraction than in understanding particular uniqueness or specificity as perceived or felt by individuals. Contrast to concrete experience, abstract conceptualization values systematic or scientific approaches to learning.

The experimentation-versus-reflection dimension is also fundamental. In light of active experimentation, learning occurs through active influences to the learner (such as manipulating the context or scenario) and particularly focuses on practical applications of the newly acquired information (knowledge) rather than detailed understanding of it. Active experimentation manifests a pragmatic interest in "what works" rather than "the underlying truth (rule) that makes something work." This suggests an individual obtaining first-hand personal observations (such as short, intensive exposures to learning materials) can quickly apply them in different contexts or

scenarios, without a full or detailed understanding of the materials. Reflective observation, on the other hand, emphasizes understanding the underlying governing rules or semantics of an idea or situation, thus encouraging detailed observations and impartial descriptions of them. Understanding through careful scrutiny and detailed analysis is essential to reflective observation which primarily concerns with “what is true” and “how things happen” rather than “what works or appears to work” (Kolb et al. 1990).

Figure 1 depicts the bipolar concreteness-versus-abstractness and experimentation-versus-reflection dimensions which jointly categorize individual learners as accommodators, assimilators, convergers and divergers. Anchored at concrete experience and active experimentation, accommodators place high values in doing things, carrying out tasks, and getting involved through personal, live experiences. Accommodators are relatively receptive of risk-taking and tend to solve problems in an intuitive manner. They often rely on personal or others’ experiences or information heavily rather than on their own analysis or conceptualization. On the other hand, an assimilator learns through abstract conceptualization and reflective observation. Assimilators typically learn through inductive reasoning, theorization, model building, and/or integrating disparate observations into a systematic explanation. Assimilators internalize more than accommodators and show particular interests in generalized ideas, intuitions, rules, patterns by observing their own learning as well as others’ learning. Convergers are strong in abstract conceptualization and are fond of active experimentation. By and large, convergers are effective problem solvers (or decision makers) and often acquire and organize information (knowledge) through hypothetical deductive reasoning. On the other hand, divergers focus on concrete experience and reflective observation. A diverger views concrete situations from different perspectives and can organize multiple, complex relationships into a meaningful “Gestalt.” Divergers perform well in situations that demand alternative idea generations and explorations of their implications, such as brainstorming. A review of prior learning-style research suggests the effectiveness of e-learning to vary with learning style. In the following section, we describe the specific hypotheses suggested by the learning style literature as well as highlight the evaluated system and our study design (including data collection).

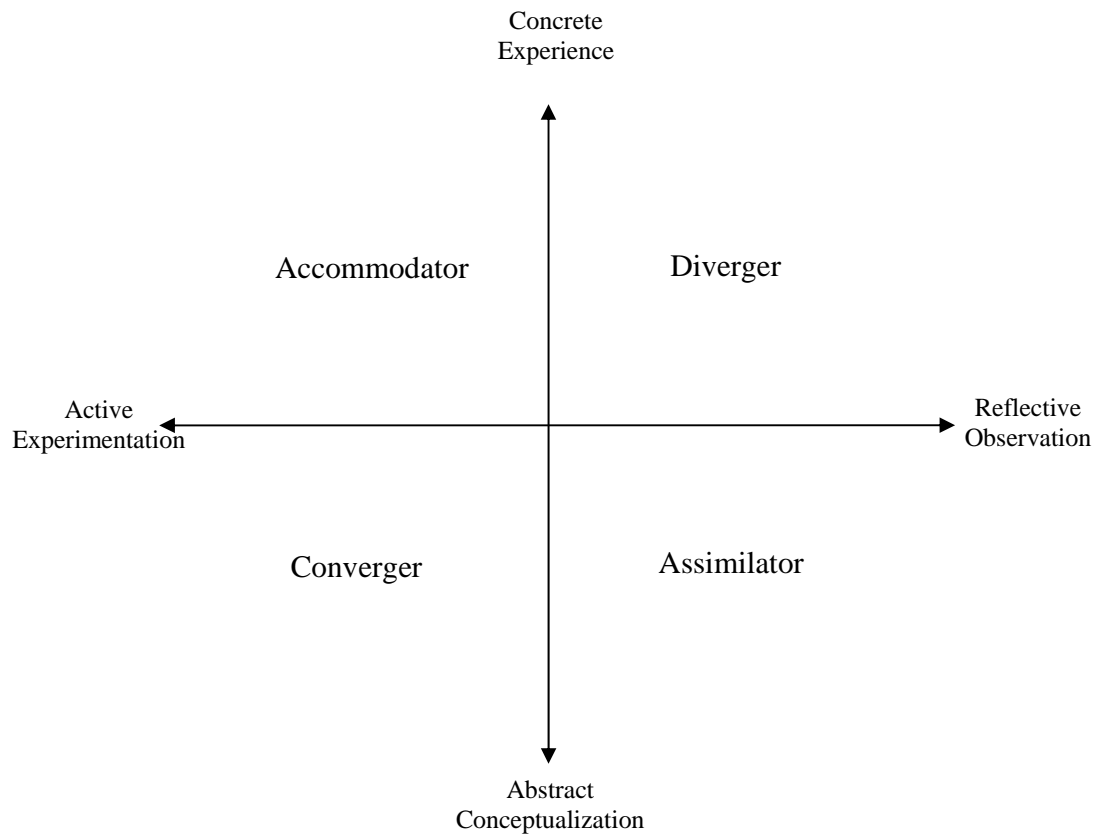


Figure 1: Analysis of Learning Style by Kolb et al. (1990)

4. Evaluated System, Hypotheses, and Study Design

In this section, we described the e-learning system studied, the particular hypotheses to be tested, and our research design.

4.1 E-Learning System under Examination

The e-learning system under study is an interactive online English website. Similar to most Web-based learning systems, this website offers limited support of personal interactions between or among students and their instructor, though it supports a virtual discussion forum. The design of this e-learning system embrace all fundamental aspects of English language, such as listening, speaking, vocabulary, writing, and reading. Students can access and interact with the programmed multimedia contents repeatedly and are supported by an array of built-in functions in their learning. For instance, students can participate in different online multimedia activities to

improve their listening, use an online verbal discussion forum to practice and improve their speaking, use a word-list tool to acquire new vocabularies, use scripted online role plays (a toolbar running in MSWord with embedded hyperlinked comments by the instructor) to improve their writing, and reading recommended articles available at other websites explicitly linked to the course website. Subjects progressed through defined units over the course of the semester, completing the specified requirements which were then graded for objective learning achievement assessments. Most, if not all of the activities supported by the e-learning system encourage students' use of look-up tools (available in the context menu) and other online self-diagnosis resources for improving their proper use of the English in terms of accuracy and fluency. Figure 2 provides a screenshot of the interactive English e-learning system under study.

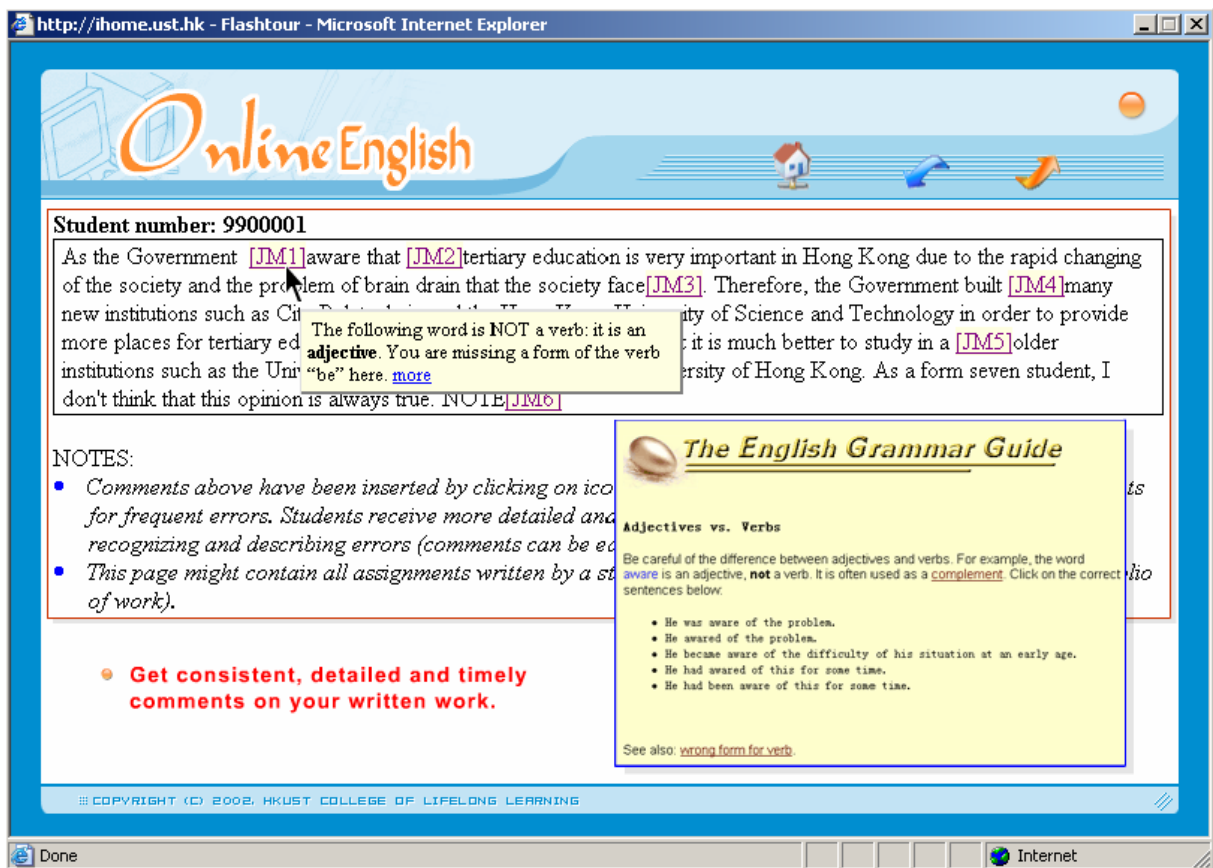


Figure 2: Screenshot of the English E-learning System

4.2 Hypotheses

Spear, Portas and Pettigrew (2001) advocated designing comprehensive e-learning systems that greatly support all individual learners, regardless how they perceive information/knowledge (such as concrete experience or abstract conceptualization) or process it (such as active experimentation or reflective observation). When effectively designed, such systems can substitute conventional face-to-face learning to some degree. We, however, took a complementary view of e-learning and suggest its use in conjunction with conventional face-to-face learning. This complementary view is consistent with the discussions of prior research (Black 2001) and echoes the prevailing practices of developing designated websites housing a rich array of interactive multimedia contents, online exercises and instructional assistance. Most designated course websites are asynchronous; i.e., providing limited support of “live” feedback or simultaneous personal interactions. From a perspective of learning style, these websites conceivably may be ineffective for individuals who greatly depend on active experimentation and concrete experience for their learning.

According to Kolb et al. (1990), both assimilators and convergers learn using abstract conceptualization and typically would prefer working individually rather than in a group context. Such conceptualization can be initiated, further refined and solidified through active experimentation and/or reflective observation. In general, assimilators learn effectively through reflective observation while convergers greatly benefit from active experimentation. In the context of language training, active experimentation, to some degree, is relatively less important as compared with that pertinent to design, engineering, and nature (life) science in which actual manipulation, experimentation and observation are critical. Instead, repetitive, intensive practices and frequent, routine exposures to designated contents are important for an individual’s learning English which can be effectively supported by his or her iterative reviews of course materials and repetitively access to online exercises with instructional (diagnostic) assistance available on a 24/7 basis. Flexible content delivery support, detailed analysis (diagnosis), and systematic synthesis are essential for individuals’ conceptualizing course materials at an abstract level (such as developing generalized rules of thumb or patterns) which require repetitively accessible course contents delivered in complementary formats with rich visual cues. In our case, assimilators can learn from the online activities and exercises supported by the e-learning system,

which can facilitate their internalizing the observations made from their interactions with the programmed multimedia exercises and online instructions as well as the experiences or suggestions by their peers and instructors participating in the system's supported virtual learning community above and beyond geographic and temporal constraints.

On the other hand, accommodators and divergers greatly rely on concrete experience for learning and tend to anchor their learning using people participating in these activities, including peer students, instructors or tutors. This people-centric orientation emphasizes on "live" interactions and simultaneous personal interactions which are better supported in conventional face-to-face classroom settings than in an e-learning environment. In particular, accommodators greatly benefit from in-class lecturing, classroom discussions and demonstrations which offer personal experiences and "live" observations. As such, conventional face-to-face learning is likely to result in favorable learning effectiveness and outcomes for accommodators who may not benefit greatly from e-learning. Therefore, we postulate that the improvements in learning effectiveness and outcomes resulting from e-learning are more prominent and significant with assimilators than with accommodators.

The effectiveness and outcomes resulting from the use of e-learning may be comparable between convergers and divergers. While gaining support in abstract conceptualizations through repeated and convenient access to hyperlinked multimedia contents, convergers has limited active experimentation using the e-learning system because of its constraints in providing "live" interactions and feedback by the instructor or advanced learners. On the other hand, divergers may benefit from intensive, repetitive and detailed observations using the e-learning system of which virtual and asynchronous nature offers limited support to their learning through people-centric concrete experience. Therefore, we expect the effectiveness and outcomes associated with e-learning to be largely comparable between convergers and divergers. Based on our overall propositions, we the developed specific hypotheses to be tested empirically, detailed as follow.

Learning Effectiveness: We posit that learning effectiveness associated with e-learning was higher than that of conventional face-to-face learning in our experimental context, mainly because our e-learning (treatment-group) subjects were supported by both classroom activities

and the designated course website. We further hypothesize that individuals whose learning styles anchored at reflective observation and abstract conceptualization (i.e., assimilators) were more likely to benefit from e-learning than individuals who mostly learned from active experimentation and concrete experience (i.e., accommodators). In addition, we expected the learning achievement and outcomes associated with e-learning to be comparable between convergers and divergers. Thus, we tested the following hypothesis.

H1: The objective learning achievement resulting from the use of e-learning is higher than that that of conventional face-to-face learning.

H1-A: The objective learning achievement improvement resulting from e-learning as opposed to conventional classrooms is higher with assimilators than with accommodators.

H1-B: The objective learning achievement improvement resulting from using e-learning as opposed to conventional classrooms is comparable between convergers and divergers.

H2: The perceived learning effectiveness resulting from the use of e-learning is higher than that of conventional face-to-face learning.

H2-A: The perceived learning effectiveness improvement from using e-learning as opposed to conventional classrooms is higher with assimilators than with accommodators.

H2-B: The perceived learning effectiveness improvement from using e-learning as opposed to conventional classrooms is comparable between convergers and divergers.

Learning Satisfaction: We also examined learning satisfactions associated with e-learning and conventional face-to-face learning. We anticipated that learner satisfaction would be an important factor in learning outcome assessment (Biner et al. 1994, Chute et al. 1999). Results from the meta-analysis by Allen et al. (2000) suggested students experienced higher satisfactions with traditional classroom settings than with technology-enabled distance learning. We posit that learning satisfaction would be higher by assimilators than by accommodators, and comparable between convergers and divergers. Thus, we tested the following hypotheses.

H3: Learning satisfaction resulting from the use of conventional face-to-face learning is higher than that e-learning.

H3-A: Learning satisfaction resulting from using e-learning as opposed to conventional classrooms is higher with assimilators than with accommodators.

H3-B: Learning satisfaction from using e-learning as opposed to conventional classrooms is comparable between convergers and divergers.

Personalized Learning Support: E-learning has great potential to support personalized learning towards which conventional face-to-face learning is constrained. Moallem (2001) analyzed technology-enabled learning and advocated its value in enhancing personalized e-learning support. Accordingly, we expected more favorable assessments of e-learning in supporting

personalized learning than conventional face-to-face learning. We further postulate that assimilators would perceive the personalized learning support by e-learning as being of greater value than would accommodators, and that the assessments are comparable between convergers and divergers. Therefore, we tested the following hypotheses.

H4: Personalized learning support is higher in e-learning than in conventional face-to-face learning.

H4-A: Personalized learning support improvement resulting from e-learning as opposed to conventional classrooms is higher with assimilators than with accommodators.

H4-B: Personalized learning support improvement resulting from e-learning as opposed to conventional classrooms is comparable between convergers and divergers.

Learning Community Support: Perceived learning community support refers to the extent to which a learning environment can create an active community supporting and enriching an individuals' learning, such as access to and interaction with the instructor and peers. The learning community common to conventional face-to-face learning can better support individuals' learning than can that by e-learning, partially because of its virtual, asynchronous and distributed nature. However, we posit greater perceived learning community support by e-learning with assimilators than with accommodators, and comparable assessments between convergers and divergers and therefore tested the following hypotheses.

H5: Learning community support is higher in conventional face-to-face learning than in e-learning.

H5-A: Learning community support resulting from e-learning as opposed to conventional classrooms is higher with assimilators than with accommodators.

H5-B: Learning community support resulting from e-learning as opposed to conventional classrooms is comparable between convergers and divergers.

Overall Course Learnability: We evaluated assessments of the overall course learnability by subjects in e-learning and in conventional face-to-face learning environment. Because of convenient access to multimedia course contents, online exercises and instructional (diagnostic) assistance, we posit that subjects using e-learning would find the overall course more learnable than by their counterparts using conventional classrooms exclusively. We further hypothesized the improvement in perceived course learnability resulting from e-learning to be greater with assimilators than with accommodators, and comparable between convergers and divergers. Therefore, we tested the following hypotheses.

H6: Subjects using e-learning perceive the overall course more learnable than those using conventional face-to-face classrooms.

H6-A: The course learnability improvement resulting from e-learning as opposed to conventional face-to-face learning is higher with assimilators than with accommodators.

H6-B: The course learnability improvement resulting from e-learning as opposed to conventional face-to-face learning is comparable between convergers and divergers.

Course Contents Assessment: We also examined subjects' assessments of the course contents. Previous research suggests the relative advantage of e-learning in course contents, such as hyperlinked multimedia conveniently and repeatedly accessible (Chin 1999). Therefore, we posit more favorable assessments of course contents by subjects using e-learning than by those using conventional face-to-face learning. We further expected more prominent positive assessments of course contents by assimilators than by accommodators, and comparable assessments between convergers and divergers.

H7: Subjects using e-learning perceive course contents more favorably than their counterparts using conventional face-to-face learning.

H7-A: The course content assessment resulting from e-learning as opposed to conventional learning is higher with assimilators than with accommodators.

H7-B: The course content assessment resulting from e-learning as opposed to conventional learning is comparable between convergers and divergers.

4.3 Study Design

To examine and compare the learning achievement and outcomes by students in e-learning versus conventional classroom settings, we conducted a longitudinal field experiment, a research design extending from controlled laboratory experimentation that allows analyses of an event as it takes place in its natural setting (Zmud et al. 1989). Our study targeted freshmen at a major university in Hong Kong and specifically emphasized on their learning in the Freshman English classes mandated by the university. A total of 507 subjects voluntarily took part in the study, accounting for 29.4% of the targeted student population. All subjects received equal cash compensations for their participations and could gain additional financial awards based on their performances in the study. We adopted a randomized design in which approximately 25% of the subjects were assigned to the treatment group (i.e., using e-learning) while the remaining used the conventional classroom setting exclusively; i.e., the control group. Congruent with the suggestions by prior research (Frederickson et al. 2004), the treatment group had face-to-face

classroom sessions and embraced a substantial use of a designated website which delivers course materials and supports students' assignments and practices. The control group met in the classroom twice as often as the treatment group but received no support or assistance in terms of accessing course materials, practice exercises and diagnostic feedback, and completing assignments via the website.

Measures: Our evaluation focused on objective learning achievement and perceived learning effectiveness as well as on self-reported outcome assessments germane to learning satisfaction, personalized learning support, learning community support, overall course learnability, and course content assessment, as suggested by Wang (2003). We measured objective learning achievement using the difference in score between the examinations taken at the beginning and the completion of the semester. Both examinations were designed with an emphasis on vocabulary, grammar, listening and reading comprehension. The question items used to operationalize the respective constructs were mostly adapted from relevant previous research, with minor wording changes to tailor to the target context. All items for measuring learning outcome used a seven-point Likert scale, with 1 being "strongly disagreed" and 7 being "strongly agreed." All items in the questionnaire were randomly sequenced and many of them were negated so as to reduce a potential ceiling or floor effect that might have induced monotonous responses from the subject. The particular items used to measure each construct are listed in Appendix A, together with the respective sources.

Data Collections: We collected data longitudinally, between September and December 2004. At the beginning of the semester (September), subjects took an English test online of which the test score offered a baseline of the respective individuals' English skills. Subjects took a similar test online at the end of the semester (December). We used the difference between the two test scores to approximate the objective learning achievement by an individual. We also obtained subjects' learning styles and demographics at the beginning of the semester (September) and collected their assessments germane to perceived learning effectiveness, learning satisfaction, personalized learning support, learning community support, overall course learnability, and course contents in December. Before every data collection (including a test), we used a documented script to

explicitly inform subjects of our objectives and intended data analysis at an aggregate level; i.e., not in any personally identifiable manner.

5. Evaluation Results and Discussions

A total of 507 subjects participated in the study, averaging 19.1 years in age and showing a largely balanced gender distribution slightly in favor of male. We had more subjects in the face-to-face group than in the e-learning group of which the dominant majority was male (70.2%). As shown in Table 1, subjects in both groups were fairly comparable to those in the face-to-face (control) group in terms of age and A-Level English Examination score. More than half of the face-to-face subjects were from the business school and the dominant group of the e-learning subjects was from the engineering school. Science students accounted for approximately 30% of the subjects in each group. Proportionally, we had more assimilators in the face-to-face group than in the e-learning group (25.8% versus 13.4%), whereas the number of accommodators was comparable between the groups. The distribution of convergers and divergers was highly similar between the groups: convergers accounting for 37% while divergers representing 11% of the subjects in each group. In addition, subjects in both groups showed comparable general computer competency and reported similar Internet experiences and usage.

	Face-to-Face Group	e-Learning Group
Age (in Years)	18.9	19.2
Gender	Male: 131 (46.3%) Female: 152 (53.7%)	Male: 146 (70.2%) Female: 62 (29.8%)
Affiliated School	Business: 145 (51.6%) Engineering: 50 (17.8%) Science: 86 (30.6%)	Business: 47 (21.0%) Engineering: 116 (51.8%) Science: 61 (27.2%)
A-Level English Exam	A = 1; B = 11; C = 32; D = 76; E = 84; F = 0	A = 5; B = 25; C = 64; D = 95; E = 43; F = 4
Learning Style	Assimilator: 73 (25.8%) Converger: 104 (36.7%) Accommodator: 74 (26.1%) Diverger: 32 (11.3%)	Assimilator: 32 (13.4%) Converger: 77 (37.0%) Accommodator: 74 (35.6%) Diverger: 25 (12.0%)

Table 1: Summary of Subjects in Control and Treatment Group

We used Cronbach's alpha (Straub 1989) to assess our instrument's reliability (internal consistency), a critical dimension of construct validity. As shown in Table 2, the alpha value of each investigated

construct exceeded 0.7, a commonly suggested threshold for the instrument’s reliability assessment (Nunnally and Bernstein 1994). In turn, the observed alpha values suggest satisfactory reliability of the items used to measure the respective constructs.

	Chronbach’s Alpha
Overall Satisfaction (7 Items)	0.90
Personalized Learning (5 Items)	0.73
Learner Community (5 Items)	0.73
Course Learnability (6 Items)	0.80
Course Contents (5 Items)	0.76
Perceived Effectiveness (15 Items)	0.89

Table 2: Construct Validity – Reliability

Our analysis suggests that the use of e-learning can result in significantly higher learning effectiveness, as compared with conventional face-to-face classrooms. As summarized in Table 3, the objective learning achievement as well as the self-reported perceived learning effectiveness was significantly higher in e-learning than in the conventional classroom, showing the p-value less than 0.05 and 0.01 respectively. Subjects supported by e-learning were significantly more favorable about the course contents than those using the face-to-face classrooms, p-value less than 0.01. On the other hand, subjects in the conventional classroom perceived the learning community support to be significantly stronger than did their e-learning counterparts (p-value less than 0.01) and showed a learning satisfaction noticeably higher than that of e-learning, though not statistically significant. Subjects perceived the personalized learning support to be greater in e-learning than in face-to-face classrooms; however, the difference is statistically insignificant. Overall, our results suggest that e-learning is likely to enhance students’ learning effectiveness (measured in objective or subject terms) as well as to generate favorable course content assessments and enhance personalized learning support. Compared with the conventional face-to-face classroom setting, e-learning may provide a weaker learning community support and make the course less learnable, thus leading to lower learning satisfaction.

	Face-to-Face	e-Learning	t-statistic	P-Value
Objective Learning Achievement ²	1.0 (7.6)	2.4 (7.6)	-1.861	0.032
	Sep: 64.5 (10.7)	Sep: 62.6 (10.3)	2.033	0.022
	Dec: 65.5 (11.3)	Dec: 64.9 (10.1)	0.589	0.278
Perceived Learning Effectiveness	4.14 (0.74)	4.35 (0.75)	-2.972	0.002
Learning Satisfaction	4.31 (0.93)	4.29 (0.98)	0.199	0.421
Personalized Learning Support	4.05 (0.76)	4.09 (0.82)	-0.518	0.303
Learning Community Support	4.31 (0.73)	4.10 (0.79)	2.847	0.003
Overall Course Learnability	4.62 (0.81)	4.49 (0.75)	1.624	0.053
Course Content Assessment	4.13 (0.86)	4.32 (0.83)	-2.368	0.009

Table 3: Summary of Experimental Results

We further examined the learning effectiveness and outcomes associated with e-learning, based on learning style. As shown in Table 4, assimilators appeared to benefit greatly from e-learning, showing considerable improvements in all the effectiveness and outcome assessments evaluated. Based on our analysis, only the improvement in perceived learning effectiveness and course learnability was statistically significant. The limited significance may be in part attributed to the relatively small number of assimilators in the e-learning group (32 out of 308). On the other hand, accommodators seemed to benefit less from e-learning, if at all. When supported by e-learning, accommodators gained learning effectiveness but exhibited a lower learning satisfaction and perceived less personalized learning support and learning community support. Overall, our results suggest learning effectiveness and outcome improvements were more prominent and significant with assimilators than with accommodators, consistent with our overall proposition suggesting assimilators would benefit more from e-learning than accommodators. Our findings support the two hypotheses germane to the comparative analysis between assimilators and accommodators and showing overall congruence with our proposition.

	Assimilators			Accommodators		
	Face-to-Face	e-Learning	P-Value	Face-to-Face	e-Learning	P-Value
Objective Learning Achievement	1.27 (6.23)	2.95 (7.45)	0.15	0.41 (8.51)	1.88 (7.00)	0.88
Perceived Learning Effectiveness	4.12 (0.65)	4.50 (0.97)	0.03	4.15 (0.71)	4.37 (0.68)	0.96

² In this study, objective learning achievement is operationalized using the difference in score between the examination the subject took at the end of study semester and that at the beginning of the semester.

Learning Satisfaction	4.32 (0.83)	4.49 (1.19)	0.23	4.24 (1.01)	4.23 (0.84)	0.50
Personalized Learning	4.08 (0.68)	4.13 (1.03)	0.41	4.12 (0.79)	4.09 (0.79)	0.43
Learning Community	4.27 (0.63)	4.37 (0.90)	0.30	4.29 (0.71)	4.10 (0.71)	0.07
Course Learnability	4.53 (0.69)	4.85 (0.79)	0.03	4.62 (0.89)	4.39 (0.71)	0.06
Content Assessment	4.18 (0.75)	4.49 (1.05)	0.08	4.03 (0.91)	4.32 (0.72)	0.97

Table 4: Comparative Evaluation Results – Accommodators versus Assimilators

We also compared convergers and divergers using their respective learning effectiveness and outcome improvements resulting from the use of e-learning. Overall, our analysis supported most of the hypotheses pertinent to this comparison, suggesting comparable gains by convergers and divergers from e-learning. Specifically, the improvement in learning effectiveness and outcomes is limited and insignificant statistically for both convergers and divergers. The exception was the difference in learning community support which was perceived significantly lower by convergers than by divergers. Interestingly, we observed noticeable improvements in learning effectiveness as well as positive course content assessment and enhanced personalized learning support by convergers in the e-learning than in the conventional face-to-face environment. On the other hand, divergers appeared to favor the conventional face-to-face classroom setting in which they showed greater learning effectiveness than in the e-learning environment. Overall, our analysis and findings supported the proposition suggesting comparable effects of e-learning on convergers and divergers. Convergers seemed to benefit more from e-learning than divergers and this, in turn, might imply the effect of enhancing abstract conceptualization in e-learning outweigh the importance of the reflective observations supported by e-learning.

	Convergers			Divergers		
	Face-to-Face	e-Learning	P-Value	Face-to-Face	e-Learning	P-Value
Objective Learning Achievement	0.94 (8.01)	2.74 (8.11)	0.16	2.24 (7.38)	2.21 (8.07)	0.99
Perceived Learning Effectiveness	4.08 (0.75)	4.28 (0.70)	0.09	4.38 (0.93)	4.35 (0.74)	0.89
Learning Satisfaction	4.31 (0.91)	4.29 (1.00)	0.89	4.49 (1.09)	4.20 (1.02)	0.32
Personalized Learning	4.02 (0.72)	4.06 (0.81)	0.70	4.03 (1.05)	4.14 (0.69)	0.63
Learning Community	4.31 (0.75)	4.00 (0.77)	0.01	4.47 (0.98)	4.06 (0.90)	0.11
Course Learnability	4.67 (0.84)	4.48 (0.71)	0.12	4.68 (0.86)	4.36 (0.86)	0.18
Content Assessment	4.09 (0.86)	4.24 (0.87)	0.26	4.40 (1.00)	4.38 (0.67)	0.92

Table 5: Comparative Evaluation Results – Accommodators versus Assimilators

Overall, our findings suggested increased individual learning effectiveness through e-learning which also had positive effects on their learning outcomes, particularly in course content assessment and, to a lesser extent, personalized learning support. Further analysis using learning style shows that assimilators were likely to benefit more from e-learning and thus perceive it more favorably than accommodators. The relative improvements in individuals' learning effectiveness and learning outcome assessments associated from e-learning (as opposed to the conventional classroom setting) were largely comparable between convergers and divergers. This comparability suggested a plausible trade-off between e-learning's support of abstract conceptualization and reflective observation for convergers and divergers. Specifically, convergers were likely to gain in abstract conceptualization through e-learning which however may have limited their reflective observations. Similarly, divergers were able to benefit from e-learning in reflective observations but were also constrained in their abstract conceptualization. Table 6 summarizes our analysis results with respect to the particular hypotheses tested.

Hypothesis	Result
H1: Higher objective learning achievement in e-learning than in conventional. H1-A: Greater improvement in objective learning achievement with assimilators than with accommodators. H1-B: Comparable improvements in objective learning achievement between convergers and divergers.	Supported Not Supported Supported
H2: Higher perceived learning effectiveness in e-learning than in conventional. H2-A: Greater perceived learning effectiveness with assimilators than with accommodators. H2-B: Comparable perceived learning effectiveness between convergers and divergers.	Supported Supported Supported
H3: Higher learning satisfaction in conventional than in e-learning. H3-A: Higher learning satisfaction resulting from e-learning as opposed to conventional learning with assimilators than with accommodators. H3-B: Comparable learning satisfaction resulting from e-learning as opposed to conventional learning between convergers and divergers.	Not Supported Not Supported Supported
H4: Greater personalized learning support by e-learning than by conventional learning. H4-A: Higher personalized learning support resulting from e-learning as opposed to conventional learning with assimilators than with accommodators. H4-B: Comparable personalized learning support resulting from e-learning as opposed to conventional learning between convergers and divergers.	Not Supported Not Supported Supported
H5: Higher learning community support in conventional than in e-learning. H5-A: Higher learning community support resulting from e-learning as opposed to conventional learning with assimilators than with accommodators. H5-B: Comparable learning community support resulting from e-learning as opposed to conventional learning between convergers and divergers.	Supported Not Supported Supported

H6: Higher overall course learnability in e-learning than in conventional learning. H6-A: Higher overall course learnability resulting from e-learning as opposed to conventional learning with assimilators than with accommodators. H6-B: Comparable overall course learnability resulting from e-learning as opposed to conventional learning between convergers and divergers.	Not Supported Supported Supported
H7: More favorable course content assessment in e-learning than in conventional learning. H7-A: More favorable course content assessment resulting from e-learning as opposed to conventional learning with assimilators than with accommodators. H7-B: More favorable course content assessment resulting from e-learning as opposed to conventional learning between convergers and divergers.	Supported Not Supported Supported

Table 6: Summary of Findings

6. Summary

The expanding use of e-learning in a growing array of training and education activities demands research attention for examining the associated learning effectiveness and outcomes. Most prior research investigation of e-learning effectiveness and outcomes has focused on domain-specific topic and adopted ad-hoc evaluation designs. In contrast, we assessed e-learning effectiveness and outcome in the context of language learning (i.e., English) by undergraduate students at a major university in Hong Kong where both online and traditional classroom teaching contexts were designed to provide the best possible implementations of teaching and learning materials and resources available in each environment. Our evaluation used both longitudinal and comprehensive approaches, with effectiveness and outcome measurements providing significantly more complete sources of data and learning than those used by most prior studies in more constrained and artificial learning experimental contexts. Over the course of a semester, we comparatively analyzed students' progress and assessments in e-learning versus conventional face-to-face classroom settings.

Our overall findings suggest that use of e-learning resulted in significant improvements in both objective learning achievement and perceived learning effectiveness. Based on our analysis, e-learning resulted in more favorable assessment of the course contents by students, but these same students also experienced lower learning satisfaction and were concerned about the relative lack of learning community support in the e-learning context. We also observed the effects of learning style on e-learning effectiveness and outcomes, in which our analysis indicated that

assimilators were more likely to benefit from e-learning and exhibited more positive assessments of e-learning than accommodators. Our results also suggested that convergers and divergers may have comparable gains from e-learning in terms of their learning effectiveness and outcomes. Overall, our findings suggest the importance of e-learning for better supporting abstract conceptualization and reflective observations; this may shed light on the contingency conditions where the use of e-learning would be beneficiary and desirable.

The current study makes several contributions to the e-learning literature. First, we assess the learning effectiveness and outcomes associated with e-learning by conducting a longitudinal field experiment embracing the conventional face-to-face classroom as well as a comprehensive set of measurements. As a result, our results arguably may be of increasing validity and be more generalizable and can augment the inconsistent findings of e-learning effects by prior research. Second, this study focused on e-learning's support of language training which is relatively more difficult than domain-specific tasks or skills. Results from the study therefore may shed light on e-learning effectiveness and outcome assessments in a challenging learning context. Third, we examine the effect of learning style on the learning effectiveness and outcome improvements resulting from the use of e-learning, based on a well-established taxonomy of learning style. Our analysis shows considerable effects of learning styles and highlight the particular learning styles likely or not likely to benefit from e-learning in terms of objective achievement, perceived effectiveness, satisfaction, and personalized learning, learning community support, course content assessment. The current study represents a point of departure for continued research investigating the effects of learning style which will generate findings important for enhancing e-learning system designs and identifying the specific conditions where the use of e-learning is beneficiary, desirable or otherwise.

This study has several limitations which must be taken into consideration when interpreting its results. First, our study design follows quasi field experimentation and therefore is limited in its controls. While gaining actuality (and external validity), our design did not incorporate tight controls common to laboratory experimentation. For instance, we cannot rule out interactions between e-learning subjects and those using conventional learning and how they benefit from such interactions respectively. Second, our subjects are highly comparable in most demographic

dimensions but show subtle, if not noticeable differences in A-level English Examination results and gender distribution (i.e., more males than females in the e-learning group), as well as in school affiliations (i.e., more business students in the face-to-face group and more engineering students in the e-learning group). The unbalanced distribution in learning style represents another limitation. We suspect the moderate contrast observed between assimilators and accommodators be partially attributed to the relative small number of assimilators in the e-learning group. In addition, findings from this study are subject to single-study biases, particularly with respect to subject area and subject pools. In turn, these limitations shed light on desirable directions of our continued research in assessing the effectiveness and outcomes of e-learning.

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Appendix A: Listing of Question Items Used in the Study

Perceived Effectiveness

- The course gives me chances to practice what I learn.
- The course gives me chances to review what I learn.
- This course can help me improve my ability to use English in various social occasions.
- This course can help me improve my overall academic ability.
- This course can help me improve my career-related skills.
- This course supports my learning English by providing many resources and tools.
- This course allows me to learn English in many different ways.
- This course allows me to improve my understanding of the basic elements of English.
- This course allows me to learn factual aspects of using English.
- This course allows me to learn to identify the central issues in learning English.
- I have an opportunity to practice and improve my English listening skills.
- I have an opportunity to practice and improve my English speaking skills.
- I have an opportunity to practice and improve my reading skills in English.
- I have an opportunity to practice and improve my writing skills in English.
- I am more confident in expressing ideas in English after taking this course.

Overall Learning Satisfaction

- Learning by taking a course like this is a good idea.
- I like the idea of learning English in a class like this; i.e., the one I have this semester.
- Learning English in a class like this is enjoyable.
- Overall, I am satisfied with the course.
- As a whole, the course is effective for my learning.
- In sum, my learning in the course is pleasant.
- My learning experience in this course is positive.

Personalized Learning Support

- In this class, I have good control over the pace at which I learn.
- The course supports my preferred way of learning.
- The course allows me to learn the particular contents I need.
- The course allows me to choose how I want to learn.
- The course provides me with timely feedback on my learning progress or performance.

Learning Community Support

- My interaction with the instructor regarding course-related concerns effective was.
- It is easy for me to discuss with other students concerns related to course contents.
- The course facilitates my sharing of what I have learned with other students.
- The course makes it easy for me to learn from other students.
- Overall, the course has created a supportive community for my learning of English.

Course Learnability

- Overall, I find this course easy to learn.
- I have no difficulty understanding course materials delivered in class or via the Web.
- The course content is presented in a way that is easy to understand.
- The course is delivered in a way that is easy to learn.
- I find the delivery of the course content consistent.
- I find the delivery of the course content clear; i.e., not ambiguous.

Course Content Assessment

- The course content fits the learning objectives specified in the syllabus.
- Overall, I find the course content useful.
- I feel that the course content is sufficient for my learning of English.
- The course content is current and up-to-date.
- In general, the course content meets my expectation.