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# E-learning tools for andragogy: a scale model of technology-based active learning

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# e-Learning tools for andragogy: a scale model of technology-based active learning

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**Abstract:** Andragogy is an educational philosophy on how to facilitate active learning for adult students. In today's higher education, most of the courses are still pedagogy-oriented using traditional instruction and assessment methods. However, undergraduate and graduate students are in need of experiential and collaborative learning for the preparation of their future careers in the real world. It requires instructors to engage students in other learning activities than just lecturing, including problem solving, essay writing, discussions, group projects, and so on. The challenge is how to facilitate student participation and assess learning outcomes under this new approach. The emergence of e-learning tools, such as Discussion Board, Wiki, Blogs, and Wimba provide technical support for the new learning approach. Based on the review of information systems and education literature, this study develops a taxonomy of e-learning tools for andragogy-oriented online courses. In particular, it proposes a scale model based on the premise that e-learning tools must facilitate both content contribution and content appraisal for students. For different learning activities, various tools facilitate the two processes in different ways. The taxonomy is validated with a simulation study based on the premises of media synchronicity theory, and the results demonstrate its relevance and applicability. This framework provides a guideline on how to choose appropriate e-learning tools for various learning activities of online and hybrid courses at undergraduate and graduate levels. [AQ1]

**AQ1:** Please reduce length of abstract to a maximum of 150 words.

**Keywords:** services; standards; andragogy; assessment; taxonomy; e-learning; pedagogy.

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## 1 Introduction

Unlike the traditional pedagogy that is oriented towards young learners, andragogy is a relatively new educational philosophy that is oriented towards adult learners based on the premise that the two groups of learners have different needs and capacities (Knowles, 1970). Compared with teenagers, adults generally have clearer and stronger motives for learning and they are more capable of learning by themselves (Knowles et al., 2011). Thus, the essence of andragogy is to give adult students the control of how they learn in form of active learning (Smith, 2002). The role of instructors, therefore, is not just to teach the course material but also to facilitate the participation of students in learning.

In today's higher education, most of the courses are still pedagogy-oriented using traditional instruction and assessment methods. For instance, students are often required to read textbooks, memorise the concepts, and answer the multiple-choice questions in standardised tests. According to revised Bloom's learning taxonomy (Anderson et al., 2005), such learning is mostly at the lowest knowledge level. However, the goal of the higher education is to prepare students for their future career in the real world. Rather than traditional lecturing, andragogy-oriented courses engage students in contributing course content, collaborating with classmates and instructors, and other activities involving active practice (Bale and Dudney, 2000; Cooper and Henschke, 2005). Such learning activities include problem solving, essay writing, discussions, group projects, and so on. Through the participation in these learning activities, students can assess and develop their own skills to discover and accommodate limitations and tradeoffs for handling real-world problems in contemporary organisations (Simonson et al., 2000).

In practice, andragogy has gone through a relatively slow development though its main concept of active learning is well accepted (Pratt, 1993). The main challenge is how to facilitate student participation and assess learning outcomes under this new approach. The emergence of electronic learning (e-learning) tools, such as Discussion Board, Wiki, and Blog, provide much needed technical support for the new learning approach (Dron, 2003; Tosh and Werdmuller, 2004; Glogoff, 2005; Weller et al., 2005; Parker and Chao, 2007).

For example, Blog allows people to post their thoughts and opinions online for others to read (Blood, 2000). When used as an e-learning tool, it enables students share their understandings, experiences and ideas related to a topic with each other (Glogoff, 2005; Weller et al., 2005). Compared with traditional essays that are mostly for the purpose of being graded by the instructors, Blog posts can be viewed by peer students to provide comments and feedbacks (Dron, 2003). Such interaction among students greatly stimulates the active learning process leading to knowledge building and even creation (Tosh and Werdmuller, 2004).

Another useful e-learning tool that allows students to generate their own content on specific learning subjects is Wiki. Wiki stands for 'what I know is' and each student in a group can use it to contribute his/her own pieces of information that complete a whole article (Parker and Chao, 2007; Augar et al., 2012). Compared with Blog that allows students to comment on each other's posts, Wiki enables them to directly add to and even modify the content contributed by others. Thus, students largely take the control of learning by creating their own content on relevant course topics, leading to active learning (Dron, 2003; Tosh and Werdmuller, 2004; Glogoff, 2005; Parker and Chao, 2007; Augar et al., 2012).

As the use of e-learning tools for active learning has the potential to transform higher education, there is a need for systematic investigations of how the technologies facilitate the transition from pedagogy to andragogy. To establish a theoretical foundation for understanding such a new socio-technical phenomenon, this study will examine the roles that various e-learning tools play in active learning. For researchers and practitioners in higher education, such a discussion may be helpful for the design and implementation of online and hybrid courses in terms of tool choice and usage for different learning activities.

## 2 Statement of the problem

A brief review of e-learning development is helpful for the understanding of the relationship between emerging e-learning tools and andragogy. Generally speaking, e-learning aims to improve student learning outcomes by using information technologies that generate and disseminate knowledge (Rosenberg, 2001). More specifically, e-learning involves the use of computer network technology, especially the Internet, to deliver information and instructions to students (Welsh et al., 2003). In higher education, e-learning mainly takes the form of online courses. In USA, around 25% of college students are enrolled in courses purely online, and most of all have taken some online courses (Allen and Seaman, 2009).

e-Learning begins with posting syllabus, slides, assignments and grades on websites to let the student access course materials and submit works anytime and anywhere (Mason, 2006). Actually, as the name of the most widely used online teaching application – Blackboard – indicates, the first generation of e-learning tools simply extends the in-class instructions to the online environment (Moore and Kearsley, 2011). However, the new generation of e-learning tools are no longer instructor-centric, but allows students to post information by themselves and share it not only with their teachers but also with peer classmates (Augar et al., 2012). That is, an instructor is not

the sole contributor of course content but takes the additional roles of facilitator and moderator of student participation (Ellis, 2002). Such capabilities of new e-learning tools greatly expand the scope of active learning from face-to-face settings to virtual world.

Despite the huge demand and great potential of e-learning, researchers have found that the failure rate of online courses is significantly higher than that of traditional face-to-face courses (Xu and Jaggers, 2011). Lacking the standards and guidelines on how to develop online courses contribute to the quality issue (Haugen et al., 2004; Liu, 2007; Phusavat and Anussornnitisarn, 2007). As the aforementioned examples of Blog and Wiki show, one e-learning tool may fit a learning activity better than another. However, few researchers have systematically discussed how to choose appropriate e-learning tools for certain types of learning activities in the design of online or hybrid courses. This is mainly due to the lack of a theoretical framework on the relationship between information technology and active learning. Without such a framework, the design and evaluation of andragogy-oriented courses is an art rather than a science. This problem is what motivates the current study.

## 3 Statement of the objective

The advent of technology are dramatically altering the teaching and learning in education (Galagan, 2000; Weller et al., 2005). The existing studies on e-learning have focused mainly on the factors that contribute to the adoption of e-learning. For instance, Sun et al. (2008) developed an integrated model with six dimensions: learners, instructors, courses, technology, design and environment. These dimensions are proposed to influence the e-learning adoption, in specific, the perceived e-learner satisfaction. They conducted a survey in two public universities in Taiwan, and the result shows that 'learner computer anxiety, instructor attitude towards e-Learning, e-Learning course flexibility, e-Learning course quality, perceived usefulness, perceived ease of use and diversity in assessments are the critical factors affecting learners' perceived satisfaction' (Sun et al., 2008). However, this exploratory study did not explain how these factors influence e-learners satisfactions and the interactions among the factors. Moreover, e-learners' satisfaction is not an objective measure for e-learning efficiency and effectiveness. Similarly, Piccoli et al. (2001) suggest that both human and design dimensions affect the e-learning effectiveness, but the conceptual model does not specify how different e-learning tools affect learning outcomes.

Another area of research comprises studies conducted mostly by the researchers from the education discipline based on various learning theories. For example, Beard et al. (2007) built a model based on the Experiential Learning Theory as the practical basis for the design of an induction CD-ROM for students (Beard et al., 2007). Such studies focused on how to facilitate student learning processes with the use of e-learning technologies. Furthermore, several researchers have explored the e-learning methods from the asynchronous and synchronous perspectives. For instance, Hrastinski (2008) claimed that the e-learning success depends on the understanding of the benefits and limitations of different e-learning techniques and methods. He proposed a framework to utilise asynchronous and synchronous e-learning in different learning contexts. However, the model treats synchronicity as a simple construct of a single dimension. In addition, the model does not take active learning into account.

Instructors in higher education are in need of some guidelines on how to use e-learning tools to facilitate active learning. As an initial effort, the primary objective of this study is to develop a model of e-learning and andragogy as well as a taxonomy of how e-learning tools facilitate active learning. Such discussions need to indicate the major dimensions of active learning and the roles that e-learning tools play in it. The understanding will help educators choose different e-learning tools for different learning activities in the design of online and hybrid courses for adult learners. The discussions may be interesting not only to the researchers who want to further investigate e-learning and andragogy but also to the practitioners who intend to employ emerging e-learning tools to engage students in active learning.

## 4 Proposed model and taxonomy

To build a model that depicts the relationship between e-learning and andragogy, this study adopts the Kolb's (1984) Experiential Learning Theory (ELT), an established and influential theory of active learning, as the theoretical foundation. Experiential learning refers to 'the process whereby knowledge is created through the transformation of experience' (Kolb, 1984, p.P41). It is closely related to andragogy as ELT provides a holistic model of the learning process of adult development (Kolb et al., 2001).

Experiential learning engages students in two dimensions of processes (Kolb, 1984):

- *Processing continuum*: task-oriented processes
  - Watching: reflective observation from different perspectives
  - Doing: active experimentation to get things done
- *Perception Continuum*: psychological processes
  - Feeling: learning from concrete experiences
  - Thinking: abstract conceptualisation to achieve intellectual understanding.

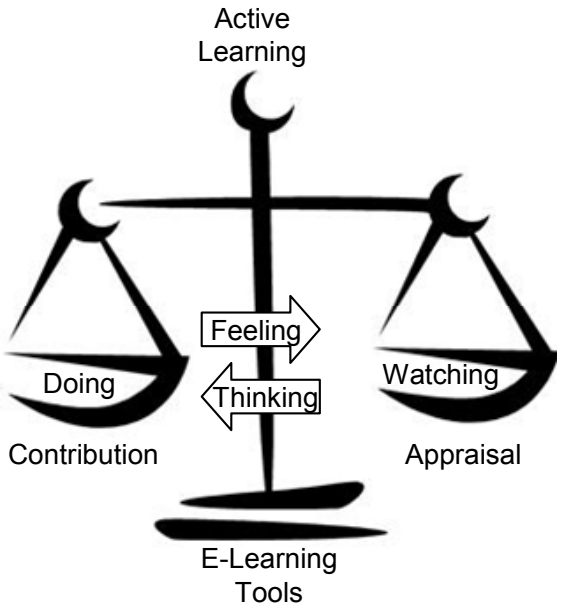
These four processes comprise a continuous cycle: doing → feeling → watching → thinking (Kolb, 1984). As the source of learning and development, the experiences that students have with learning objects in the cycle need be balanced to evoke both right-brain and left-brain functioning (Kolb, 1999).

To facilitate active learning, the use of e-learning tools also needs to balance student experiences in the learning cycle. Thus, this study proposes a scale model as shown in Figure 1. In this model, the e-learning tools provide the technical support for balancing the content contribution and content appraisal of students in active learning. On one hand, e-learning tools keep records of what students are 'doing' in terms of content contribution. On the other hand, they provide students the means of 'watching' what others have done. The two sides are connected with the 'feeling' and 'thinking' processes into a continuous cycle.

The scale model emphasises the balancing between content contribution and content appraisal with the use of e-learning tools that are capable of facilitating all four aspects of learning experiences. For example, when a student comment on a blog post of another student, the individual complete the watching (i.e. reading the post), thinking (i.e. judging the post with his/her own experiences and opinions), doing (i.e. giving feedback)

and feeling (i.e. experiencing the emotions, such as enjoyment and flow). In traditional education, on the other hand, the four aspects of learning experiences are rather separated: students watch instructors doing things and instructors grade what students have done. Through the mediation of e-learning tools, students together can learn from doing and watching at the same time.

**Figure 1** Scale model of e-learning and andragogy




There are different ways that students can contribute and appraise course content in active learning. To enhance the learning experiences of students, different e-learning tools need to be used to facilitate the activities of different natures on both sides. For content contribution, students can generate inputs on an interactive or non-interactive basis depending on whether the process involves relatively intensive communication and coordination among them or not. For content appraisal, students can review, digest and evaluate others' inputs on an atomistic or holistic basis depending on whether the process focuses on individual contributions or group deliverables.

Table 1 classifies e-learning tools along the dimensions of content contribution and content appraisal. Blog allows each student to post thoughts, experiences and ideas on a personal space. Other students can view the individual posts sorted by dates or topics and give comments. Thus, it is an exemplary tool that facilitates non-interactive contribution and atomistic appraisal. Similarly, wiki allows students to compile essays on an online space. However, the space is shared among multiple users so that a group of students can collaborate on the writing. Yet, only one student can work on an article at a time. As the name of the tool indicates, each student contributes what he/she knows about the subject. Thus, each student is still largely autonomous in generating his/her own input. On the other hand, once a group of students complete a wiki entry, others view the article as a whole. Thus, wiki is an exemplary tool that facilitates non-interactive contribution and holistic appraisal.

**Table 1** Dimensions of active learning and e-learning tools

| *Appraisal* | *Contribution* | |
|---|---|---|
| | *Non-interactive* | *Interactive* |
| Atomistic | Blog | Discussion Board |
| Holistic | Wiki | Wimba |

Discussion Board is an application that allows students to communicate with each other on a certain topic by posting individual comments. One needs to read others' posts in order to make meaningful comments. If one student asks a question, others are supposed to answer it. Thus, Discussion Board is an exemplary tool that facilitates interactive contribution and atomistic appraisal. Wimba is a web conferencing tool that allows multiple users to communicate and coordinate on a group task. For example, a group of students can work on the presentation of a project together. They need to coordinate who present which parts and compile the final presentation as a group deliverable for others to watch and evaluate. Thus, Wimba is an exemplary tool that facilitates interactive contribution and holistic appraisal.

The classification of e-learning tools is based on how they facilitate different aspects of learning. To enhance student learning experiences, therefore, instructors may involve students in different learning activities with the use of different e-learning tools. For example, an online course on information security may first let each student write about his/her own security-related experiences (e.g. virus infection, data loss. etc.) on Blog. The sharing of personal experiences may motivate students and arouse their interests in the subject. After the students learn more about information security, they can work on specific topics (e.g. data back-up, anti-virus protection) in groups on Wiki. Each will contribute what he/she knows about the subject, leading to a final deliverable that is more than the simple aggregate of individual inputs (i.e. 1+1>2). Finally, students can work on group projects to come up with a workable plan to enhance information security. During the project, they can brain-storm ideas, plan the scope of the project,and coordinate with each other using Discussion Board. At the end of project, they can complete the group presentations together using Wimba.

## 5 Theoretical validation

In an andragogy-based course, the active learning of students can be regarded as a communication process among them as it involves both content contribution and content appraisal. According to Berlo's (1960) model of communication, there are four elements in a communication process: sender → message → channel → receiver: a sender generates a message and sends it through a communication channel to a receiver. Furthermore, Barnlund (2008) proposes a transactional model of communication that suggests people are simultaneously engaging in the sending messages and receiving feedback through communication channels. In active learning, some students (as the senders) contribute some content (as the messages) for other students (as the receivers) to appraise through the mediation of various e-learning tools (as the channels), and the receivers become senders when they provide feedback in form of critics, comments and

suggestions. To validate the aforementioned model and taxonomy, it is necessary to examine the roles and characteristics of e-learning tools as the communication channels that facilitate the communications among students in active learning.

## 6 Media characteristics

There are two IS theories on communication channels, Media Richness Theory (Daft and Lengel, 1986) and Media Synchronicity Theory (Dennis and Kinney, 1998; Dennis et al., 2008). Media Richness Theory benchmarks computer-mediated communication with face-to-face communication that is regarded as the communication with the highest richness (Daft and Lengel, 1986). The basic premise is that electronic media may assimilate face-to-face communication but can never surpass it in terms of richness. Media synchronicity theory, on the other hand, is rooted in the mathematic modelling of communication (Dennis et al., 2008). It claims that different electronic media are effective for different communication purposes (Dennis et al., 2008). The taxonomy proposed in this study suggests that different e-learning tools are useful for different learning activities. Thus, media synchronicity theory provides a more appropriate framework to validate the taxonomy.

Computer-mediated communications vary in their means/processes and ends/purposes (Thurlow et al., 2004). The means/processes of communication can be impersonal (i.e. one-to-many), interpersonal (i.e. one-to-one) or hyperpersonal (i.e. many-to-many) depending on whether the electronic media provide a mechanism for reciprocal interactions between or among the participants involved (Walther, 1996). There are generally two communication purposes for which electronic media are used for: conveyance and convergence (Dennis and Kinney, 1998; Dennis et al., 2008). Conveyance refers to 'the discussion of preprocessed information about each individual's interpretation of a situation, not the raw information itself" and convergence refers to 'the transmission of a diversity of new information – as much new, relevant information as needed – to enable the receiver to create and revise a mental model of the situation' (Dennis et al., 2008).

In terms of the processes of computer-mediated communications, electronic media need to have at least a certain level of synchronicity to enable interpersonal and/or hyperpersonal communications by facilitating reciprocal interactions among participants (Herring, 1999). When students use non-interactive e-learning tools, such as Blog and Wiki, to post messages, they may or may not get feedbacks from others. Likewise, they are not obliged to respond to others' comments either. Thus, such computer-mediated communication is largely impersonal, demanding relatively low synchronicity of the e-learning tools. On the other hand, when a group of students use interactive e-learning tools, such as Discussion Board and Wimba, they start a dialog with each other on a certain topic. Such interpersonal and/or hyperpersonal communications demand a relatively high level of synchronicity to enable reciprocal interactions among participants.

In terms of the purposes of computer-mediated communications, electronic media of high synchronicity are more appropriate for the communication of convergence purposes, but the media of low synchronicity are more appropriate for the communication of conveyance purposes (Dennis et al., 2008). For instance, email is of relatively low

synchronicity and it is useful for delivering one's point of view to others. On the other hand, video-conferencing is of relatively high synchronicity and it allows people to reach agreement on certain agenda after some discussions.

## 7 Media requirement in e-learning

In e-learning, content appraisal is related to the purposes of computer-mediated communication in terms of how the messages are received and evaluated. Focusing on the points delivered by individual messages, atomistic appraisal is closely related to conveyance purpose. On the other hand, holistic appraisal emphasises the coherence in the final deliverable rather than the pieces that comprise it. For recipients to accept the final deliverable, it must be logically and cohesively presented. Thus, holistic appraisal is closely related to convergence purpose.

e-Learning tools that facilitate holistic appraisal demand a higher level of synchronicity than those that facilitate atomistic appraisal. With atomistic appraisal, a message is evaluated by itself. With holistic appraisal, however, even though a part is excellent by itself, it may weaken the whole piece if it does not blend into it. To come up with a sound and coherent final deliverable, therefore, students in a group must take others' point of view into account and be willing to compromise. The process requires a certain level of synchronicity, such as turn taking in the use of Wiki and active coordination in the use of Wimba. When students use Blog and Discussion Board for atomistic appraisal, on the other hand, they do not have to agree with each other. Thus, the requirement of synchronicity is lower on these e-learning tools.

Table 2 gives the classification of e-learning tools based on the processes and purposes that they facilitate in computer-mediated communications. Blog is supposed to have relatively low synchronicity as it facilitates impersonal communications for conveyance purposes. Wimba is supposed to have relatively high synchronicity as it facilitates inter/hyperpersonal communications for convergence purpose. The synchronicity level of Wiki and Discussion Board is likely to be medium as the former facilitates impersonal communication but for convergent purpose and the latter facilitates inter/hyperpersonal communication but for conveyance purpose.

**Table 2** Media synchronicity and communication context

| *Purpose* | *Process* | |
|---|---|---|
| | *Impersonal* | *Inter/hyperpersonal* |
| Conveyance | Blog: low synchronicity | Discussion Board: medium synchronicity |
| Convergence | Wiki: medium synchronicity | Wimba: high synchronicity |

The predicted synchronicity levels of e-learning tools based on the roles that they play in andragogy-oriented courses as electronic media can be assessed of their actual synchronicity levels. If the predicted and actual levels are consistent, there is supporting evidence of the taxonomy developed in this study. The next section will discuss the assessment using mathematical simulation.

## 8 Mathematical assessment

Media synchronicity is a multi-dimensional construct and an electronic media can be characterised from five major aspects (Dennis et al., 2008):

- transmission velocity: how fast information can be sent and received;
- parallelism: how many transmissions can take place simultaneously;
- symbol sets: what are the different ways of encoding a message;
- rehearsability: the ability to revise a message before sending it;
- reprocessability: the ability to retrieve a sent message and process it again.

Among the five characteristics, transmission velocity and parallelism are transmission capabilities, rehearsability and reprocessability are processing capabilities, and symbol sets is both a transmission capability and a processing capability (Dennis et al., 2008). An electronic media has higher level of synchronicity when it has higher capabilities of transmission velocity, parallelism and symbol sets, but lower capabilities of rehearsability and reprocessability (Robert and Dennis, 2005; Dennis et al., 2008).

The actual synchronicity levels of e-learning tools can be assessed from these dimensions. In this study, such an assessment is done through a mathematical simulation. First of all, the author will assign scores to all the five dimensions for each learning tool as follows:

- If the tool has relatively low level of a dimension: assigned the value of 1
- If the tool has relatively medium level of a dimension: assigned the value of 2
- If the tool has relatively high level of a dimension: assigned the value of 3

Then, the overall synchronicity score will be calculated as the average of all dimension scores based on Formula (1):

$$\begin{aligned}\text{Synchronicity score} = [&\text{Transmission Velocity score} + \text{Parallelism score} + \\ &\text{Symbol Sets score} + (4\text{-Rehearsability score}) + \\ &(4\text{-Reprocessability score})] / 5\end{aligned} \tag{1}$$

Note that the scores of rehearsability and reprocessability are reversed due to their negative relationships with media synchronicity. If the overall synchronicity scores of e-learning tools are consistent with the predicted levels of synchronicity, there is supporting evidence for the taxonomy based on which such predictions are made.

Table 3 gives the scores of five dimensions for each e-learning tool, and the overall synchronicity score calculated based on Formula (1). As for Blog, only the individual who owns the personal space is allowed to post and change original articles, and therefore, the parallelism is low (i.e. score = 1). The exclusiveness also implies that Blog does not need to refresh and update the content very fast and frequently, and the requirement on transmission velocity is relatively low (i.e. score=1). However, a Blog owner can draft an article before posting it, as well as revise an article after it is posted. Thus, Blog has relatively high rehearsability and reprocessability (i.e. scores = 3). Meanwhile, an author can use multiple sets of symbols, such as formatted texts and various graphics, to enrich the content of a Blog article. Of course, Blog generally does

not support multimedia content (such as video and sound) except for embedded hyperlinks pointing to external third-party service providers (e.g. YouTube). That is why Blog has a medium score on the dimension of symbol sets (i.e. score = 2). The overall synchronicity score is 1.2, a little bit over the lowest possible score of 1. Therefore, the simulated synchronicity level of Blog is low, which is consistent with what is predicted based on the taxonomy.

**Table 3** Synchronicity assessment of e-learning tools

| | *Blog* | *Wiki* | *Discussion Board* | *Wimba* |
|---|---|---|---|---|
| Transmission Velocity | 1 | 2 | 2 | 3 |
| Parallelism | 1 | 2 | 3 | 2 |
| Symbol Sets | 2 | 2 | 1 | 3 |
| Rehearsability | 3 | 3 | 2 | 1 |
| Reprocessability | 3 | 2 | 1 | 1 |
| Synchronicity | 1.2 | 1.8 | 2.2 | 2.8 |

Compared with Blog, Wiki allows multiple individuals to work on the same article in turn. When a contributor is working on a Wiki entry, its status is locked so that others cannot modify it and cause conflicts. After the individual finishes his/her work, the content needs to be updated and the lock must be released in a timely manner so that another person can continue the work. Moderately higher than those of Blog, the transmission velocity and parallelism of Wiki have medium scores (i.e. scores = 2). Similar to Blog, Wiki allows people to post articles that contain texts and graphics, and the score on the symbol sets is also medium (i.e. score = 2). Likewise, contributors can draft the content before posting it on Wiki, and the rehearsabilty is high (i.e. score = 3). However, they may not be able to revise it after it is posted if someone else makes changes first. Therefore, Wiki has medium level of reprocessability (i.e. score = 2), lower than that of Blog. The overall synchronicity score is 1.8, close to the medium score of 2. It is consistent with the predicted synchronicity level of Wiki using the taxonomy.

Discussion Board allows a group of students to post messages on a topic and give feedback to each other. To enable the timely exchange of messages, the transmission velocity is moderately high (i.e. score = 2). Multiple individuals can post messages at the same time on Discussion Board, and its parallelism level is relatively high (i.e. score = 3). Discussion Board messages typically only contain plain text, and the score of symbol sets is low (i.e. score = 1). When people post on Discussion Board, they usually just type in the textbox and click submit without drafting it first in a separate word processor. Thus, the reversibility is medium (i.e. score = 2). Once a user posts a message on Discussion Board, he/she may or may not be able to change it depending on system settings. Even if it is allowed, it is not a common practice to change posted messages, especially when there are already responses. Other readers need to see both the original messages and responses to understand the discourse of communication. In this sense, Discussion Board has a low level of reprocessability (i.e. score = 1). The overall synchronicity score is 2.2, a little bit above the medium score of 2. Similarly, the taxonomy yields a predicted medium level of synchronicity for Discussion Board.

Finally, Wimba allows members of a group to work on a project together through active coordination. Thus the transmission velocity is high to facilitate real-time interactions among them (i.e. score = 3). However, they cannot work on the same part of

the project at the same time but rather adopt the divide-and-conquer strategy. Thus, the parallelism is at the medium level (i.e. score = 2). To present a project, the members of a group can record voices or even videos in addition to textual and graphic content. Thus, the symbol sets of Wimba are rich (i.e. score = 3). Unlike a text message that can be revised, the audio and video recordings can hardly be modified. Therefore, both rehearsability and reprocessability of Wimba are at low levels (i.e. scores = 1). The overall synchronicity score is 2.8, just shy of the highest possible score of 3. It is close to what the taxonomy predicts for Wimba: a high level of synchronicity.

The mathematical simulation results suggest that the characteristics of e-learning tools fit well to the purposes for which they can be used in andragogy-oriented courses to facilitate active learning for students. The results provide supporting evidence to the validity of the scale model of technology-based active learning and the taxonomy of relevant e-learning tools. The next section will discuss the implications of this study for researchers and practitioners in the field of e-learning.

## 9 Conclusions and implications

To understand the roles that information technology plays in andragogy-oriented courses, this study develops a conceptual model and taxonomy of how different e-learning tools facilitate active learning. The basic premise is that students in higher education are adult learners who need to and are able to explore the subjects of study by themselves to a large extent in order to get prepared for the real individual tasks and group projects in their future career. The two sources of learning are doing and watching, which represent content contribution and content appraisal in andragogy-oriented courses, and they are connected by feeling and thinking. The scale model proposed in this study shows that information technology can play an essential role in active learning process by facilitating both content contribution and content appraisal in a balanced way. Furthermore, the taxonomy delineates different approaches of content contribution and content appraisal and classifies e-learning tools along the two dimensions.

The systematic discussion of the relationship between information technology and active learning lays the foundation for quality assurance in the design and implementation of hybrid and online courses in higher education. In particular, the model and texonomy provides a guideline on how to choose and use e-learning tools in andragogy-oriented courses. The scale model indicates the general principle of e-learning in andragogy-oriented courses: the tools used must facilitate both content contribution and content appraisal for students to enhance their active learning experiences. The taxonomy suggests different e-learning tools are useful for different types of learning activities. Both the model and taxonomy point to the best practices for the design and implementation of online and/or hybrid courses in andragogy-oriented courses.

First of all, instructors need to design the course in terms of learning activities to cover different sources and ways of active learning for students, including: non-interactive contribution for atomistic appraisal, interactive contribution for atomistic appraisal, non-interactive contribution for holistic appraisal and interactive contribution for holistic appraisal. They correspond to different types of tasks and projects in the contemporary organisations, so that students have the chance to practice how to watch,

do, think and feel as individuals and group members in the real and virtual classrooms. This will help bridge the gap between the academia and industry in terms of the skills needed to solve real-world problems.

Next, instructors may select appropriate e-learning tools for each type of learning activities. e-Learning tools can be regarded as electronic media in computer-mediated communications among students, and they are useful for different communication processes and communication purposes. A specific type of learning activities involve either impersonal or inter/hypoerpersonal communication process for either conveyance or convergence communication purpose. Therefore, different e-learning tools are appropriate for different learning activities. Instructors can choose Blog for the learning activities of non-interactive contribution and atomistic appraisal because such a tool is useful for the impersonal communication involved for conveyance purpose. They can choose Wiki for the learning activities of non-interactive contribution and holistic appraisal as it fits impersonal communication for convergence purpose. Discussion Board is appropriate for the learning activities of interactive contribution and atomistic appraisal since it is a tool that mediate inter/hyperpersonal communication for conveyance purpose. Finally, Wimba is good for the learning activities of interactive contribution and holistic appraisal as the tool facilitates inter/hyperpersonal communication for convergence purpose.

The characteristics of e-learning tools are summarised with the multi-dimensional construct of synchronicity in computer-mediated communication. The simulation study assesses and validates the model and taxonomy by examining the characteristics of e-learning tools from the five dimensions of synchronicity: Transmission Velocity, Parallelism, Symbol Sets, Rehearsability and Reprocessability. The simulation suggests that Wiki, Discussion Board and Wimba meet the requirements of different learning activities on synchronicity. The mathematical simulation not only supports the validity of the model and taxonomy developed in this study, but also provides a means to quantify the selection of e-learning tools for different learning activities. Involving impersonal communications for conveyance purpose, for instance, the learning activities of non-interactive contribution and atomistic appraisal demand low synchronicity, which features Blog as it has relatively low levels of Transmission Velocity, Parallelism and Symbol Sets but high levels of Rehearsability and Reprocessability.

## 10 Limitations and directions for future studies

In presenting the taxonomy, this study uses only four e-learning tools: Blog, Wiki, Discussion Board and Wimba. Though they are the common tools used by instructors for online and hybrid courses, there are many other e-learning tools. Without including more tools, it raises the questions on whether the proposed framework can be applied to other e-learning tools. Of course, the use of exemplary tools enhances the generalisability of the proposed framework. Nevertheless, other researchers may find this taxonomy useful for analysing other existing or emerging e-learning tools.

One of the learning tools included in this study, Wimba, is somewhat problematic compared with other tools. Wimba is the brand name of a commercial product, whereas the names of other tools are not. In addition to Wimba, there are other commercial products to facilitate group project presentation. Thus it poses another limitation of this study in terms of whether Wimba is truly representative of the e-learning tools of the

same kind. Of course, Wimba is the most-widely used product at the moment and recognised as a leading product or even an industrial standard by many. The use of it as an exemplary tool in this study does not compromise the validity of the taxonomy. Nevertheless, researchers may include other similar products in future studies. Another solution is to come up with a general name for such tools rather than using a specific brand name. This will also reduce the commercialism of research articles.

The mathematical simulation is helpful for assessing the taxonomy. However, it is the students who have the final say regarding whether an e-learning tool is appropriate for a learning activity in terms of the match between tool characteristics and activity requirements. Even though the simulation suggests a match between an e-learning tool and a type of learning activity in the perfect world, the actual effects depend on the specific implementation and use of e-learning tools by instructors. If students perceive a mismatch between a learning activity and the e-learning tool used, they may be hesitant to participate. One solution is to conduct a survey study on students' perceptions of e-learning tools in the context of learning activities. The results will also provide further insights on the relationship between e-learning tools and active learning from the perspective of students.

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