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# Examining e-Learning Effectiveness, Outcomes and Learning Style: A Longitudinal Field Experiment

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## Examining e-Learning Effectiveness, Outcomes and Learning Style: A Longitudinal Field Experiment

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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 classroom based 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 based as opposed to conventional classroom based 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.*

**Keywords:** E-learning, Kolb's Learning Style Model, Longitudinal Field Experiment

## 1. Introduction

The use of information technology in education has accelerated rapidly. In a nutshell, the prevailing e-learning 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).

Previous information systems (IS) research has investigated different aspects of technology-enabled learning, e.g., 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 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 classroom. On the other hand, several studies that include 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. 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 classroom based learning in the context of English learning. We assessed effectiveness using objective learning achievement and the learning effectiveness perceived by individual learners. We evaluated the respective learning outcomes associated with e-learning and conventional classroom based learning in terms of learning satisfaction, personalized learning support, and learning community support, overall course learnability, and course content assessment. Overall, our analysis shows that the learning effectiveness associated with e-learning is significantly higher than that observed with conventional classroom based learning. 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 classroom based 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.

## **2. Literature Review and Motivation**

Technology-enabled learning has been investigated by information systems (IS) researchers and practitioners alike. 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 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) compared two collaborative distributed learning arrangements and reported that individuals using the e-mail technology learned more than those using a more sophisticated Beta system.

The cumulating empirical evidences suggesting desirable impacts of e-learning have been mostly equivocal. Abraham (2002) found insignificant differences in the learning outcomes between the conventional face-to-face and the virtual classroom. Piccoli et al. (2001) showed that 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. 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.

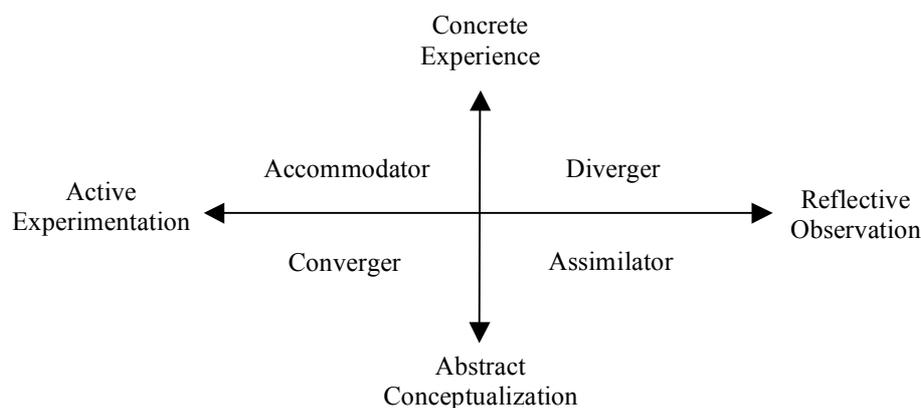
The equivocal findings on desirability of e-learning may be scrutinized in light of salient theories or models in educational psychology literature, such as Corno and Snow (1986) and Jonassen and Grabowski (1993). Of particular relevance is learning style, which has been examined in the context of designing hypermedia contents, such as MacGregor (1999) and Chen and Macredie (2002). The relationships between learning medium and learning style preferences have been studied. Using the Learning Style Inventory developed by Dunn et al. (1989), Cohen (2001) 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 conventional classroom environment based on the Learning Modality Preferences Inventory and the Keirsey Temperament Inventory. Aragon et al. (2002) emphasized on learning achievement and suggested students learn as effectively in an online environment as in conventional classroom 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 outcomes associated with e-learning suggests the need for longitudinal investigations based on comprehensive measurements.

## **3. Analysis of Learning Style**

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). Kolb (1976) proposed Learning Style Model, which is built upon concreteness-versus-abstraction 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 rather than theories or their generalizations. On the other hand, abstract conceptualization focuses on logics, concepts, intuitions or patterns and highly values thinking and shows interests in theory building, intuition development, or pattern extraction. The experimentation-versus-reflection dimension is also fundamental. In light of active experimentation, learning occurs through active influences to the learner and particularly focuses on practical applications of the newly acquired information rather than detailed understanding of it. This suggests an individual obtaining first-hand personal observations 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 (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. On the other hand, assimilators typically learn through inductive reasoning, theorization, model building, and/or integrating disparate observations into a systematic explanation. By and large, convergers are effective problem solvers and often acquire and organize information through hypothetical deductive reasoning. 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.



**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. 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. 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.

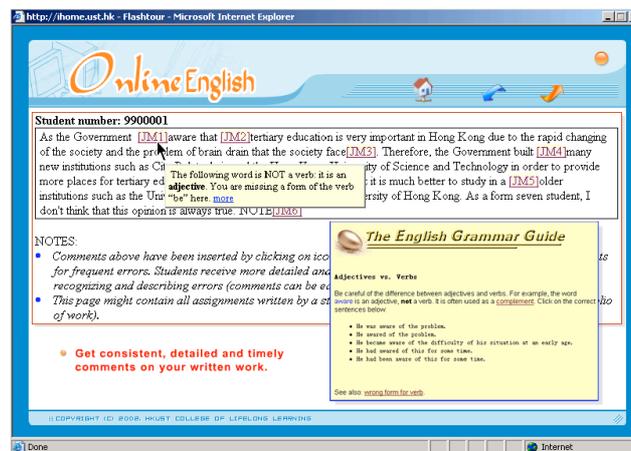


Figure 2: Screenshot of the English E-learning System

#### 4.2 Hypotheses

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, 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 simultaneous personal interactions which are better supported in conventional 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 classroom based 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 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 the e-learning based group was higher than that of conventional classroom based group in our experimental context, mainly because our e-learning based 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 from the e-learning based group is higher than that from the conventional classroom based group.

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

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

H2: The perceived learning effectiveness from the e-learning based group is higher than that from the conventional classroom based group.

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

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

*Learning Satisfaction:* We also examined learning satisfactions associated with e-learning and conventional classroom based learning. We anticipated that learner satisfaction would be an important factor in learning outcome assessment (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 from the conventional classroom based group is higher than that from e-learning based group.

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

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

*Personalized Learning Support:* E-learning has great potential to support personalized learning towards which conventional classroom based 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 classroom based 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 perceived to be higher in the e-learning based group than in the conventional classroom based group.

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

H4-B: Personalized learning support improvement resulting from e-learning based as opposed to conventional classroom based learning 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 classroom based 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 perceived to be higher in the conventional classroom based group than in e-learning based group.

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

H5-B: Learning community support resulting from e-learning based as opposed to conventional classroom based learning 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 classroom based learning environment. Because of convenient access to multimedia course contents, online exercises and instructional (diagnostic) assistance, we posit that subjects supported by 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 from the e-learning based group perceive the overall course more learnable than those from the conventional classroom based group.

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

H6-B: The course learnability improvement from e-learning based as opposed to conventional classroom based 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 from the e-learning based group than by those from the conventional classroom based group. We further expected more prominent positive assessments of course contents by assimilators than by accommodators, and comparable assessments between convergers and divergers.

H7: Subjects from the e-learning based group perceive course contents more favorably than their counterparts from the conventional classroom based group.

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

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

### **4.3 Study Design**

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. 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. The purpose of the additional financial rewards is to provide them incentives to try their best in the English tests. We adopted a randomized design in which approximately 25% of the subjects were assigned to the treatment group (i.e., supported by 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 conventional classroom sessions and embraced a substantial use of a designated website which delivers course materials and supports students' assignments. 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.

*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.

*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.

## 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 conventional classroom based group than in the e-learning based group of which the dominant majority was male (70.2%). Subjects in both groups were fairly comparable in terms of age and A-Level English Examination score. More than half of the conventional classroom 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 conventional classroom based group than in the e-learning based 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. In addition, subjects in both groups showed comparable general computer competency and reported similar Internet experiences and usage.

	Conventional Classroom	e-Learning
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 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.

	Cronbach'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 classrooms. As summarized in Table 3, the

objective learning achievement ( $p < 0.05$ ) as well as the perceived learning effectiveness ( $p < 0.01$ ) was significantly higher in e-learning than in the conventional classroom. Subjects supported by e-learning were significantly more favorable about the course contents than those using the conventional classrooms ( $p < 0.01$ ). On the other hand, subjects in the conventional classrooms perceived the learning community support to be significantly stronger than did their e-learning based counterparts ( $p < 0.01$ ) and showed a learning satisfaction noticeably higher than that of the e-learning based group, though not statistically significant. Subjects perceived the personalized learning support to be slightly greater in e-learning supported than in conventional classrooms. Overall, our results suggest that e-learning is likely to enhance students' learning effectiveness, generate favorable course content assessments and enhance personalized learning support. However, compared with the conventional classroom setting, it may provide a weaker learning community support and make the course less learnable, thus leading to lower learning satisfaction.

	Conventional Classroom	e-Learning	t-statistic	p-Value
Objective Learning Achievement	1.0 (7.6)	2.4 (7.6)	-1.861	<b>0.032</b>
	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	<b>0.002</b>
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	<b>0.003</b>
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	<b>0.009</b>

**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. However, 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. On the other hand, accommodators seemed to benefit less from e-learning. When supported by e-learning, accommodators gained learning effectiveness but exhibited lower learning satisfaction and perceived less personalized learning and learning community support. Overall, our results suggest learning outcome improvements were more prominent and significant with assimilators than with accommodators, consistent with our overall proposition.

	Assimilators			Accommodators		
	Conventional Classroom	e-Learning	P-Value	Conventional Classroom	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)	<b>0.03</b>	4.15 (0.71)	4.37 (0.68)	0.96
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)	<b>0.03</b>	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. 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 classroom environment. On the other hand, divergers appeared to favor the conventional 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			Divergers		
	Conventional Classroom	e-Learning	P-Value	Conventional Classroom	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)	<b>0.01</b>	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. Table 6 summarizes our analysis results with respect to the particular hypotheses tested.

## 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. Our evaluation used both longitudinal and comprehensive approaches, providing significantly more complete sources of data 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 based versus conventional classroom based settings. Our overall findings suggest that use of e-learning resulted in significant improvements in both objective learning achievement and perceived learning effectiveness. 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.

<b>Hypothesis</b>	<b>Result</b>
H1: Higher objective learning achievement in the e-learning based group than in the conventional classroom based group.	<b>Supported</b>
H1-A: Greater improvement in objective learning achievement with assimilators than with accommodators.	Not Supported
H1-B: Comparable improvements in objective learning achievement between convergers and divergers.	<b>Supported</b>
H2: Higher perceived learning effectiveness in the e-learning based group than in the conventional classroom based group.	<b>Supported</b>
H2-A: Greater perceived learning effectiveness with assimilators than with accommodators.	<b>Supported</b>
H2-B: Comparable perceived learning effectiveness between convergers and divergers.	<b>Supported</b>
H3: Higher learning satisfaction in the conventional classroom based group than in the e-learning based group.	Not Supported
H3-A: Higher learning satisfaction resulting from e-learning based as opposed to conventional classroom based learning with assimilators than with accommodators.	Not Supported
H3-B: Comparable learning satisfaction resulting from e-learning based as opposed to conventional classroom based learning between convergers and divergers.	<b>Supported</b>
H4: Greater personalized learning support by the e-learning based group than by the conventional classroom based group.	Not Supported
H4-A: Higher personalized learning support resulting from e-learning based as opposed to conventional classroom based learning with assimilators than with accommodators.	Not Supported
H4-B: Comparable personalized learning support resulting from e-learning based as opposed to conventional classroom based learning between convergers and divergers.	<b>Supported</b>
H5: Higher learning community support in the conventional classroom based group than in the e-learning based group.	<b>Supported</b>
H5-A: Higher learning community support resulting from e-learning based as opposed to conventional classroom based learning with assimilators than with accommodators.	Not Supported
H5-B: Comparable learning community support resulting from e-learning based as opposed to conventional classroom based learning between convergers and divergers.	<b>Supported</b>
H6: Higher overall course learnability in the e-learning based group than in conventional classroom based group.	Not Supported
H6-A: Higher overall course learnability resulting from e-learning based as opposed to conventional classroom based learning with assimilators than with accommodators.	<b>Supported</b>
H6-B: Comparable overall course learnability resulting from e-learning based as opposed to conventional classroom based learning between convergers and divergers.	<b>Supported</b>
H7: More favorable course content assessment in the e-learning based group than in conventional classroom based group.	<b>Supported</b>
H7-A: More favorable course content assessment resulting from e-learning based as opposed to conventional classroom based learning with assimilators than with accommodators.	Not Supported
H7-B: Comparable course content assessment resulting from the e-learning based as opposed to the conventional classroom based learning between convergers and divergers.	<b>Supported</b>

**Table 6: Summary of Findings**

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 classroom as well as a comprehensive set of measurements. 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 highlights the particular learning styles likely or not likely to benefit from e-learning. 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. 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 conventional classroom 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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