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What type of learning style leads to online participation in the mixed-mode e-learning environment? A study of software usage instruction

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A B S T R A C T

Learning style is traditionally assumed to be a predictor of learning performance, yet few studies have identified the mediating and moderating effects between the two. This study extends previous research by proposing and testing a model that examines the mediating processes in the relationship between learning style and e-learning performance and the moderating effects of prior knowledge. The results show that the sensory/intuitive dimension of learning style predicts learning performance indirectly through the mediation of online participation. However, other types of learning styles do not affect online participation. Sensory students demonstrate a higher level and intuitive students a lower level of online participation. Prior knowledge plays an important role as a moderator between online participation and learning performance. This study was conducted in the context of software usage instruction using empirical data from 219 undergraduate students.

1. Introduction

With the rapid increase in Internet use, online instruction is now widely adopted in universities. According to a survey of the National Postsecondary Education Cooperative in 2006 and 2007, 61% of degree-granting postsecondary institutions run online courses (National Postsecondary Education Cooperative, 2008). An e-learning environment provides flexibility for students to learn across different times and locations, allows self-paced learning, and provides a non-traditional learning alternative (Carver, Howard, & Lane, 1999; Graff, 2003; Terrell & Dringus, 2000). Online courses are embraced by many undergraduate students (Ngai, Poon, & Chan, 2007) and are regarded as common, uncomplicated learning tools.

Basic computer application software, including word processing, spreadsheet, presentation, and graphics and webpage creation packages, is essential for conducting businesses nowadays. Fundamental courses in the use of such applications are in increasing demand, and many colleges and universities are turning these traditionally classroom-based, hands-on courses into programs that largely use an e-learning mode. e-learning alternatives greatly reduce the burden for instructors of repetitive demonstrations of software application use over multiple class sessions. However, unlike traditional classroom-based teaching, e-learning has the inherent limitation of being unable to provide interactive feedback and the necessary encouragement or assurance. A mixed-mode – the integration of e-learning with a traditional classroom environment – thus seems to be a more sensible solution for courses on computer software.

Students adapt differently to web-based learning (Lee, 2001). Goldstein (1998) thus believes that it is necessary to evaluate students' learning styles to assess their e-learning performance. Learning style is critically important in laying the groundwork for understanding 'students' learning performance (Furnham, Monsen, & Ahmetoglu, 2009; Gadzella, Ginther, & Bryant, 1997; Jackson, Baguma, & Furnham, 2009; Liu, Magjuka, & Lee, 2008). The evaluation of leaning style would thus appear to determine whether online education is suitable. However, few studies have investigated learning styles in relation to online courses (Phoha, 1999; Tucker, 2000) or to courses with a stronger

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emphasis on information communication technology (Shaw & Marlow, 1999). Furthermore, although several studies (Day, Raven, & Newman, 1998; Lu, Yu, & Liu, 2003; Shih, Ingebritsen, Pleasants, Flickinger, & Brown, 1998) have investigated the relationship between learning style and performance, most have adopted a dichotomous definition of learning style that does not offer sufficient information for an in-depth investigation of the relationship. For example, Witkin (1949) and several later studies (Day et al., 1998; Lu et al., 2003; Shih et al., 1998) identified two learning styles: field dependence and field independence. This categorization gives a basic understanding of learning styles, but greater insight is needed. Furthermore, the samples used in the studies (Day et al., 1998; Lu et al., 2003; Shih et al., 1998) that have employed this categorization are too small to confirm its validity. In this study, we used a large sample and adopted the Felder-Solomon Index of Learning Styles (ILS) scale (Felder & Soloman, 1997) to investigate the effect of learning style in an online environment. As discussed in the following section, we believe that the ILS is a comprehensive tool for measuring learning styles and is thus most suitable for our study.

The Internet is an attractive supplement for classroom instruction, but most research concerning e-learning has focused on a purely online environment, and only a few studies have investigated learning performance in a mixed-mode setting (Huang, Lin, & Huang, 2010; Jackson et al., 2009). This study aimed to collect empirical data from an online/classroom mixed-mode learning environment and investigate the antecedents and effects of online participation. The subjects were students participating in four sessions of an undergraduate software applications course that involved both classroom and online instruction. The classroom instruction included lectures and brief demonstrations of various software applications, whereas the online instruction consisted of lecture notes, viewgraphs, and videos with step-by-step demonstrations.

Online participation includes the time students spend reading online materials and their use of online functions. If some course material or instruction is available only online, as in a mixed-mode environment, then online participation is necessary for learning. Shih et al. (1998) and Liu and Reed (1994) found that students with a field-dependent learning style spent more time on e-learning and accessed online material more often, but found no significant difference in learning performance between field-dependent and field-independent groups. As Shih et al. (1998) and Lu et al. (2003) concluded that neither online participation nor learning style had a significant effect on learning performance. They further explained that this result may be due to the simplistic categorization of learning styles as either field dependent or field independent. Clearly, an improved categorization is necessary to gain deeper insight into the effects of learning style on performance.

The objective of this study is to investigate the following research questions with a more comprehensive measure of learning style in a mix-mode e-learning environment.

(1) Does learning style influence online participation? Further, what type of learning style matters?
(2) Does a higher level of online participation bring about better learning performance? Are active and passive participation equally important, and if not, then which best predicts learning performance?
(3) Does prior knowledge of the course subject influence the relationship between online participation and e-learning performance?

To answer the research questions require the investigation of the mediating effect of online participation and the moderating effect of prior knowledge. The purpose of studying the mediating effect is to explore the underlying mechanism in the given relationships. If the mediating effect is confirmed, it means that the independent variable affects the dependent variable through a mediating variable. A moderator of a model is useful in exploring the boundary conditions of existing theory to discover its application conditions and scope. The purpose of introducing the moderator and mediator to our model is to further develop the theory.

2. Literature review

In the field of e-learning research, work has largely focused on the implementation of e-learning Web sites and the evolution of online learning platforms, and issues concerning the degree of assimilation and acceptance by students have received less attention. When designing a curriculum, whether for e-learning or a traditional learning environment, attention should be paid not only to the richness of the course content, but also to the 'students' capacity to assimilate the content, taking into consideration that their leaning capacity is closely linked to their learning style.

2.1. *Mixed-mode e-learning (MMEL)*

Distance learning has been a valuable alternative to classroom teaching for decades. Its initial platform was as simple as the postal mail system; later, e-mail became the prevalent platform, and a Web-based environment has been used more recently. The latter two approaches fall in the category of e-learning, because they are electronically supported. Approximately 92% of universities report offering online courses that use asynchronous computer-based instruction (National Postsecondary Education Cooperative, 2008). These include courses taught entirely through the Internet or via e-mail. Most studies on e-learning were conducted in the context of the asynchronous e-learning environment (Kim & Schniederjans, 2004), and most were Web-based rather than e-mail based, as the quality of courses taught entirely via e-mail caused some concerns (Phoha, 1999).

Totally web-based education (TWE) seems to remedy this problem, because the web is more visually oriented than e-mail. With rapid technological improvement to Internet access, the trend of TWE instruction is likely to persist and the completely e-mail–based approach was essentially phased out. However, although that means that e-mail is less likely to be used as a platform for online instruction by itself, it is by no means forsaken, but is rather integrated into web-based instruction.

Nevertheless, many worry that learning performance in TWE still falls short of expectations, and as distance education through TWE courses evolves, concerns about its effectiveness are mounting (Bruckman, 2002; Decker, Frailey, McNell, & Mould, 2000; Liaw, 2008; Piccoli, Ahmad, & Ives, 2001; Sitzmann, Kraiger, Stewart, & Wisher, 2006). In other words, the completely Web-based approach is facing the challenge of online participation and learning performance. To counter these challenges, the college at which our study was conducted has adopted the mixed-mode e-learning (MMEL) approach. MMEL is a type of blended or hybrid learning that combines classroom and Web-based methods. As the terms “blended learning”, “hybrid learning” and “mixed learning” are used interchangeably in literatures (Martyn, 2003; So & Brush, 2008), they refer to the integration of learning delivery methods, including most often face-to-face instruction with multiple asynchronous and/or synchronous technologies by means of computer, mobile phone, satellite television channels and other emerging electronic media.

Obviously, there are advantages and disadvantages to the traditional face to face classroom and e-learning platform. The advantages of classroom learning include instant feedback, close instructor-student relationships, and the opportunity for instructors to motivate students. e-learning has the benefits of being student-centered and flexible in terms of time and location, and allowing knowledge reuse and easy sharing (Zhang, Zhao, Zhou, & Nunamaker, 2004). We conducted this study based on the belief that a balance between the two will provide the best solution for e-learning.

e-learning has become an indispensable and complementary part of classroom teaching (Zhang, Zhao, Zhou, & Jr. Nunamaker, 2004), yet it is often limited by a lack of system interactivity, which provides students with an interactive environment. With advances in Internet technology, system interactivity has made great progress. For instance, simulators such as SAM2010 from Cengage Learning provide a highly interactive environment by simulating real scenarios of Microsoft Office products for students to learn computer skills. However, lacking the software integration, course customization, and classmate interaction, use of simulators has not yet become the norm for colleges.

In addition, with the advancement of Internet technologies, Web 2.0 applications are expected to be integrated into online learning environments to facilitate a learner-centered teaching approach, referred to as Learning 2.0. Redecker’s (2009) review of Learning 2.0 practices indicates that social computer tools help learning and teaching in several ways. For example, a social computer application can diversify and simplify instructions to improve teaching methods. It can also make distributed learning and self-directed learning more attainable, and increase ’learners’ motivation to participate online. However, the policy-making process that precedes a full-scale deployment of Learning 2.0 is still in the initial phase. Its challenge is that making these tools accessible needs more support from authorities (Redecker, 2009). In other words, the online learning environment has not yet entered the Web 2.0 era. Since there may not be an urgent need for software skills training, and the effect of Web 2.0 on this training is unclear, the relevant development will probably lag behind those of other areas.

There are several reasons why an MMEL environment that integrates online and classroom learning may be the best way to improve learning efficiency. First, at the beginning of a course, instructors can help students to understand and master e-learning strategies during class time, which allows students to gain the greatest benefit from the online portion of the course. Second, instructors can play an important role as motivators of more interactive learning, and can encourage students to use communication tools such as e-mail, bulletin boards, and discussion forums on the Web-based learning platform (Benbunan-Fich & Hiltz, 2002; Shih, Ingebritsen, & Flickinger, 1998). TWE may produce less engaged students because it is not possible to give constant reminders to visit the online instruction web site. Third, Tiene’s (2000) study indicated that when given the choice, students would rather have face-to-face than online discussions. Online discussions can be reasonably regarded as a valuable supplement to, rather than as a substitution for, in-class discussions (Zhang, Zhao, Zhou, and Nunamaker, 2004).

It seems that classroom instruction is still indispensible in many contexts, despite the proliferation of online instruction. In the context of learning to use software applications, this may be especially true. Research (Bandura, 1977; Decker, 1980; Saks, 1997) has indicated that the best way to teach computer skills is through behavior modeling, which involves visual observation of a trainer performing a task. Decker (1980) found that when trainees were exposed to behavior modeling and symbolic codes, including the trainer’s verbal behavior and stated principles, learning performance improved. Bandura (1977) clearly indicated that live and symbolic modeling influences self-efficacy. According to Saks (1997), trainers can increase the self-efficacy of trainees by 1) providing trainees with opportunities to practice the training task, 2) demonstrating the behavior necessary for trainees to complete the training task, 3) providing positive feedback to encourage trainees to learn continuously, and 4) eliminating fear and anxiety about performing the training task to increase ’trainees’ confidence.

2.2. Learning styles

Learning styles are viewed as a subset of cognitive styles (Riding & Rayner, 1998; Sternberg & Grigorenko, 1997), which are generally classified as cognition centered, personality centered, or activity centered. The activity-centered cognitive style is actually a learning style, whereas the cognition-centered style relates to measures of intelligence and the personality-centered style is closely linked to personality traits (Sternberg & Grigorenko, 1997). The measurement of learning styles should thus aim to determine a person’s cognitive style in relation to learning activities.

The development of learning style models has followed that of cognitive styles. For instance, Riding (1991) summarized the studies on cognitive style and combined their fundamental elements to develop a learning style model called Cognitive Styles Analysis (CSA), which is composed of the holistic-analytic dimension and the verbal-imagery dimension. CSA measures an individual’s preference for processing information holistically or analytically and to think verbally or visually. In the following, we make a concise description of three measurement instruments of learning styles.

The Learning Style Inventory (LSI; Kolb, 1984) is one of the most frequently used instruments in studies of the relationship between personal attributes and learning. Kolb’s model breaks the learning cycle down into four stages: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). Based on Kolb’s learning cycle model, the Learning Style Questionnaire (LSQ; Honey & Mumford, 1992) contains 80 items on four scales to identify four types of learners (activists, reflectors, theorists, pragmatists). The LSQ measures a learner’s preferred learning approach and the degree to which he or she is likely to learn. As most people have never consciously considered how they really learn, Honey and Mumford’s questionnaire probes general behavioral tendencies, rather than asking people directly how they learn, as the LSI does. The LSQ indicates the degree to which an individual’s learning style leans toward abstraction or concreteness and is reflective or active.

The Felder-Silverman Learning Style Model (FSLSM) proposed by Felder and Silverman (1988) is more comprehensive than other popular learning style models such as the LSI (Kolb, 1984) and LSQ (Honey & Mumford, 1992). A detailed measurement of learning styles is crucial to identify relationships between learning styles and student performance in an online course (Graf, Viola, Leo, & Kinshuk, 2007). Whereas other learning style models classify learners into a few groups, FSLSM categories a learner's preferences on four dimensions with detailed descriptions of the characteristics. In this regard, FSLSM provides the most appropriate measurement for studying hypermedia courseware learning (Carver et al., 1999). After comparing several learning style models, Kuljis and Liu (2005) suggested that the FSLSM is the most appropriate model with respect to the application in e-learning systems.

The FSLSM describes each learner's learning style in four dimensions: active/reflective, sensory/intuitive, visual/verbal, and sequential/global. The model posits that active students learn by trying things out and working with others; reflective students prefer to think things through and work alone; sensory students are practical and oriented toward facts and procedures; and intuitive students are more conceptual, innovative, and oriented toward theories and meanings. Visual students prefer visual representations of material such as pictures, diagrams, or flow charts; verbal students prefer written and spoken explanations; sequential students tend to follow linear and orderly reasoning processes; and global students prefer to learn in intuitive leaps.

Felder and Soloman (1997) developed the Index of Learning Styles (ILS) based on the FSLSM. The ILS is a 44-item questionnaire with four polar scales related to learning style preferences. Each scale contains 11 items. The reliability and validity of the instrument were confirmed in a study that reviewed the results of various analyses based on data collected using the ILS instrument (Felder & Spurlin, 2005). An earlier study (Van Zwanenberg, Wilkinson, & Anderson, 2000) commented on the lack of reliability of the ILS scale, yet many studies still choose to measure learning styles by using the ILS. The disagreement about the instrument's reliability may be related to the study context. More results based on ILS would improve our understanding of this issue.

The ILS measures dimensions that correspond to other learning style scales developed earlier, as shown in Table 1. According to Van Zwanenberg et al. (2000), the sequential/global scale contains facets corresponding to Witkin's (1949) field dependence-independence dimension; the sensory-intuitive scale is related to the sensation/intuition dimension of the Myers-Briggs Type Indicator (MBTI) scale (Myers, 1962); and the visual/verbal and sequential/global scales correspond to two dimensions of CSA (e.g., verbal/imagery and holistic/analytic). The ILS and LSQ share the learning style concepts of reflection and action, which are similar to the reflective observation (RO) and active experimentation (AE) continuum in the LSI (Kolb, 1984). In summary, the ILS has the most comprehensive dimensions of all of the proposed learning style scales, and thus has the potential to generate more in-depth findings in studies of the effect of learning styles.

As Felder and Silverman (1988) stated, students with specific learning styles may encounter difficulties in learning if the teaching style does not match their learning style. Lumsdaine and Lumsdaine (1993) concluded that the lack of congruence between preferred learning style and the nature of the subject matter and the method of teaching is related to comparatively lower motivation and poorer performance, and hence possible failure to complete a course. Felder and Silverman (1988) further stated that when there is congruence among the preferred learning style, subject matter, and method of teaching, the level of performance is higher and the drop-out rate is lower. Employing the ILS, Hayes and Allinson (1993, 1996) concluded that each preferred learning style corresponds to a specific teaching style. Although the ILS was originally used to study engineering 'students' learning styles in traditional classrooms, it has been widely used in the measurement of technology-enhanced learning. Carver et al. (1999) also successfully used the Felder-Silverman Learning Style Model (FSLSM), which is the basis for the ILS scale, to measure 'students' learning style.

3. Theory and hypotheses

Numerous studies maintain that learning style is a significant predictor of performance. Furnham and Medhurst (1995) identified a predictable and consistent set of correlations between a pragmatic learning style, which is a dimension of the LSQ, and positive performance in university seminars. Furnham, Jackson, and Miller (1999) reported that personality and learning style together account for a small but important variance in measures of work performance. Other studies have taken the stance that learning style is a subset of personality (Furnham, 1992, 1996; Jackson & Lawty-Jones, 1996), and that learning styles represent the learned components of personality (Jackson & Lawty-Jones, 1996). Although a relationship between learning style and learning performance has been confirmed, it remains to be ascertained which learning style leads to better learning performance, especially in an MMEL environment. In the following section, the mechanisms that link learning style and learning performance in the MMEL environment are discussed.

3.1. Learning style and online participation

Learning style is known to be related to participation. For example, Graf and Kinshuk (2006) analyzed learning styles with respect to the behavior of students on online courses, and concluded that students with different learning styles exhibit different behavior in such courses, and have dissimilar tendencies to go online and stay online to view material. Several studies have shown that students with different learning styles pursue quite different ways of learning (Garcia, Amandi, Schiaffino, & Campo, 2007; Meng & Patty, 1991; Stansfield & Hansen,

Table 1
Summary of learning style dimensions.

Dimensions of FSLSM	Similar concepts or scales	Authors
Active/Reflective	Active/Reflective in ILS	Felder and Soloman (1997)
	Activist/Reflector in LSQ	Honey & Mumford (1992)
	Active Experimentation(AE)/Reflective Observation in LSI(RO)	Kolb (1984)
Sensory/Intuitive	Sensory/Intuitive dimension in ILS	Felder and Soloman (1997)
	Sensation-Intuition in MBTI	Myers (1962)
Visual/Verbal	Visual/Verbal dimension in ILS	Felder and Soloman (1997)
	Verbal/Imagery style dimension in CSA	Riding (1991)
Sequential/Global	Sequential/Global dimension in ILS	Felder and Soloman (1997)
	Holistic/Analytic style dimension in CSA	Riding (1991)
	Field dependence-independence	Witkin (1949)

1983). For example, Liu and Reed (1994) showed that field-dependent students spend more time on Web-based courses. Studies on this topic support the postulation that students with different learning styles participate in online courses to differing degrees.

"Online participation" in this study refers to the level of 'students' online involvement as measured quantitatively. An integrated e-learning environment is typically multimedia oriented, and includes video lectures, PowerPoint slides, and lecture notes. Designers of e-learning environments anticipate that students will interact with the online materials by clicking and reading them, posting their opinions on online forums and chat rooms, and conducting discussions online. Thus, improving collaborative learning is also an important objective of the functional design of MMEL environments.

This study posits that learning style predicts the level of online participation. This concept is captured in the following hypothesis.

Hypothesis 1:Learning style is positively related to online participation.

The ILS (Felder & Soloman, 1997) comprises four dimensions: active/reflective, sensory/intuitive, visual/verbal, and sequential/global. Hypothesis 1 is thus expanded as follows.

Hypothesis 1a:An active/reflective learning style is positively related to online participation.
Hypothesis 1b:A sensory/intuitive learning style is positively related to online participation.
Hypothesis 1c:A visual/verbal learning style is positively related to online participation.
Hypothesis 1d:A sequential/global learning style is positively related to online participation.

3.2. Online participation and learning performance

Studies have provided mixed support for the relationship between online participation and learning performance. One study concluded that online participation enhances student engagement and thus improves learning effectiveness (Zhang, Zhou, Briggs, & Nunamaker, 2006). Another concluded that students who fail their courses tend to interact less frequently (Davies & Graff, 2005). However, Lu et al. (2003) found that students were able to learn equally well on online courses regardless of their level of online participation. This finding was later supported by Davies and Graff (2005). Given these contradictory conclusions about online participation and learning performance, it is important to reexamine the relationship with a more comprehensive measurement of both constructs.

Common sense seems to agree with the findings on the benefits of an e-learning environment. First, online collaborative environments have been proven to encourage wider student participation, as online discussions encourage more reticent students to participate to a greater extent (Citera, 1988). Second, online environments provide less opportunity for intimidation and less time pressure (Warschauer, 1997). Third, in a computer-supported collaborative learning (CSCL) community, 'learners' performance is significantly influenced by social network properties (Cho, Gay, Davidson, & Ingraffea, 2007), which are a consequence of online participation. These benefits imply that online participation by students increases their involvement and improves the quality of discussions. However, whether online participation has any tangible benefits, such as improved student achievement, remains to be determined. Based on this perspective, the following hypothesis is proposed.

Hypothesis 2:Online participation is positively related to e-learning performance.

3.3. Moderating role of prior knowledge

Several studies have argued that individual differences have significant effects on e-learning performance within student groups (Felix, 2001; Holscherl & Strubel, 2000; Kim, 2001). There are obviously numerous aspects of individual differences. The aspect that is most relevant to our understanding of learning performance is prior knowledge. According to Last, O'Donnell, and Kelly (2001), even limited prior knowledge may help to improve learning performance. This study thus examines the relationship between online participation and e-learning performance under different states of prior knowledge.

Prior knowledge means some degree of earlier understanding of the subject matter being taught. Note that Web navigation ability is assumed to be common, and is not considered part of the definition of prior knowledge. Although this assumption could have been invalid a decades ago, as we are now well into the third decade of Web usage we can reasonably assume that few college students have difficulty with online navigation. The following hypothesis describes the moderating effect of prior knowledge.

Hypothesis 3:The greater the prior knowledge, the stronger the relationship between online participation and learning performance.

As shown in Fig. 1, our research model indicates that learning style affects online participation, which in turn enhances learning performance. Based on previous studies (Felder & Silverman, 1988; Felder & Soloman, 1997), we focus on four key aspects of learning style: Active/Reflective, Sensory/Intuitive, Visual/Verbal and Sequential/Global. We posit that 'learners' prior knowledge moderates the relationship between their online participation and e-learning performance.

4. Method

Empirical data were used to test the research model. The data for learning style and prior knowledge were collected by administering questionnaires to four sessions of students on the same MMEL course. The questionnaires were administered during a class break when most students were still in the classroom. No incentives were offered for completing the questionnaire. Students could choose not to answer

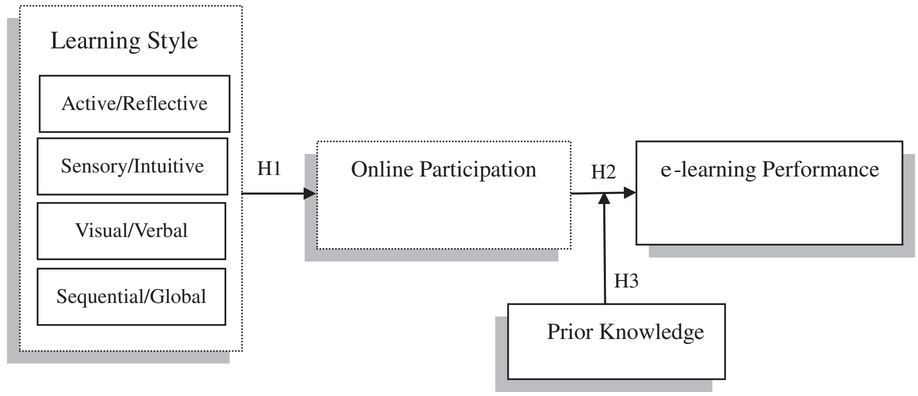

Fig. 1. Research model.

the questionnaire, but most participated because the survey was not long. Online participation data were tracked by the e-learning network server, and learning performance was measured by lab test scores.

Two hundred and twenty-four students were enrolled in four sessions of the same class. This so-called "breadth course" offered by the IS Department course can be taken for credit only by students who are not CS or IS majors. Therefore, most students in the course were not CS or IS majors, and few students who are proficient in computer use take this course. However, as a precaution, we included computer experience and Internet experience as control variables in our analysis. Each session was taught by the same instructor using the same teaching materials and in the same MMEL environment. The course had undergone seven years of refinement, and its teaching effectiveness is widely acknowledged among students, resulting in full classes with long waiting lists.

4.1. Course description

We believe that all instructors of this MMEL course were competent to some degree, because they were screened before teaching the course. After a seven-member course committee checked their credentials, potential instructors demonstrated their teaching styles by teaching the material. The committee members chose instructors based on passion in teaching and communication skills. A head instructor who oversaw the planning and teaching of the course monitored the performance of all instructors, including whether they checked and responded 'students' postings regularly and guided students when they encountered difficulties. Although one-to-one matching of instructor–student learning styles is not possible, this system was devised to guarantee high quality teaching. Furthermore, the course has won three university-wide best teaching awards in the past seven years.

In this study, the online environment is a teaching-learning method, rather than a method used to present supplementary material only. There are six parts of the course, and each part consists of three units. Unique content is taught in each unit without repetition. The first unit of each part introduces basic skills and is taught in a traditional classroom, whereas the subsequent two units of each part cover advanced skills. Therefore two-thirds of the teaching is conducted online. This design is intended to reduce 'students' resistance to learn on their own online; the face-to-face classroom setting helps with self-pacing and time management. In this way, the students are reminded to move on to the next unit every three weeks.

The classroom instruction focused on hands-on teaching of the use of software such as Excel, Office VBA, and Access. The online component focused on self-learning materials, such as videos showing step-by-step software use and PowerPoint slides of the course content. Face-to-face teaching was arranged to give students an overview of the basic concepts and teach them the main functions of the software. There were also frequent assignments that are formative in nature aiming to help students master the skills learned and become familiar with the content.

The online materials consisted of several sections. First, the interactive learning section contained lecture notes (PowerPoint slides, HTML files, and video files), which provided students with a convenient means to review the steps for using the software. A discussion board allowed students to post articles and questions, debate issues, and share ideas. The assessment section consisted of quizzes and online tests. The information section contained the course syllabus, grades, participation ranking, and a student e-mail directory. Finally, the personal section contained each student's online trail, and allowed students to track their own online participation. Each class session had one teaching assistant who answered questions both in the lab and online. The presentation of the online material was identical across all four sessions.

4.2. Measurement

The independent variable was student learning style as measured by the ILS scale (Felder & Soloman, 1997). By means of ILS, the study intends to describe each student in four dimensions, namely active/reflective, sensory/intuitive, visual/verbal and sequential/global, rather than to divide all students into four categories. The 'students' online participation trails were recorded using the tracking function of the e-learning Web site. The dependent variable was student e-learning performance as measured by scores in hands-on lab tests in the use of various software tools.

The measurement of each construct is further described as follows.

4.2.1. Learning style

Learning style was measured by the ILS scale, which contains 44 items in the form of two-choice questions (polar scale) to assess learning style on four axes: active/reflective, sensory/intuitive, visual/verbal, and sequential/global. Many studies have reported that measurements using this scale are reliable. As Felder and Spurlin (2005) stated, the Web-based version of the ILS is taken hundreds of thousands of times each year, and responses can be submitted and automatically scored on the Web. Felder and Spurlin (2005) also summarized the Cronbach's α results of four separate studies. These values and those of our study are shown in Table 2. Tuckman (1999) suggested that an alpha value greater than .5 is acceptable for attitude assessments, whereas .75 is needed for instruments that measure achievement. Learning style is a measurement of attitudes, rather than achievement; therefore, Felder and Spurlin (2005) take the alpha value of .5 as the criterion for the ILS reliability check. The Cronbach's α values for active/reflective, sensory/intuitive, visual/verbal, and sequential/global in this study were .56, .64, .60 and .58, respectively, exceeding the threshold of .5.

4.2.2. Online participation

Online participation data were extracted from the recorded student online trails, which is a function offered by the e-learning Web site. Online participation was evaluated by several indicators, including the number of discussion board posts, the number of file views (e.g., videos, PowerPoint slides), session duration in viewing non-interactive pages, and total number of pages read. These indicators could not be summed up as a single factor because they are not in the same dimension. Hence, exploratory factor analysis was used to condense the four indicators. This generated a two-factor solution that explained 63.5% of the variance, with all loadings exceeding .50. The Cronbach's α of the factors was .79 and .81, respectively. Items in the first factor, labeled "active participation," assessed how frequently individuals posted on the discussion board and viewed the files. Items in the second factor, labeled "passive participation," assessed the duration spent online and the number of page views.

4.2.3. Learning performance

The 'students' learning performance was measured by scores in hands-on lab tests on the use of software tools, including Microsoft Excel and Access.

4.2.4. Prior knowledge

'Students' prior knowledge of the subject matter was measured by 5-point Likert scale, asking them the degree of exposure to the knowledge of Excel and Access before they took the course. The Cronbach's α for this four-item measure was .83. If prior knowledge were measured by a knowledge acquisition test (e.g., test of specific skills), their scores would vary little because most students would fail. We aimed to measure 'students' exposure to the software tools before taking the course rather than their precise skill level. We believe that if students have some exposure to the software before the course, they are mentally prepared to learn. Seeing other people use the tools or reading information about the tools were both considered prior exposure. Replacing "prior knowledge" with "exposure" better conveys what we intended to measure. However, "prior knowledge" has often been used in education literature, and in a few studies it was used to represent exposure as in our study. Therefore, we decided to use the term "prior knowledge" instead of "exposure."

4.2.5. Control variable

Three control variables were included: gender, computer experience, and Internet experience. These were not the variables of interest, but may affect the observation of the relationships among the main variables. In the analysis, their correlations with other variables were calculated to identify and control their potential effects. Although we did not believe computer and Internet experience would affect our observations because the majority of college students are proficient in Internet use, earlier studies on e-learning have reported computer and Internet experience to have some effects, and we thus included the two control variables as a precaution. Students learn more efficiently and effectively from material that is well presented, which leads to greater participation (Carver et al., 1999). Hence, the way in which the web material was presented was kept identical across all four sessions to prevent the introduction of any extraneous effects.

5. Data analysis and results

As the assessment of the overall fit of the model was crucial to the study, structural equation modeling (SEM) was used to analyze the data. SEM is the most efficient estimation method for examining a system of multiple regression equations simultaneously for various sets of dependent variables (Hair, Anderson, Tatham, Ronald, & Black, 1998).

Questionnaires were sent to all 224 students who enrolled on the course, 219 of whom (97%) responded. The resulting valid sample consisted of 43% males and 57% females. Freshmen and sophomores comprised 62% of the student sample, and juniors and seniors comprised the remaining 38%. The average level of computer usage and Internet usage history was 6 and 8 years, respectively. The subjects were students majoring in business (49%), social science (27%), science (6%), communications (5%), law (4%), foreign languages (3%), education (3%), liberal arts (2%), and international affairs (1%), which reflected a wide range of disciplines.

Table 3 shows the distribution of the ILS scores of the subjects. For each dimension of measurement, the scores ranged from 0 to 11, with the lowest possible score being 0 and the highest 11. A score of 0 signified the extreme ends of Active, Sensory, Visual, or Sequence, and a score of 11 signified the extreme ends of Reflective, Intuitive, Verbal, or Global.

Table 2
Cronbach Alpha coefficients (adapted from Felder & Spurlin, 2005).

Active/Reflective	Sensory/Intuitive	Visual/Verbal	Sequential/Global	N	Source
.56	.72	.60	.54	242	Livesay, Dee, Nauman, and Jr. Hites (2002)
.62	.76	.69	.55	584	Spurlin (2002)
.51	.65	.56	.41	284	Van Zwanenberg et al. (2000)
.60	.70	.63	.53	557	Zywno (2003)
.56	.64	.60	.58	219	This study

Table 3
Distribution of ILS scores.

Learning style group	Score	Percent	Number of Subjects
Absolutely Active	0–2	15	32
Active	3–5	31	69
Reflective	6–8	46	100
Absolutely Reflective	9–11	8	18
Absolutely Sensory	0–2	16	36
Sensory	3–5	54	118
Intuitive	6–8	24	53
Absolutely Intuitive	9–11	6	12
Absolutely Visual	0–2	33	73
Visual	3–5	48	104
Verbal	6–8	18	39
Absolutely Verbal	9–11	1	3
Absolutely Sequential	0–2	12	27
Sequential	3–5	47	103
Global	6–8	37	80
Absolutely Global	9–11	4	9

The ILS is used to describe each student's learning style in a four-dimensional space, rather than categorizing students into separate groups labeled as active/reflective, sensory/intuitive, visual/verbal and sequential/global. A student's learning style is represented by a point in the four-dimensional space, with active/reflective, sensory/intuitive, visual/verbal, and sequential/global as the axes. Thus, each student is described in four dimensions simultaneously, and the distribution of 'students' learning style along each dimension is 100%. If we take the active/reflective dimension as an example, 15% of students are absolutely active, 31% are active, 46% are reflective, and 8% are absolutely reflective, totaling 100%. The distributions of learning style along other dimensions are demonstrated in the same way in Table 3.

Table 4 shows the correlations and descriptive statistics for the variables. As we expected, computer experience and Internet experience were not correlated with the other variables. The control variable gender was positively related to passive participation ($r = .16$, $p < .05$) and e-learning performance ($r = .14$, $p < .05$), which indicates that gender may influence both variables.

5.1. Main paths analysis

SEM analysis was used to test the hypotheses. Fig. 2 shows the test results. The dotted lines and solid lines represent the fully mediated model, but the results of the analysis showed that some paths (indicated by dotted lines) did not pass the statistical tests of significance. They were the direct links between Active/Reflective, Visual/Verbal, Sequential/Global, and either active participation or passive participation. The corresponding β coefficients and p values are $\beta = .04$, $\beta = .06$, $\beta = .01$, $p > .05$; and $\beta = .02$, $\beta = -.02$, $\beta = .11$, $p > .05$, respectively. The presence of insignificant paths implies that a partially mediated model (as indicated by the solid paths) may be a better choice. A comparison of model fitness between these two models showed that there was no significant difference ($\Delta\chi^2$ (6) = 4.232, $p > .05$) between them.

Fully mediated model: χ^2 (3, $N = 219$) = 12.013; GFI = .987, AGFI = .947, RMSEA = .039.
Partially mediated model: χ^2 (9, $N = 219$) = 7.781; GFI = .986, AGFI = .931, RMSEA = .085.

Thus, the partially mediated model was retained for subsequent analysis.

The underlying structure of online participation was then extracted by factor analysis, which revealed two dimensions. Further examination of the item loadings characterized these two dimensions as active participation and passive participation. Hypothesis 2 was thus expanded as follows.

Hypothesis 2a: Active participation is positively related to e-learning performance.

Table 4
Means, standard deviations, and correlations among the variables.

	Mean	S.D.	1	2	3	4	5	6	7	8	9
1. Active/Reflective	16.82	2.30	1								
2. Sensory/Intuitive	15.75	2.35	−.11	1							
3. Visual/Verbal	13.38	2.15	.10	.07	1						
4. Sequential/Global	16.01	2.24	−.02	.27**	−.04	1					
5. Active Participation[a]	–	1.64	.08	−.24**	.04	−.07	1				
6. Passive Participation[b]	–	1.57	.03	−.18*	−.04	.08	.32**	1			
7. e-learning Performance	76.74	17.85	.02	−.25**	−.09	−.04	.33**	.23**	1		
8. Gender	–	–	−.03	−.04	.13	−.10	.03	.16*	.14*	1	
9. Computer Experience	3.35	.92	−.03	.00	.08	−.01	−.05	−.06	−.03	.05	1
10.Internet Experience	3.02	.98	−.05	−.01	.05	−.03	.05	−.06	−.01	.14*	.80**

*$p < .05$. **$p < .01$.
[a,b]These variables are standardized, therefore the mean values are zero.
The possible scores of variable #1 through variable #4 are from 11 to 22, therefore the median is 16.5.
Variable #9 and variable #10 are converted to 5-point scale, therefore the median is 3.

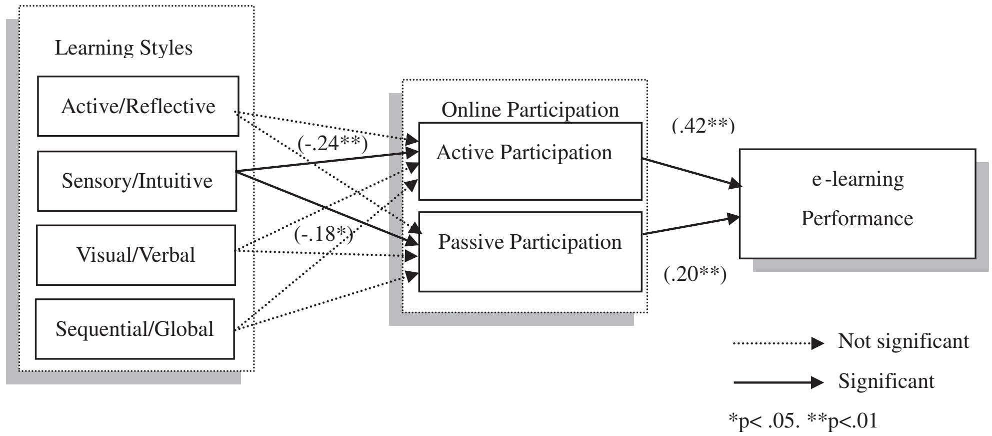

Fig. 2. Standardized path coefficients of the final model.

Hypothesis 2b: Passive participation is positively related to e-learning performance.

The analysis of the partially mediated model found support for Hypotheses 1b, 2a, and 2b ($\beta = -.24, -.18, .42, .20, p < .05$), but disconfirmed Hypotheses 1a, 1c, and 1d. Along the continuum between Sensory and Intuitive, higher scores indicate the more Intuitive end of the continuum. The negative coefficient between Sensory/Intuitive and online participation suggests that the sensory/intuitive dimension of learning styles positively influences online participation.

5.2. Moderators of e-learning performance

The interaction effects of prior knowledge were tested by SEM. First, the subjects were split into two groups – high and low – according to their prior knowledge. The relationship between online participation and e-learning performance was then assessed for these groups. Both the main effect and the marginal effect were examined.

As online participation was represented by two factors – active participation and passive participation – Hypothesis 3 was expanded as follows.

Hypothesis 3a: The greater the prior knowledge, the stronger the relationship between active participation and learning performance.
Hypothesis 3b: The greater the prior knowledge, the stronger the relationship between passive participation and learning performance.

The results showed that the model fit the data well (χ^2 (5, $N = 219$) = 5.601; GFI = .99, AGFI = .96, RMSEA = .023; see Table 5, Model 1). The moderating effect of prior knowledge on the relationship between passive participation and e-learning performance was significant ($\beta = .48, p < .01$), but the moderating effect of prior knowledge on the relationship between active participation and e-learning performance was not significant ($\beta = -.08, p > .05$).

The research model was further refined by deleting the insignificant path (the effect of the interaction between active participation and prior knowledge on e-learning performance). The goodness of fit indicators of the refined model were (χ^2 (6, $N = 219$) = 5.485; GFI = .99, AGFI = .95, RMSEA = .041, see Table 5, Model 2), also indicating a good fit with the data. As the two models (Model 1 and Model 2) were not significantly different from each other ($\Delta\chi^2 = .11, p > .05$), we retained the more conservative model (Model 2) as the final model and used it to examine our hypotheses. The results showed that Hypothesis 3b was supported, but 3a was not. In Model 2 (see Table 6), the main effects of active participation ($\beta = .41, p < .01$), passive participation ($\beta = .46, p < .01$), and prior knowledge ($\beta = .57, p < .01$) on e-learning performance were significant. In addition, the effect of the interaction between passive participation and prior knowledge on e-learning performance was also significant ($\beta = .46, p < .01$). This interaction effect is illustrated in Fig. 3. When a student possessed relatively higher prior knowledge, the passive participation had a strong and positive effect on e-learning performance, but when the prior knowledge was relatively low, the effect of passive participation was greatly reduced.

6. Discussion

This study empirically examined how learning style affects 'students' learning performance. Online participation was identified as a mediating construct, and its mediating effect on this relationship was confirmed. The results also showed that students whose learning

Table 5
Comparison of Model 1 and Model 2.

Model	χ^2	GFI	AGFI	RMSEA
Model 1	5.601	.99	.96	.023
Model 2	5.485	.99	.95	.041
Recommended value	$\Delta\chi^2 = .11$ ($p > .05$)	≧.9	≧.9	≦.08

Table 6
Path coefficients of Model 1 and Model 2.

Path	Standardized Coefficient	
	Model 1	Model 2
Active Participation → e-learning Performance	.37**	.41**
Passive Participation → e-learning Performance	.47**	.46**
Prior Knowledge → Learning Performance	.53**	.57**
Active Participation × Prior Knowledge → e-learning Performance	−.08	–
Passive Participation × Prior Knowledge → e-learning Performance	.48**	.46**

**$p < .01$.

style was characterized as "sensory" participated online more frequently and for a longer duration. This higher level of online participation led to better e-learning performance. This finding may be explained by the fact that sensory learners tend to prefer learning facts and solving problems using well-established methods, and are more practical and careful than "intuitive" learners (Felder & Silverman, 1988). The sensory learning style seems to be very compatible with the current e-learning environment, which is currently limited to providing content that consists of concrete steps and easy-to-follow instructions. In such an environment, sensory students demonstrate greater online participation.

Prior knowledge was shown to partially moderate the relationship between online participation and learning performance, but only in terms of passive participation. Active participation, which is a key factor in online participation, was not a moderator of the relationship.

An important practical implication of these findings is the possibility that 'students' e-learning performance could be enhanced by improving online participation. Although it is difficult to determine the degree of influence of the mediating construct, educational institutions should take action to boost 'students' online participation in e-learning courses. For example, increasing the frequency of face-to-face teaching may facilitate better self-pacing and time management. Note that increasing the frequency of face-to-face teaching does not mean increasing the total teaching time. Various incentives may also be effective. In addition, the human–computer interface design may play an important role in countering the problem of intuitive 'learners' low level of online participation. Possible changes in the human–computer interface include integrating multimedia technology into the platform, changing the layout of materials, and redesigning the interaction scenarios. Finally, educational institutions could also conduct a learning style screening before students take e-learning courses to help them assess the potential gains they will receive through these courses.

Students who are characterized as more "intuitive" along the sensory/intuitive dimension may not adjust as well to the current e-learning environment and may need extra help to benefit from e-learning. As shown in Table 3, 70% of students are characterized by the sensory learning style (16% absolutely sensory, 54% sensory) as opposed to the intuitive learning style. In terms of economic consideration, investment in e-learning is worthwhile in that most learners appear to be able to benefit immediately. However, 'educators' concerns extend beyond a purely economic viewpoint. As information and knowledge multiply at an unprecedented pace and our life patterns become more dynamic, educators have come to view e-learning as an indispensable part of education. Therefore, we need to invest time and resource to devise methods that can help more intuitive learners. For example, increasing the face-to-face teaching component in the mixed-mode e-learning may encourage and reinforce intuitive 'learners' online participation. Alternatively, using advanced interactive and multimedia technologies that help intuitive learners pace their online activities.

The findings of this study generate a deeper understanding of the effect of learning styles on e-learning performance. By identifying two important factors of online participation – active participation and passive participation – and determining some of the mediating processes in the relationship between learning styles and e-learning performance, our study contributes to the understanding of e-learning performance.

The results of this study may in part be linked to the subject being taught. To confirm their applicability to different course subjects, the research model needs to be tested in different subject contexts. Once the categorization of course subjects has been systemized and more studies accumulated, general conclusions can be drawn with greater confidence. Nevertheless, this research represents a milestone in that it emphasizes the mediating processes involved in the relationship between learning styles and learning performance, in contrast to previous studies that have investigated only the direct relationship between the two. Future research is warranted to explore additional mediating processes that link learning styles and learning performance.

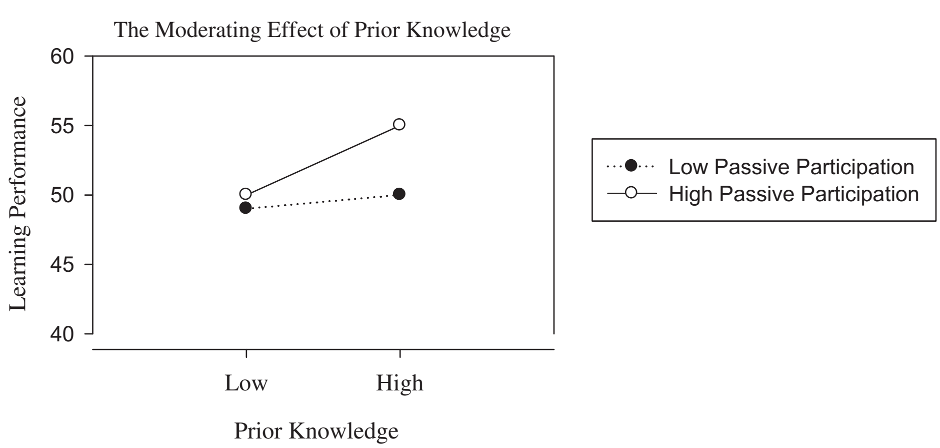

Fig. 3. Moderating effect of prior knowledge.

The sample is characterized by young less autonomous 19- to 22-year-olds, which is the typical profile of college students in Asia and a limitation in our study. Therefore, further research based on a sample of more mature, professional, and autonomous online learners is needed. Online learners are not all college students, and even among college students, some regions have seen a gradual shift to an older student composition. Thus, further research using different samples is needed to generalize our findings to other regions.

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