

Innovative Hint-Scaffolded KM E-learning Framework To Increase Meaningful Learning And Multi-Dimensional Thinking

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Abstract

Remote and rural communities are often disadvantaged in terms of access to infrastructure, information and opportunities. The authors are concerned with two specific problems crucial to promoting sustainable online learning for the remote community. First, presenting learning content may not be sufficient to help students to improve their learning as they are not competent to make meaning from the information presented. Second, students are often not competent to articulate information from different perspectives or discuss complex issues. The authors' contributions are in four aspects (i) instructional design of learning activities, especially role playing (ii) design of learning content (iii) design of hint-based teaching-learning strategies to scaffold learning and (iv) design of technology-enhanced collaborative learning. This Knowledge Management (KM) framework has been used for the development of an instructional model incorporating a germane pedagogical setup which coalesces interactive learning and learner-centered factors. The process was illustrated with a case study from SMK Bario, Sarawak (*Sekolah Menengah Kebangsaan, local secondary school*) with Form 2 students (14-15 years old) to show that the recommended matrix method has been applied to make a successful transition to a blended learning format that combines face-to-face sessions with distance communication. Findings indicated that students were able to filter and consider multiple perspectives, skillfully represent the problem in more ways than one, capable to quickly change focus and goals as the situation required and able to post questions about complicated and complex issues in open class discussions. The authors investigated whether KM processes, e-learning principles and Human Factors Engineering will promote sustainable online learning for the remote community.

Key words

e-learning, design of teaching/learning strategies, blended learning, cognitive engineering, hints as learning scaffolds, knowledge management

Introduction

The remote Bario communities live in a highland village located 3280 feet above sea level in the centre of the Kelabit Highlands in the north east of Sarawak in Borneo island. It is the main settlement in the Kelabit highlands. Life has changed in this rural community. There is a need to help local students develop more customised curricula

so that learners can create new knowledge suitable for themselves and for use in their communities (Chin & Lee, 2011). The rural students need more attention in terms of curriculum design and development compared to urban students when they participate in online or blended learning (Chin, Lee & Yeo, 2010). The authors are concerned with two specific problems faced by rural students:

- 1) Students often find difficulty in making sense or meaning from the information presented (Marzano, 2010). This may be due to lack of relevance and the lack of customization of learning materials from the urban setting to rural settings
- 2) Lack of feedback frequency and immediacy from the facilitator/instructor as compared with face-to-face communication in class. This results in students often not being able to articulate information from different perspectives or discuss complex issues (Hattie, 2012).

Objectives

This study aimed to increase meaningful learning through technology via the inculcation of multi-dimensional thinking skills as defined by Sinapova (2004); that is, the ability to analyse multidimensional thinking as involving different perspectives, abandoning implicit restrictions, and modifying the initial settings of a problem.

We aim to help students develop higher order thinking skills such as application, evaluation and syntheses of knowledge. We have applied Merrill's First Principles of Instruction and usability properties as pedagogical and usability design guidelines, KM processes as the methods by which knowledge about the users' background and application contexts are identified and Cognitive Hierarchical Task Analysis as the method by which users' predicted tasks are designed. These form our design and methodological knowledge base. Bloom's taxonomy (1956) was used to evaluate the effectiveness of these usability guidelines on learning effectiveness. The Computer System Usability Questionnaire, CUSQ evaluation (Lewis, 1995) was applied to evaluate web usability and system usability respectively by the experts.

The first three sections describe background, literature and method respectively, with the remaining headings each

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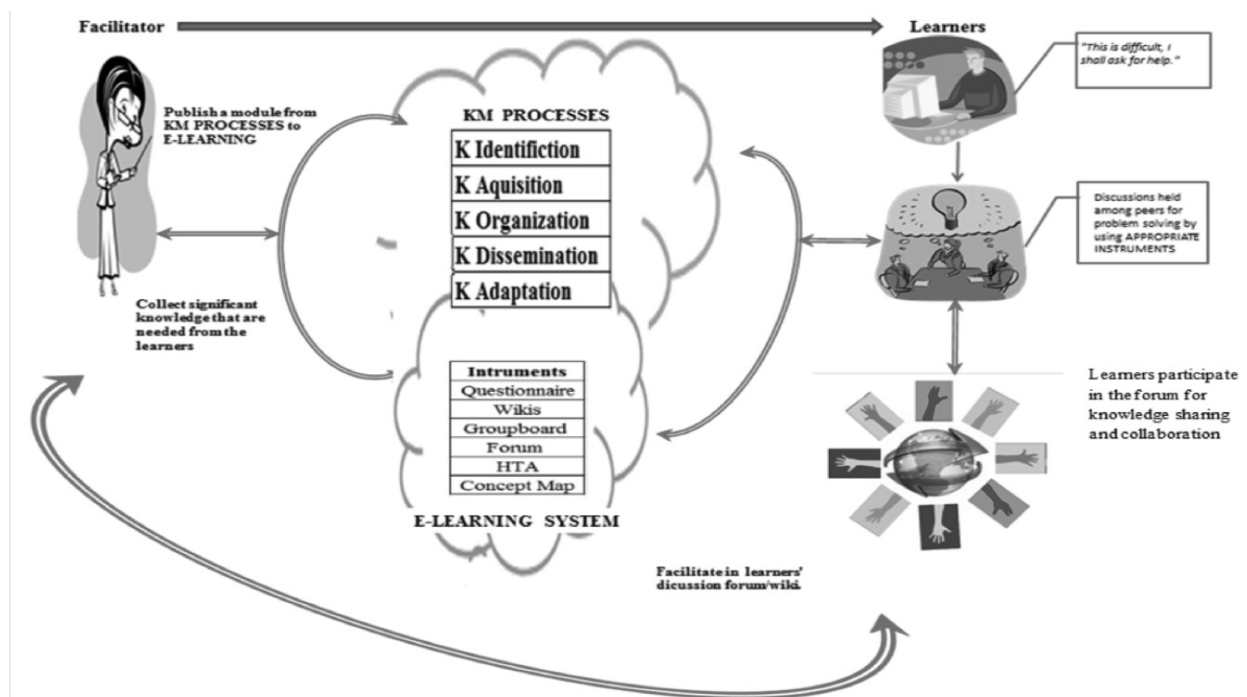


Figure 1. Usage scenario for overall interactions by using the KM e-learning system framework

presenting analysis of data and a summary. The first section gives a broad overview of KM processes – Knowledge Identification (KI), Knowledge Acquisition (KA), Knowledge Organization (KO), Knowledge Dissemination (KD) and Knowledge Adaptation (K Ad). The rest of the sections provide descriptions of all the tools (HTA, concept map, Groupboard, KWL table) and the methodology applied to form the framework design and methodological knowledge base. Experts' evaluations by using CSUQ (Lewis, 1995) have been used to test the usability for both system and web content developments of the KM-e-learning system. The authors hope that learners can stimulate their higher order thinking skills and organize knowledge in their own way and share their knowledge more effectively in our KM e-learning system.

The authors aimed to achieve this by improving on the design of learning activities, learning content; hint-based teaching-learning strategies and design of technology-enhanced collaborative learning within a hint-scaffolded KM framework (see Figure 1).

Research Questions

The research questions were:

- To what extent does web-based learning based on a Cognitive Engineering-derived KM approach help improve students' mastery of basic Internet search skills,

- To what extent does a hint-based teaching-learning strategy result in multi-dimensional critical thinking?

The authors used the following measures to quantify multi-dimensional critical thinking: the students' ability to filter and consider multiple perspectives, to represent their ideas in more ways than one, to quickly change focus and goals as the situation required and to post questions about complicated and complex issues in open class discussions. These measures were characteristic of Bloom's (1956) three higher-order thinking skills, which are evaluation, synthesis and generation of new ideas. Elaboration on the work is presented in the following sections.

System implementation

Usage scenario for overall interactions by using the KM e-learning system framework

Based on the literature reviewed in the study, the authors designed MOODLE, an open-source LMS with KWL table, concept map, visualization and Groupboard corresponding to the processes in the KM-e-learning system framework. The authors also provided a flexible array of course activities - Forums, Quizzes, Glossaries, Resources, Choices, Surveys, Assignments, Chats, and Workshops such as interactive activities in the Kelabit language (the local native's language). These learning activities were aimed at encouraging learners to identify how to

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disseminate information to as wide a community as possible in a user-friendly manner. Figure 1 shows the usage scenario of the KM e-learning system framework.

The KM e-learning system helps users organize and share learning content and learning activities. Figure 1 shows the overall interaction from facilitators to learners through different type of instruments. A facilitator uploads the learning materials into different modules in the KM-e-learning system. Learners can access to the system to search for the up-coming class learning materials. Learners can post up questions for help in wiki to collect feedbacks from different learners from the same class. Facilitator can provide hints to scaffold in this learning process.

Literature review

KM e-learning

In a society emphasizing the importance of knowledge and IT, one can hardly deal with knowledge management outside an e-learning environment. According to Rosenberg (2001), "e-learning refers to the use of Internet technologies to deliver a broad array of solutions that enhance knowledge and performance." These arrays of solutions can be either asynchronous or synchronous, providing access anytime anywhere (Downes, 1998; Gubbins, Clay, and Perkins, 1999; Cooper, 1999; Rosenkrans, 2001; Seymour, Durante, and Koohang, 1999).

KM: A human-centered system

KM systems are human-centered with each design and development phase linked to human factors. The key to human factors engineering is cognitive engineering. Cognitive Engineering consists of a variety of disciplines, including Human Factors Engineering (HFE), Human Computer Interaction (HCI), Decision science, Cognitive psychology, Computer science, and other related fields (Bonaceto and Burns, 2007).

HFE contextualizes the intersection of people and technology to the development of work system efficiency. The application of this knowledge can lead human and system performance to new milestones. HFE is distinctive in being the only discipline that relates humans to technology and therefore must be integrated within the whole project instead of being added as a component in the project or an afterthought. HFE implements practices and principles to optimize how people perform to improve and match the standards of overall organizational performance by sharing knowledge among learners, nurturing the filtered learners' knowledge, and encouraging innovative knowledge creation.

With the contribution of HFE, problems in accumulating and maintaining knowledge during the learning process could be dealt with. The accumulated archived documents can be standardized to be reused and referred to by others. In this paper, the needs and significant knowledge of the learners could be identified through HFE methods and used in the development of the KM-e-learning system.

The core component of Cognitive Engineering is task analysis. Task analysis identifies the key tasks or functions that are performed in a work domain and then systematically breaks each task into a series of lower-level tasks. The task breakdown analysis clearly states the allocation of functions between people and system. We have used the Hierarchical Task Analysis (HTA), developed by Annett, Duncan and Stammers (1971) to create overall views in every single module, to allow the users to refer back to these concepts, to monitor their own progress, and remember the key points quickly.

KM e-learning system Framework overview

Proposed solution: *Design principles, methodology and instruments*

Figure 2 illustrates our KM e-learning system framework derived from the theoretically-grounded review above. The KM e-learning system framework is formed based on the blended learning paradigm, combining face-to-face practices with online delivery approaches.

The authors applied the Merrill's first instructional principles for the customized course content in the Knowledge Management (KM) framework that follows the current educational practice when devising viable plans for innovation (Bonk, Wisher and Lee, 2003; Stephenson, 2002; The e-learning Guild, 2003; Tondeur, Braak & Valcke, 2007).

This framework (see Figure 2) has two major components: KM (consist of five processes) and E-learning (consist of Content, Activities, Community and evaluation). Each component can be incorporated into a course to enhance learning in a variety of ways and is contextualized with other components within the given environment. In each component, there are tools devoted to provide information, to motivate students, to set-up activities, to assist interaction/collaboration and to promote production of new knowledge. The KM framework has been used for the development of an instructional model incorporating a germane pedagogical setup which coalesce interactive learning and learner-centered factors across disciplines.

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	Knowledge Management			E-learning
Process 1	Knowledge Identification	Content	Target community	Traditional knowledge
		Analysis	Background, environment, culture	
		Planning	Objectives, benefits	
Process 2	Knowledge Acquisition	Acquire	Surveys, interviews, records	Database
Process 3	Knowledge Organization	Classification and Storage	Course Content	
Process 4	Knowledge Dissemination	Share	Instructional Design, Learning activities	Collaborative learning Environment
Process 5	Knowledge Adaptation	Culture	Engage community, identify challenges (barriers)	Implementation and Evaluation
		Technology	Technical requirements, in-house trainings, system evaluation	
		Sustaining Systems	Records and Quality Management	

a means to understand and organize the process of designing human-centered technology and how the component activities of design can support each other. This matrix forms the foundation for the development of our KM e-learning system, which contextualizes KM processes with e-learning content and activity development (Chin, Lee & Yeo, 2010). A suitable e-learning platform – Moodle - is chosen to manage all learning modules. It is customized to provide learners an environment that probably assists the Barrio students.

Figure 2. Proposed framework for KM e-learning development

Pedagogical design principles

The design of learning activities is based on Merrill's First Principles of Instruction with emphasis on problem solving, communication and collaboration skills. The First Principles (Merrill, 2007), is an instructional design theory based on numerous reviews of other instructional models and theories (Merrill, 2007). This instructional design theory is described as a set of interrelated principles that can be used in a Task or Problem-Centered cycle of instruction (Merrill, 2007). We choose Merrill's First Principles as the instructional design methodology as they capture the general principles pertinent to all instructional design models.

- Each of these principles has its own objective in ensuring proper delivery of instruction to learners. Other examples of design principles are: *Go through course structure and expectations*
- *Allow Flexible alterations to assignments*
- *Allow peer interaction*
- *Build leadership opportunities*
- *Customize and personalize projects*
- *Offer review opportunities*

Mapping cognitive methods to system development phases

To show how cognitive task analysis and systems development are complementary in building human-centered systems, we have applied a method matrix to map the selected methods of Cognitive Engineering to its potential uses (see Table 1). It provides

In the following section, we illustrate how the above design principles support our KM-e-learning system corresponding to each KM process in our KM e-learning properties framework.

KM processes supporting our KM-e-learning system

Although the synergistic relationship between KM and e-learning has evolved over the years, majority of the researchers have focused on the integration of KM processes and e-learning systems to create, share and reuse knowledge in academic institutions and organizations (Qwaider, 2011; Murugaboopathi, Harish and Sujathabai, 2012; Khademi, Kabir and Haghshenas, 2011). Conventional e-learning systems focus on system operability and on transferring instruction or information to the end user. However, the authors focused on the Matrix Method to distinguish the KM-e-learning framework from

System development Phases	Cognitive methods	Concept Definition
Knowledge identification	Cognitive Task Analysis <ul style="list-style-type: none"> • Hierarchical Task Analysis (HTA) 	The HTA, developed by Annett, Duncan and Stammers (1971) is used to break down the task under analysis into hierarchy of goals, operations and plans in this thesis.
Knowledge Acquisition		
Knowledge Organization		
Knowledge Dissemination		
Knowledge Adaptation		
	Usability and user experiences questionnaires <ul style="list-style-type: none"> • CUSQ, Computer System Usability Questionnaire 	Computer System Usability Questionnaire (Lewis, 1995) was adopted to evaluate the psychometric properties of questionnaires designed for use in scenario-based usability evaluation. The questionnaires address evaluation at both a global overall system level and at a more detailed scenario level.

Table 1. Mapping cognitive methods to system development phases

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CE methods / HFE Techniques categories	KM-E-LEARNING PROCESSES				
	Knowledge identification	Knowledge acquisition	Knowledge Organization	Knowledge Dissemination	Knowledge Adaptation
Interview	I	I	C		I
Questionnaires	I	I	C	C	
HTA-Hierarchical Task Analysis		I	C	C	C
Web usability	I	I	C	C	I
Heuristic evaluation-CSUQ	I	I	C	C	I
KWL	I	I	C	C	I
Concept mapping	I	I	C	C	C

Key: I = Input source, C = Used in conjunction with.

Table 2. Cognitive Engineering-KM-e-learning Methods Matrix

present how the methods of Cognitive Engineering were used to design and develop the KM-e-learning system. The authors arranged the Cognitive Engineering techniques in the form of a Methods Matrix, which mapped the various methods of Cognitive Engineering/HFE methods (in rows) to potential uses in the KM-e-learning system (columns).

Five KM processes supporting e-learning system with design methodology

The KM processes allow and enable users to organize, collaborate and share their learning resources together in a systematic manner. With the development and popularization of web technologies, it is important to integrate different web technologies to encourage more knowledge sharing activities among the students.

Table 3 shows the mapping of instruments, usability tools with components in our KM e-learning

system. The Instruments are used to create, share and reuse knowledge in the KM processes. For the Knowledge adaptation process, CSUQ attributes are used as the guidelines for the design of knowledge based e-learning usability systems.

Knowledge Identification (KI)	Knowledge Adaptation (KA)	
Knowledge Acquisition (KA)		
Knowledge Organization (KO)		
Knowledge Dissemination (KD)		
Instruments	E-learning usability properties (Jacques, 2004)	CSUQ attributes (Lewis 1995)
- Questionnaire - Wikis - Groupboard (Web conferencing)	Attitude & satisfaction	User satisfaction
- Questionnaire - Wikis - Groupboard (Web conferencing) - Forum (open discussions) - HTA - Concept Map	Attractiveness Operability	System quality System efficiency Information quality Information Satisfaction Overall satisfaction
- Questionnaire - HTA - Concept Map	Effectiveness Efficiency Flexibility Memorability	System efficiency Information quality Software satisfaction
- Questionnaire - Wikis - Groupboard (Web conferencing) - Forum (open discussions) - HTA - Concept Map - KWL	Efficiency Flexibility Memorability Reliability	System efficiency Process quality Individual impact Software satisfaction
- Questionnaire - Wikis - Groupboard (Web conferencing) - HTA - Concept Map	Understandability Learnability	Information quality Information Satisfaction

Table 3. Maps e-learning usability tools with components in the KM e-learning system

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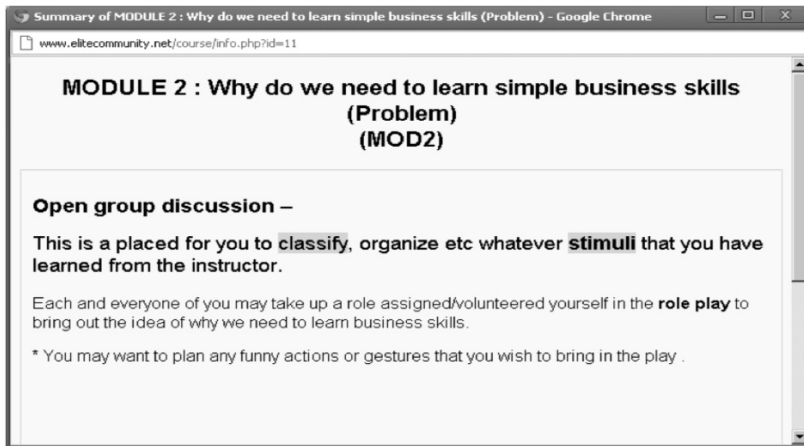


Figure 3. Merrill's First Principles Of Instruction: The task / problem

The main objective is to encourage knowledge sharing through these instruments and to evaluate its effectiveness in increasing knowledge dissemination/transfer. We have incorporated concept map, Groupboard (Web conferencing), wikis, forum, HTA, KWL, RSS reader (Rich Site Summary) and questionnaires corresponding to the processes in the KM-e-learning system framework.

We have also provided a flexible array of course activities - Forums, Quizzes, Glossaries, Resources, Choices, Surveys, Assignments, Chats, and Workshops such as interactive activities in the Kelabit language – through the CoP concept (open forum discussion). These learning activities are aimed at encouraging learners to identify how to disseminate information to as wide a community as possible in a user-friendly manner.

Groupboard allows synchronous interactive communication through drawing/chat Java applets between peers and facilitators. The embedded RSS feed enables readers/students who want to subscribe to timely updates from favorite websites or to aggregate feeds from many sites into one place.

Process 1: Knowledge Identification, KI

We conducted a questionnaire to identify significant knowledge and needs to develop the learning modules from the target learners. Subsequently, the core knowledge identified as relevant and familiar to the learners were those relevant to equipping them to promote ecotourism, namely, how to search the Internet effectively, why we need to learn simple business skills, how others set up simple businesses, how to carry out simple steps to address a problem, how to apply these and finally, how to integrate all the knowledge learnt.

We apply the HFE methods to implant practices and principles to optimize how people perform, to build organizational intelligence by improving the way people work in capturing, sharing, and using knowledge. It involves fomenting the ideas and experience of learners to improve the organization's performance in the innovative ways.

According to Polanyi, Arensberg and Pearson (1957), the unwritten tacit knowledge functions as a background to assist in accomplishing the physical task, though the authors is not fully aware of the given physical task. Dewey (1966) further points out that, "When we don't

understand what is learned, we don't have good learning". Sveiby (1997) agreed with Polanyi's emphasis on the importance of tacit knowledge. He highlighted that "because we know more than we can tell, it followed that what has been made articulate and formalized is in some degree under-determined by that of which we know tacitly. When we bring new words or concepts into our existing system of language, both affect each other. So the system itself enriches what the person has brought into it. We adapt new concepts in light of our experiences". Education must therefore, make the acquisition of knowledge strategies possible, where the learner understands the interpretations of the phenomenon of reality and the places where they are built (Santoro & Saporito, 2006).

For this paper we used a module on learning simple business skills as the sample for illustration (see Figure 3)

Process 2: Knowledge Acquisition, KA

Students were expected to integrate the knowledge elaborated in this phase with the core knowledge they identified in Process 1. This aimed at providing students with a holistic picture of the motivation as well as the critical success factors/barriers to becoming successful in business (see Figure 4). In order to help students integrate and consolidate what they have learnt in Knowledge Identification and Knowledge Acquisition, students participated in the Wiki in the Moodle system (see Figure 5).

We have applied the perceptive interfaces to the KM e-learning usability system to enhance the interaction activities quality through more common forms of communication. The Association for Computing Machinery, ACM defines HCI as "a discipline concerned with the design, evaluation and implementation of interactive

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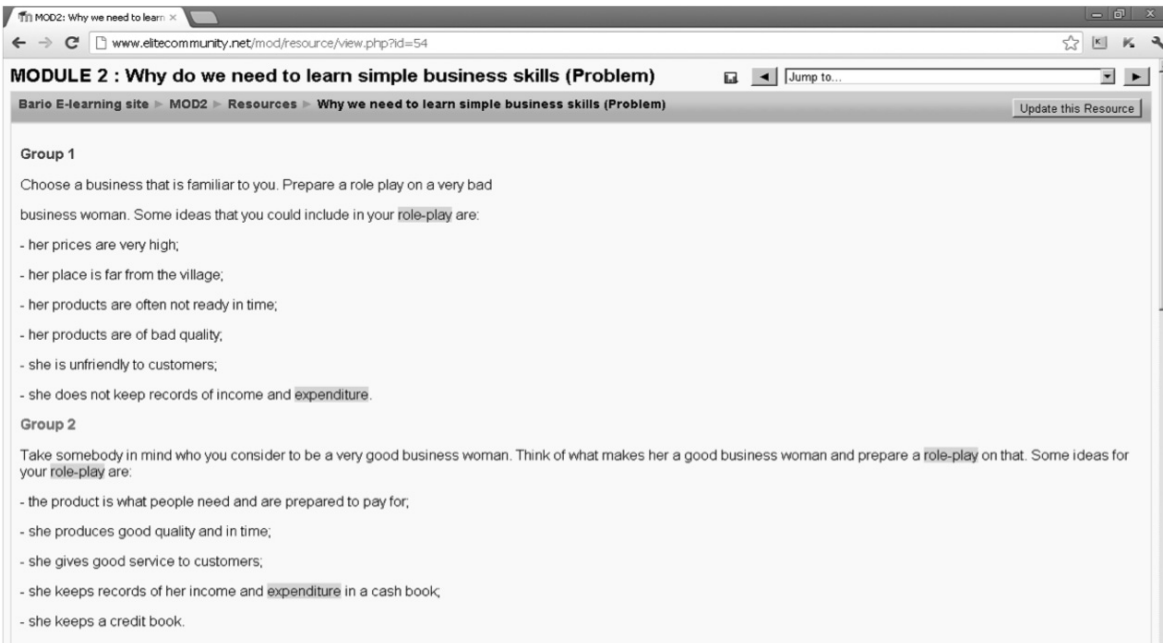


Figure 4. Merrill's First Principles Of Instruction: The activation principle

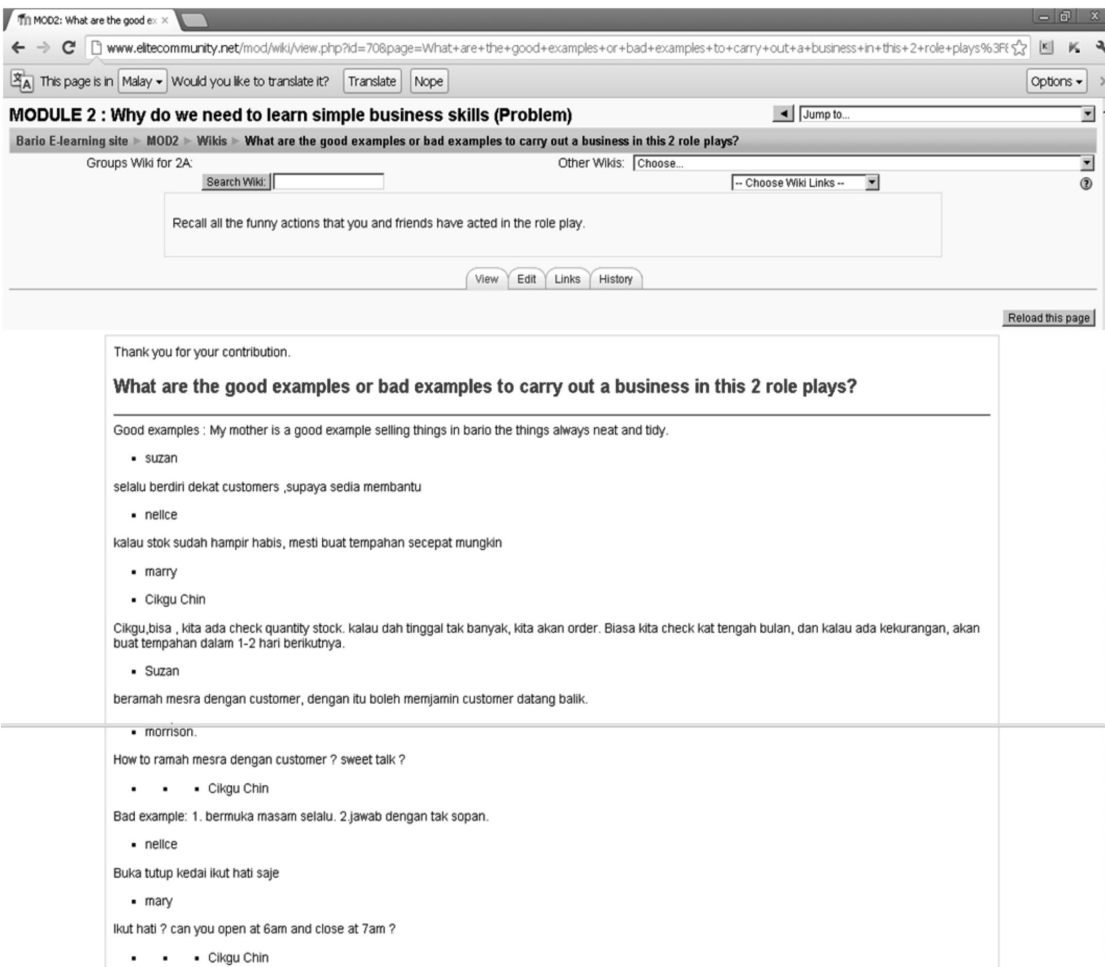


Figure 5. Merrill's First Principles of Instruction: The demonstration principle

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KWL Chart
First, list details in the first two columns before you begin your research. Fill in the last column after completing your research.

Topic : How To Set Up A Simple Business

K What I ALREADY know	W What I WANT to know	L What I have LEARNED
<ul style="list-style-type: none"> I nak buka business jual macam2 kasut Lokasi kat kedai bapa saya Harga mesti sederhana Mesti buat promo 	<ul style="list-style-type: none"> Jenis2 kasut yang saya nak jual Jenis customers dekat kedai bapa Berapa saya nak jual dalam sehari Promo apa untuk menarik customer datang Supplier dari mana ? Perlu register dengan siapa? Berapa untung saya nak? Pekerja berapa orang ? 	<ul style="list-style-type: none"> Mesti ada Nike, adidas, sebab ramai suka sukan Kebanyakan customer bapa saya terdiri drpd golongan suri rumah, mesti mereka akan beli untuk anak2 mereka. And pemuda pemudi jua akan jadi sasaran saya Mesti jual 2-5 pasang sehari baru dapat untung Selain jual kasut mesti jual sarung kaki juga, minyak kilat kasut jua. Mesti buat promosi untuk tarik perhatian orang ramai. Macam buy 1 free 1 sock. Kasih dikaun kasut 10%-20%

Table 4. KWL Table from students of class 2A.

computing systems for human use and study of major phenomena surrounding them (Baecker, Card, Carey, Hewett, Gasen, Perlman, Mantei, and Strong and Verplank, 1992). Thus, one of the critical challenges in building a usable e-learning system is to develop a flexible navigational structure and accessible and active hyperlinks in the e-learning system. To analyze usability of interaction mechanisms of e-learning systems, a number of studies have been carried out using standard assessments such as those elaborated below.

The essence of usability evaluation is the contextualization of theories of information technology, computer and social science research to the challenge of designing tools that are useful and usable to human (Mehlenbacher, Bennett, Bird, Ivey, Lucas, Morton & Whitman, 2005). Interfaces should be designed according to the way students learn with good usability, this is to encourage students interact with e-learning system in a natural and intuitive ways (Costabile et. al., 2005). On the contrary, if e-learning system usability is low, the learner can spend more time to learn the software functionality instead of learning content (Costabile et al., 2005). To overcome this problem, the authors have come out with the preliminary usability criteria guidelines to grasp features in the e-learning systems and also adopted the systematic web

and system usability evaluation (Bottazzini, Fietta, Fonti, Mandelli, & Ponasso, 2003) to evaluate the KM-e-learning usability system.

Process 3: Knowledge Organization, KO

Next, students were encouraged to work collaboratively on the KWL table by sharing what they have learnt in previous sessions and then selecting what they wanted to learn in the current session.

Concept maps, CM were used to enable the students to establish the connection between the concepts in ICT and business management skills to enable knowledge retention and enhance better problem solving skills (see Figure 6 and 7). These two tools were chosen for our project after we have done our comprehensive literature reviews from below.

Fountas and Pinnell (2001) pointed out that students can retain information longer if the learning content is illustrated with diagrams. From the initial findings in the project, it was found that many of the Class 2A and 2B students are visual-learners. Thus, a visual approach such as organizer, to organize or brainstorm for information was strongly recommended. Organizers illustrated knowledge in a meaningful way can bring clarity to ideas for learner

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Figure 6. Merrill's First Principles of Instruction: The application principle

knowledge retention. Two examples of graphic organizers used in this paper are the KWL table and CM. A KWL table /KWL chart is a graphic instructional reading organizer focus in planning a learning session and defining the learning strategy. According to Terrance (2008), who has explored the extent to which the modelled reciprocal teaching strategies of predicting, questioning, clarifying, and summarizing are specifically taught and tutored within the lessons and provide opportunities for students to generate their questions freely. The author has revealed positive feedbacks were collected from the question generation from the reader side as they raise more questions when they read the text; hence, helping them to assess their level of comprehension, and achieving independence as readers.

On the other hand, a quantitative research done by Tseng, Chang, Lou, Tan, & Chiu (2012) has investigated students' perception of concept maps as a learning tool where

knowledge transfer was the goal to provide valuable reference work for science education. The result of the study showed that positive perception with better learning attitudes could increase students' willingness to use CM and to get students to be more satisfied with their learning and thereby make the KT process more effective. It was also hoped that the KWL table and CM would help set expectations and provided an effective tool for students to relate the knowledge gained in one part with the knowledge gained in the earlier phase (see Table 4).

Process 4: Knowledge Dissemination, KD

The KM-e-learning usability system is equipped with six modules. Every module is equipped with a forum, wiki, and some small assignments. Throughout the participation in the modules, learners can interact with other class members, brainstorm each other in the same class or inter class by posting questions in the forum by using their common language/dialect.

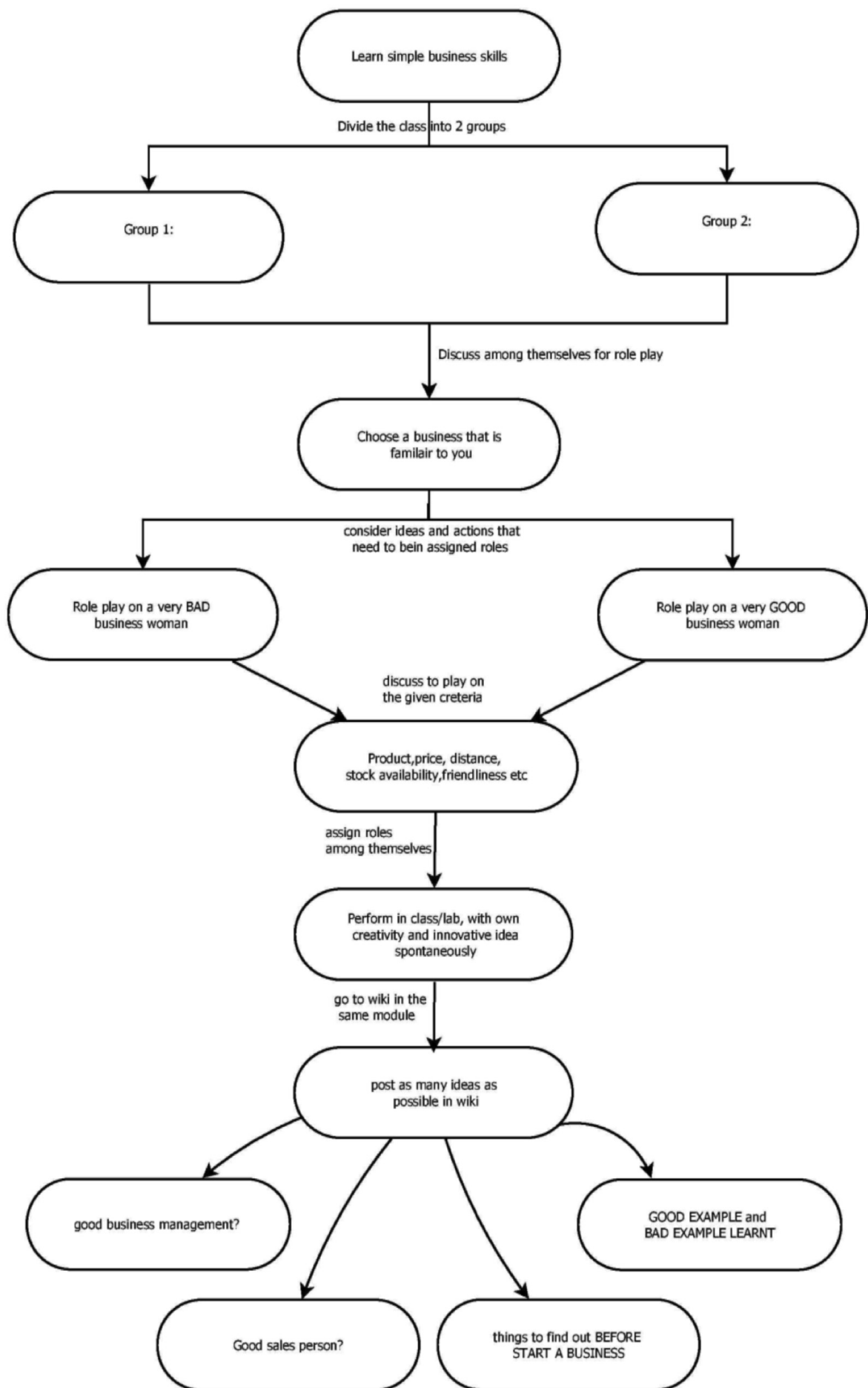


Figure 7. A sample concept map illustrating how students organized their knowledge and associated their ideas on ICT and business management

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Figure 8. Merrill's First Principles of Instruction: The integration principle

Students' learning was reinforced through the active presence of visual elements, which helped students to understand and retain more functional contents and retain these more effectively (Higgins, Beauchamp and Miller, 2007). In this study, visual representation of concepts and emphatic exercises through Interactive Whiteboards (IWBs) contributed to better cognitive development and better attitudes.

The researcher, Cannata (2009) found that students do not automatically learn chunks of information, or acquire competences and skills in a mechanical way. Hence, he proposed a new pedagogical approach based on "Connective intelligence", which combined pedagogy with empathic skills to form the appropriate psychological framework for a positive response in the language classroom through the use of Interactive Whiteboards

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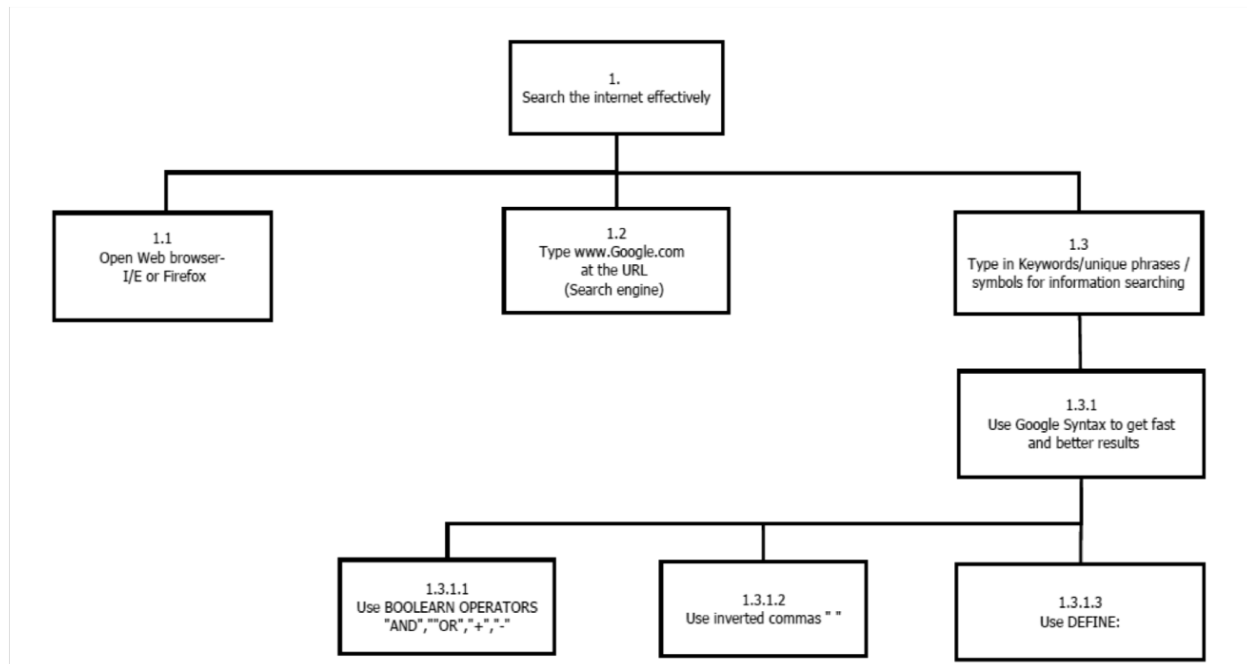


Figure 9. Design of concept map based on HTA

(IWBs). His findings indicated that Interactive whiteboards (IWBs) offered easy and practical ways for visual knowledge management and connection in language learning.

These findings illustrated that well-designed IWB activities could result in a more productive and collaborative learning environment, with better human engagement and mutual confidence. More importantly, one of the main reasons contributing to students' learning progress and to fostering connective intelligence in a shorter time and more effectively was that teachers were prompted to exploit existing resources by combining serious intentions with fun in newer ways.

Process 5: Knowledge Adaptation, K Ad

To create a sustainable system, the authors have evaluated the usability of the e-learning content and system (see Table 8, 9, 10). The usability factor is crucially important to create an effective e-learning system with comprehensive and advanced functions, however still able to preserve an easy and flexible interaction that go aligned with learners' needs and to maintain learners' savour (Triacca, Bolchini, Botturi & Inversini, 2004; Ardito, De Marsico, Lanzillotti, Levaldi, Roselli, Rossano, & Tersigni, 2004). The usability evaluation is the critical aspect to maintain the quality assessment in any e-learning system (Botturi, Cantoni, Inversini, & Succi, 2007).

Figure 8 shows an example of students' discussion in the Wiki where knowledge from prior processes 1, 2, 3 and 4

were integrated and adapted to achieve the learning goal for each Module. The discussions in the Wiki were supported by KWL and concept maps. For knowledge identification, students have identified the significant steps needed to register their business license for setting up a business at the outset. In terms of knowledge acquisition, the students have suggested applying the 4Ps' learned to capture as much information as possible to avoid making rush decision. After the students have captured the main ideas, next, they were going into details. For knowledge organization, they have listed out things needed for business operation, the making of business chop, name cards, business letterhead etc. As for business products, they have to find and filter the products needed and search for suppliers. To disseminate information /knowledge, students were discuss about the business development plan to promote their business.

Educational Context and Sample

The whole pilot system was carried out in from year 2009 to 2012. There is only one secondary school with no upper secondary classes (Form 4 and 5).The participants were chosen because we do not want to disturb Form 3 students who will be sitting for their Lower Secondary Assessment (PMR, a Malaysian public examination). The Form 2A and 2B students from SMK Bario, Sarawak were chosen for our studies. Our focus was to evaluate the potential effectiveness of these technologies for teaching and interacting with the learners. To achieve this, data was collected based on their personal and group ICT experiences.

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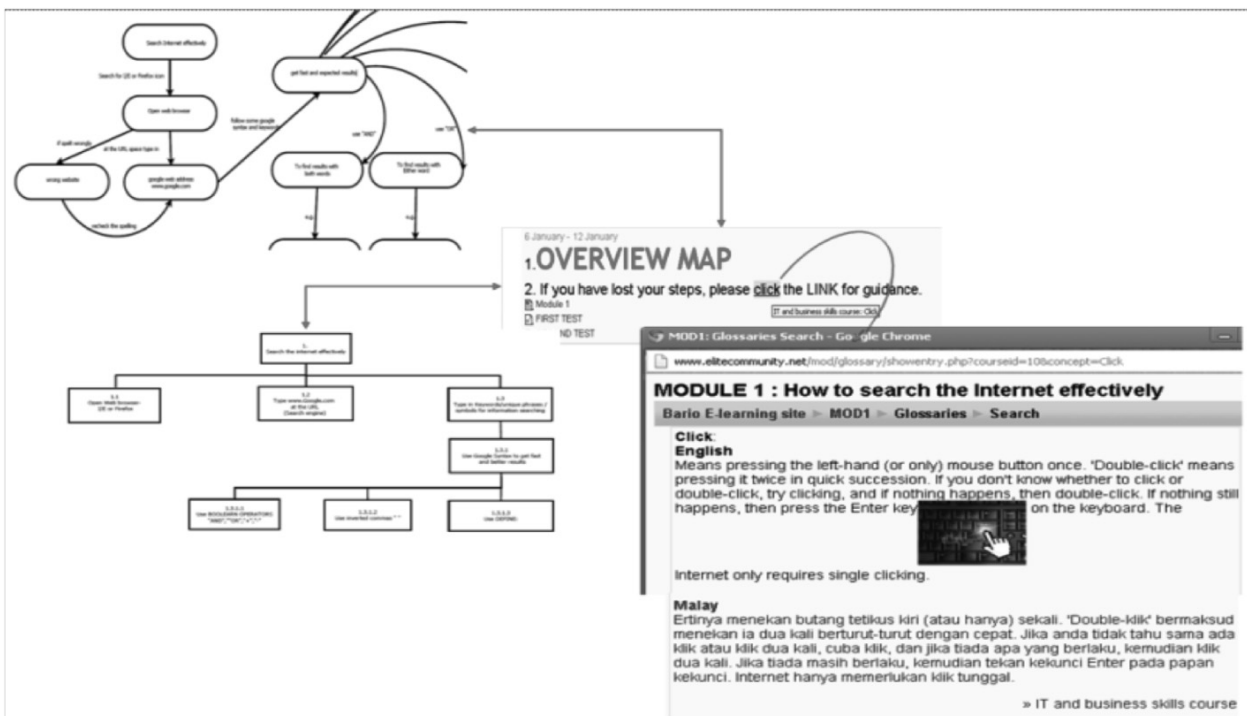


Figure 10. Sample concept map and HTA overview

System design and development

The system was developed using Moodle, an open source Learning Management System to teach basic Internet search skills and how to develop an online business website.

To help students navigate, we provided a concept map designed based on hierarchical task analysis (HTA) as shown in Figure 9 and Figure 10. HTA is used to create overall views in every single module, to allow the users to refer back to these concepts, to monitor their own progress, and remember the key points quickly.

Furthermore, we provided graphical objects in the Learning Management System, (LMS)'s notice board to direct the students to navigate the learning materials in a user-friendly manner and to create a self-regulated learning environment. This was to encourage students to organize their knowledge in a taxonomy relevant and acceptable to the local communities. For better understanding of the learning context, we also provided customized dual language terminology/definition facility.

In addition, through Web conferencing, the users would be able to communicate and share ideas both in oral and visual communication. Moreover, drawing on the whiteboard in Groupboard and inserting files were some extra features that the users could use to increase their

level of comprehension. In addition, they could make use of the RSS reader to collect the latest news for a specific scope of information. In this way, the target community could widen their horizon with better resources and information. To scaffold multidimensional thinking, role play was designed (see Figure 11), supported by collaborative learning technologies such as forum, wikis, Groupboard and RSS feed. Some of the Web design best practices (e.g. page layout, navigation and etc.) were adopted as part of our knowledge base in the creation of wikis.

A variety of activities were provided throughout the study. These were situated within *role play* (Figure 10), the challenge of *Online search education, discussions in Groupboard, forum* and creation in *wikis* and assessed via *multiple choice quizzes*. Each collaborative technology was carefully selected to help learners improve their learning performance in future e-learning course/projects/future working life. Collaborative technologies such as Groupboard web conferencing, forums and wikis were used to engage students and to guide them to develop their own understanding and to become critical thinkers and problem solvers. We responded spontaneously as discussion of the topic progressed while students gathered ideas from individual and collective activity and quickly changed focus and goals as the situation requires.

Innovative Hint-Scaffolded KM E-learning Framework To Increase Meaningful Learning And Multi-Dimensional Thinking

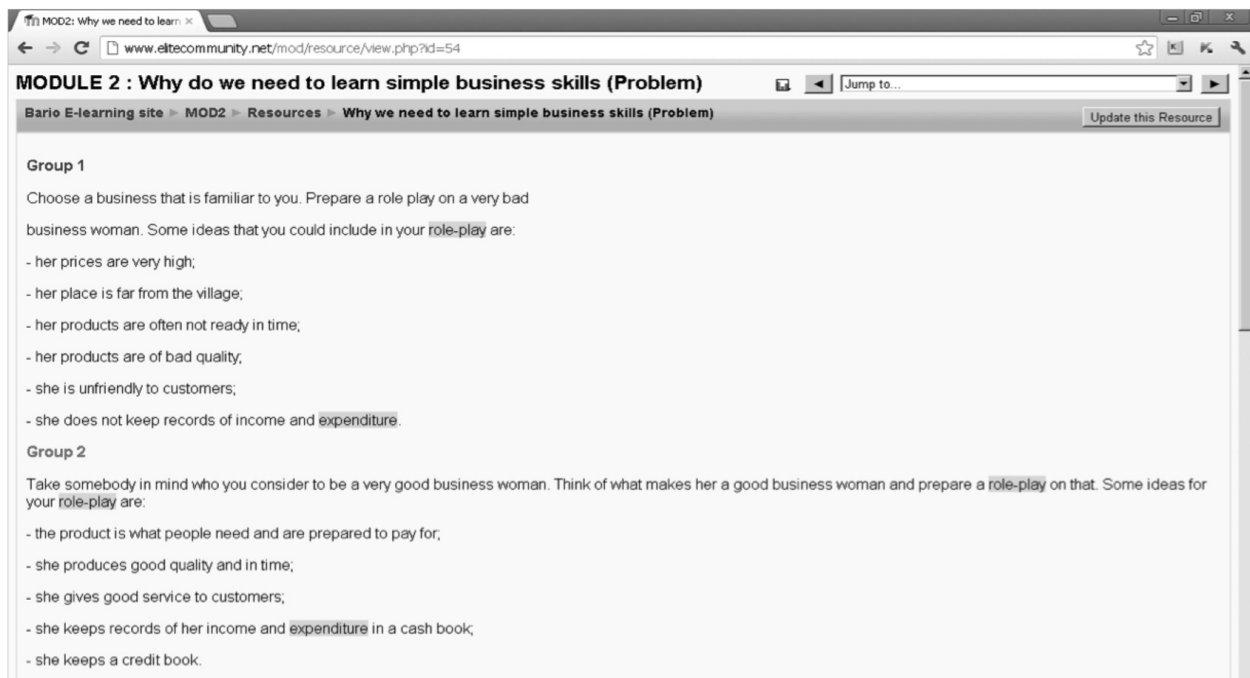


Figure 11. Knowledge based: Sample role play activity

Methods and processes

A summary of each collaborative technology and the level of learning which occurred in each (based on Bloom's taxonomy) is provided in Table 5.

The KM-e-learning System Requirements and Specifications

System requirement is an important aspect of building an information system by identifying and validating users' needs in the e-learning system. System requirement is an iterative process by which the needs and requirements of individuals and groups significant to the system development are researched and refined in the problem domain. Six areas will be used to identify the objects or concepts in the system requirement. The UML Language will be used for the modelling notations to represent the static structure and dynamic behaviour of the system.

- Identified system requirements
- The KM-e-learning system architecture components
- The KM-e-learning system functions
- Stake holders and their privileges in using KM-e-learning system (Use case diagram).
- The KM-e-learning system architecture

Identified system requirements

From the proposed framework in Knowledge Acquisition, the aim of the pre-questionnaire was to study the level of e-readiness for e-learning project and to find, identify and

verify problems faced by this secondary school.

The findings show that there is a positive movement towards the use of ICT in e-learning in the following areas:

- The SMK Bario is equipped with basic requirements including a school computer laboratory, computers, a school library; electricity.
- The school also equipped with the internet access.
- The root cause have been identified from information gathered from the people directly involve
- The overall understandings of the problems have been identified before development begins

With findings from the KA, the authors have found the following issues to be the most needed by the majority e-learning stakeholders.

- The need to have more self-learning materials especially in ICT subjects.
- The needs to have some briefing/elaborations as most of the learners are auditory learners.

The process of identifying requirements for KM-e-learning system is essential to gather primary source of data for the system development.

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Collaborative learning technology	Bloom's Taxonomy	Supporting data
Forum Encouraged students to share their knowledge and skills by answering specific questions or contributing to a topic which needs them to adapt to a novel situation.	(a) Knowledge/ Remembering (b) Comprehension/ Understanding (c) Application (d) Synthesis	a) Learners remember what have been taught (4PS), were able to identify the major problems in the assignments as well as how to solve these problems— (a, b). They shared in the forum to solve the given problems: "what is good business management?"— (c, d). b) Learners were able to understand and determine which keywords to use for Web searches to gather more information on the forum topic (b, c, d).
Groupboard Enabled students to engage in communicating and sharing ideas both through oral and visual (drawings) communication.	(a) Knowledge/ Remembering (b) Comprehension/ Understanding (c) Application (d) Creation (e) Evaluation (f) Synthesis	c) The learners were engaged in communicating and sharing ideas about the best options for their business building website. They showed priority in promoting both products and the holiday package at their e-business website. —(a, b, c, d, e, f)
Wikis In groups, students were given a content-specific activity for discussion online in their convenient language and were encouraged to read, comment and suggest alternatives to help each other. The students were involved in several learning processes: discussion, explanation, justification, sharing of information and resources, analysis and problem-solving. Then, they created wiki content, which could be utilized by their peers for learning and reference.	(a) Knowledge/ Remembering (b) Comprehension/ Understanding (c) Application (d) Creation (e) Evaluation (f) Synthesis	d) Learners provided and shared knowledge for Web design Best Practices Checklist with recommendation and suggestions. — —(a, b, c, d, e, f) e) "Wiki is easy for us, we can share our ideas, knowledge, we can add in or delete at any time, that's all" (quoted feedback from learner)—(c, d)
Glossary and popup Glossary In both English Language and Bahasa Malaysia. They provided brief definitions of key terms and concepts to the targeted learners in the context of this KM e-learning system. It is intended to clarify terms and phrases. (see figure 14)	Knowledge/ Remembering Comprehension/ Understanding Application Evaluation Synthesis	f) The glossary streamlined the learners' search process for word/phrase definitions. Learners were able to automatically create links with similar word or phrase to these entries from throughout the course without opening a new browser/tab for Google search. g) The followings are some of the learners' comments on how Glossary feature has encouraged and helped them: Learner A: We were encouraged to use any language in the forum in Module 3, and because of this, it makes me feels easy to give my ideas in the forum." Learner B: "The Glossary us just like dictionary. It has made my work easier without searching in Google." Learner C: "With the Glossary available, it is much easier, because some words have links, so when my member wanted to make a reference, he/she just has to click and will be able to obtain the similar answer."
RSS Reader	Application	h) Learners referred to the subscribed feeds for new updates in their assignments and website building.

Table 5. Learning effectiveness based on Bloom's taxonomy

The KM-e-learning system architecture components

The KM-e-learning system architecture is based on the main four components: User Components, Learning Component, Assessment Activities and Communication Environment. Figure 12 shows KM-e-learning system architecture components.

- User Components : Involved the users with assigned roles to participate in the system.
- Learning Components : Involved all areas used in delivering the modules.
- Assessment Activities : Dealt with the assessing learners understanding towards the given learning materials.
- Communication Environment : Involved collaborations among users in the system.

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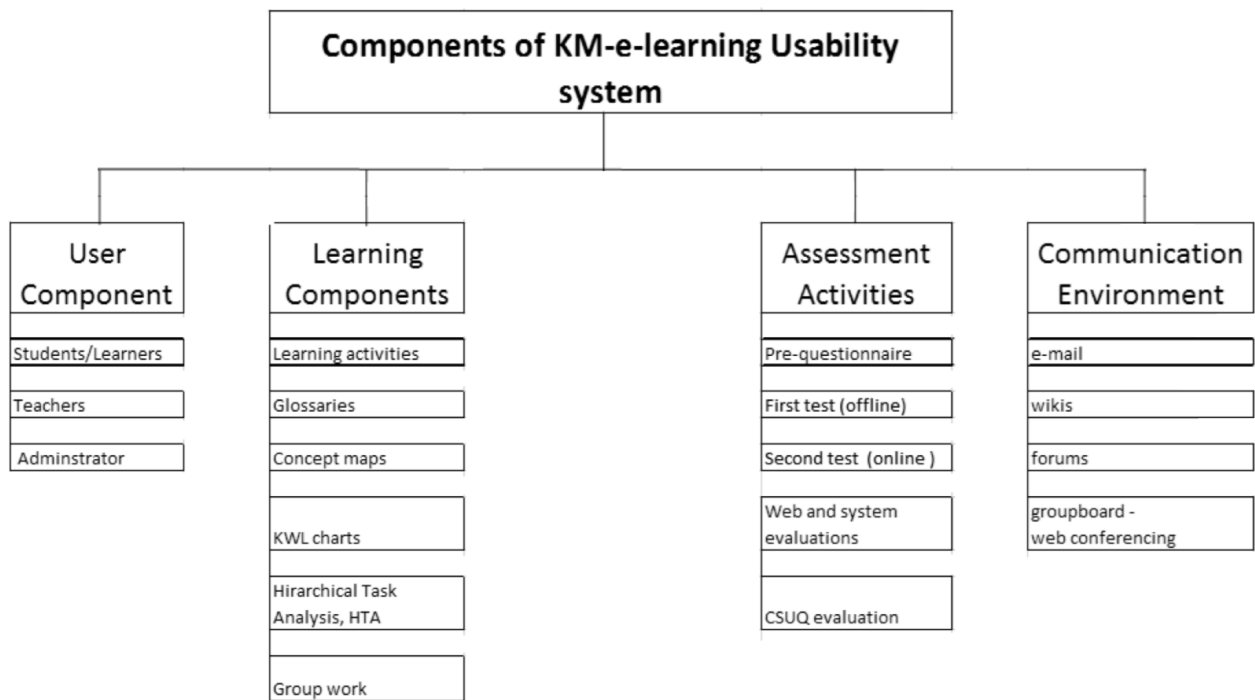


Figure 12. KM-e-learning system architecture components

Fn no.	Function Description	Status
F1	Record individual particulars (e.g. password, name, gender, group, e-mail address) to the system.	Evident
F2	Check the entered particulars and password of a user connected to the system in order to use the system and allow the registered user to login/out to the system.	Evident
F3	Display description and learning components of the selected course for the registered person.	Evident
F4	Display a list of several learning components on the selected Course offering (For example, lesson list, questionnaire, homework sheet).	Evident
F5	Display the assessment of the outcome of students' interaction with learning activities (e.g. assessment of students' group work)	Evident
F6	Handle the feedback between teachers and students by transferring messages for several learning activities.	Evident
F7	Record the detailed information of a registered user to a subject to the system.	Hidden
F8	According to the outcome of student's learning activity on a course taken, update the conditions of sequencing.	Hidden
F9	According to the sequencing conditions, sequence learning component such as lessons and quizzes.	Hidden
F10	Handle communication environments such as e-mail, groupboard-web conferencing, chat or navigating out to another web site.	Hidden
F11	Track user access to/from the system	Hidden

Table 6. The KM-e-learning system functions

The KM-e-learning system functions

The KM-e-learning system has been created to manage the learning activities in the learning components and perform a list of specific capabilities functions. Two categories of system's function, Evident function and Hidden function were used to categorize specific functions in this e-learning system (Yang & Liu, 2007). Evident functions performed by the system and user can justify the function accomplishment while Hidden functions performed and accomplished by the system. Table 6 shows the functions for the KM-e-learning system.

The authors identified respectively the other individualized functions. These individualized functions are given in Table 7 to Table 8.

Fn no.	Function Description	Status
F12	Registered a student for a course, and display registration information of the students for the course if a student was registered to the course.	Evident
F13	Update learning profile of the student on the lesson activity after a student took a lesson.	Hidden
F14	Handle group works with the other students, using communication environments such as email, groupboard-web conferencing, or chat provided.	Evident
F15	Display learning profile of a student.	Evident

Table 7. The KM-e-learning system functions-for students

Innovative Hint-Scaffolded KM E-learning Framework To Increase Meaningful Learning And Multi-Dimensional Thinking

Fn no.	Function Description	Status
F16	Assess students' solutions for a test or homework.	Evident
F17	Update the outcomes of learning activities of students who are taking a course offering currently.	Evident
F18	Handle course database, submitting content description of new lesson to database server according to scheduling.	Evident
F19	Handle course database, submitting description of new learning components such as examination and homework to database server according to scheduling	Evident
F20	Add new course to or delete a course from course database.	Evident

Table 8. The KM-e-learning system functions-for teachers

E-learning usability properties	System architecture components			
	User Component	Learning Components	Assessment Activities	Communication Environment
-Attractiveness, -Attitude & Satisfactory	F1,F12	F13		F15
-Efficiency -Flexibility -Memorability	F2	F4,F8	F3,F4,F5,F9	F6,F8,F10
-Understandability	F3,F2	F3	F3,F5,F17	F6,F10,F14
-Operability -Reliability	F1,F2	F8,F9,F18, F19,F20	F5,F16, F19,F20	F7,F10, F11
-Effectiveness -Learnability	F2	F12,F13,F18, F19, F20	F3,F5,F16, F17,F19, F20	F6,F7,F14,F15

Table 9. Mapping system architecture components with the e-learning usability properties

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		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
DV_Before	Equal variances assumed	7.677	.009	3.732	34	.001	1.600	.429	.729	2.471
	Equal variances not assumed			3.551	24.096	.002	1.600	.451	.670	2.530
DV_After	Equal variances assumed	1.413	.243	1.526	34	.136	.650	.426	-.215	1.515
	Equal variances not assumed			1.484	27.896	.149	.650	.438	-.247	1.547

Figure 13. Use case Diagram for all user roles

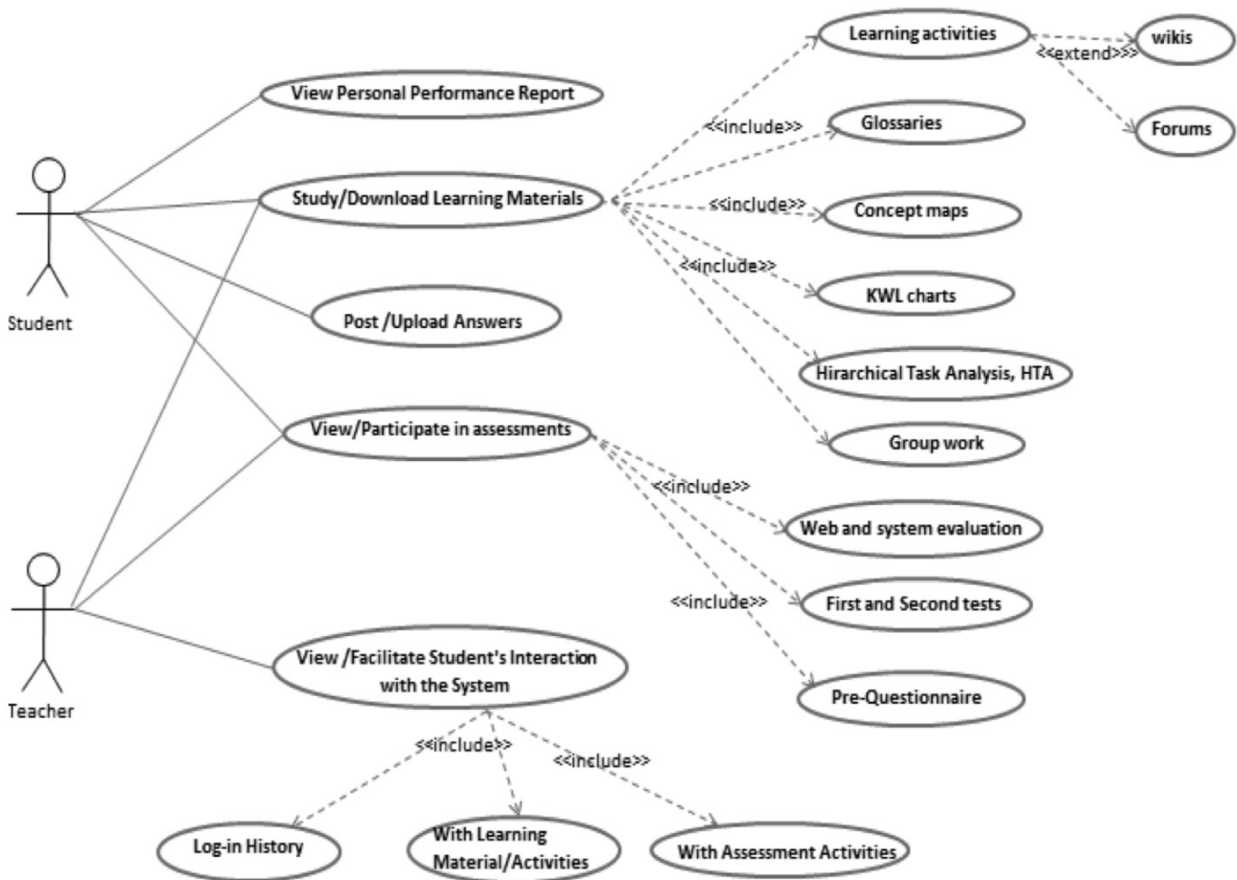


Figure 14. Use case diagram for student and teacher role

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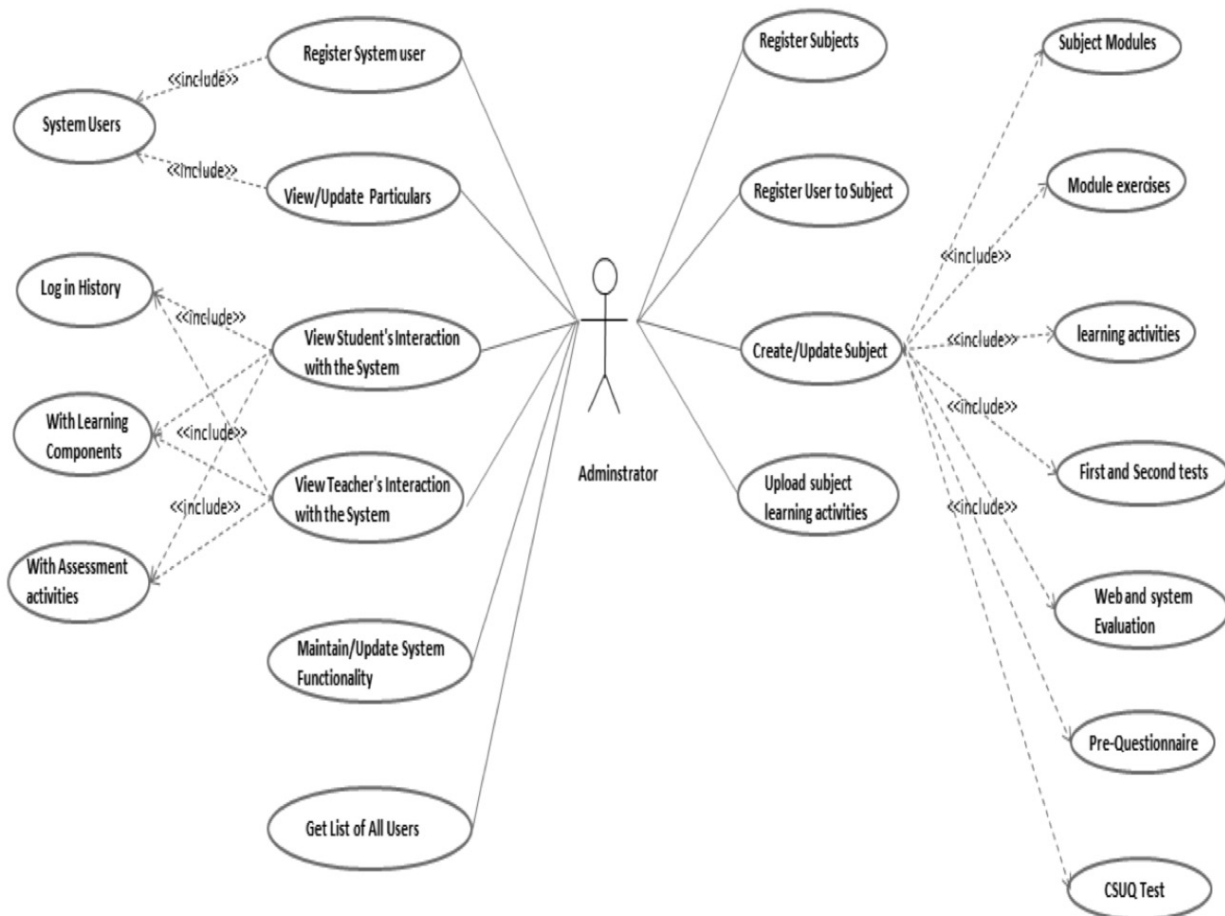


Figure 15. Use case diagram Administrator role

Mapping system architecture components with the e-learning usability properties (Table 7).

In the process to fine tune for system requirements, it is essential to identify the significant of software quality factors. This is to ensure these factors are incorporated in the system development. The authors have mapped the system requirements with the e-learning usability properties (see Table 9) to identify the significant impact in the system

Role and permission of stakeholders in using KM-e-learning system

KM-e-learning system is a system based on roles and permissions. Every user is associated with a specific role. In each role, use case model is shown to summarize the external interactions between use cases and actors. Every user would be able to perform the functions for Log in/out of the system, Change password, View self-login report, Send emails to other users and Interact with the system. Figure 13 shows the overall view in use case diagram.

Students/Learners

In the Figure 14, a registered student/learner can perform the specific functions as shown in the use case diagram.

Teacher/Facilitator

A teacher can perform the following specific functions in the system as listed in use case diagram in Figure 14.

Administrator

System administrator is the overall in-charge of the KM-e-learning system. This person in charge of monitoring the KM-e-learning system database and manages system resources and assigns privileges to users. The list of functions being carried out listed in the Figure 15 in use case diagram:

Entity Relationship Diagram, ERD for KM-e-learning system Below is the entity relationship diagram, ERD used to represent the overall different entities in this KM-e-learning system in Figure 16.

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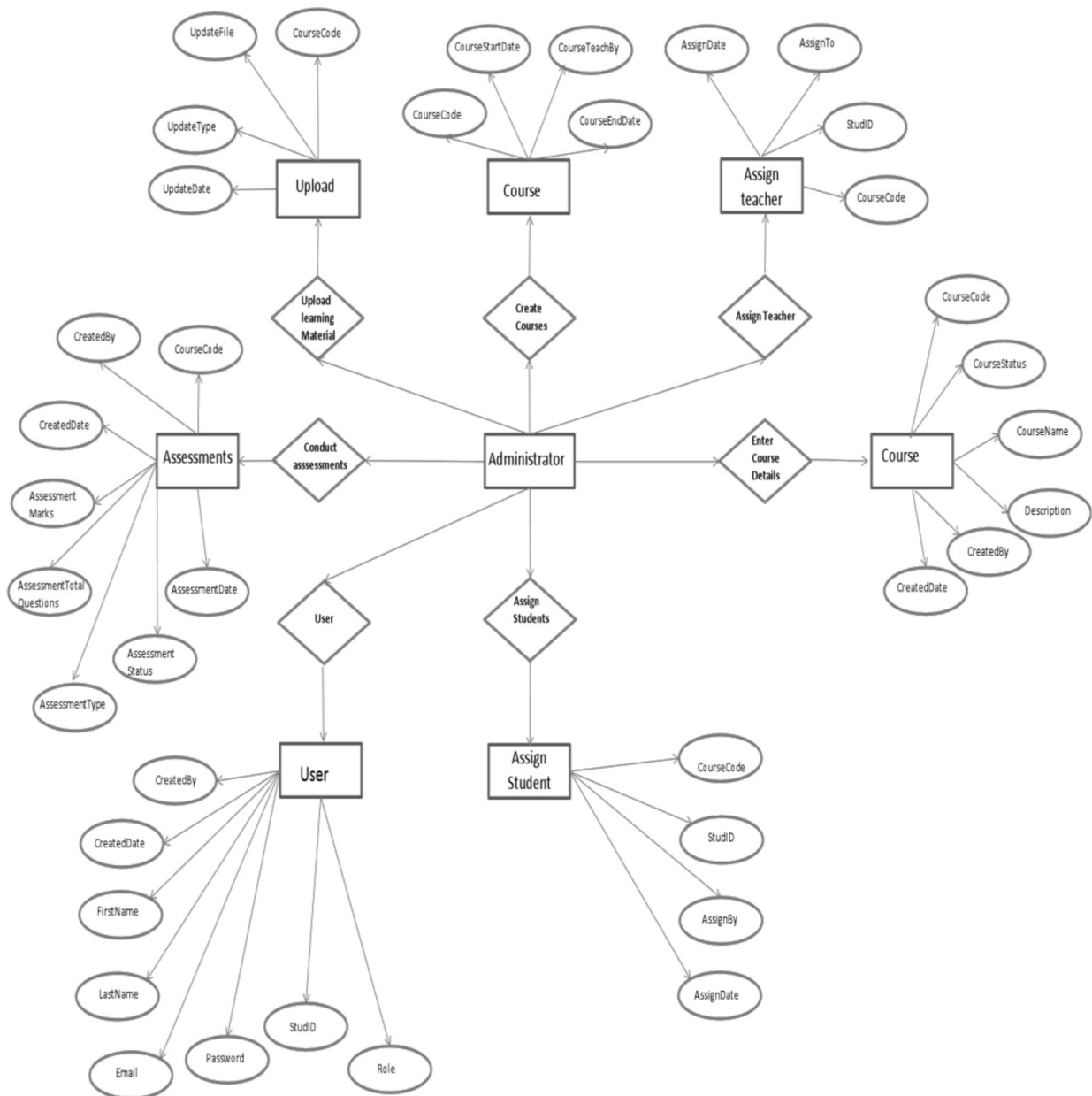


Figure 16. ERD for KM-e-learning system

The KM-e-learning system architecture

The KM-e-learning system is a client- server; Web based system with the three-tier architecture. The system consists of three major components:

Client tier – the front end layer provides the user interface for users to access data from the server (Web interface accessible via standard Web browsers e.g. Google chrome, Firefox, I/E).

Apache application server controls the communication (basic system functionalities). This tier receives and

process data request from the client, retrieve and responds information to and from database. This Apache web server runs in Window platform with PHP scripting language connect to the database.

MySQL database server stores information and data links to the learning content repository. The database server maintains the data needed for the Web application. It is a back-end layer which maintain data constrains and integrity and the restriction of unauthorized access.

The Application server, database server and learning

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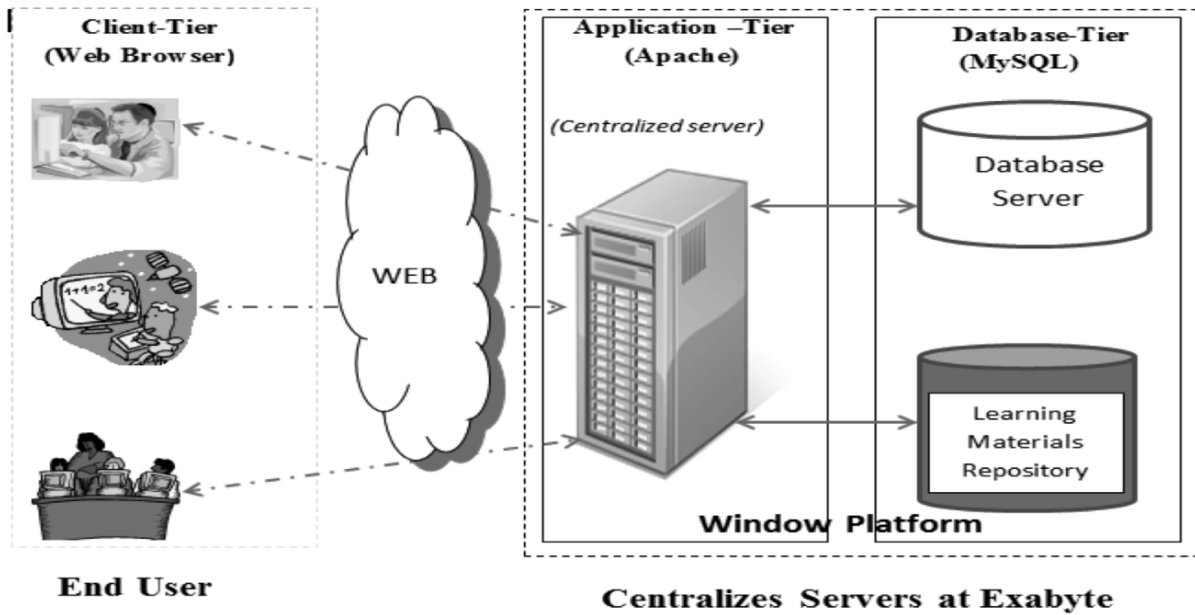


Figure 17. the KM-e-learning System Architecture

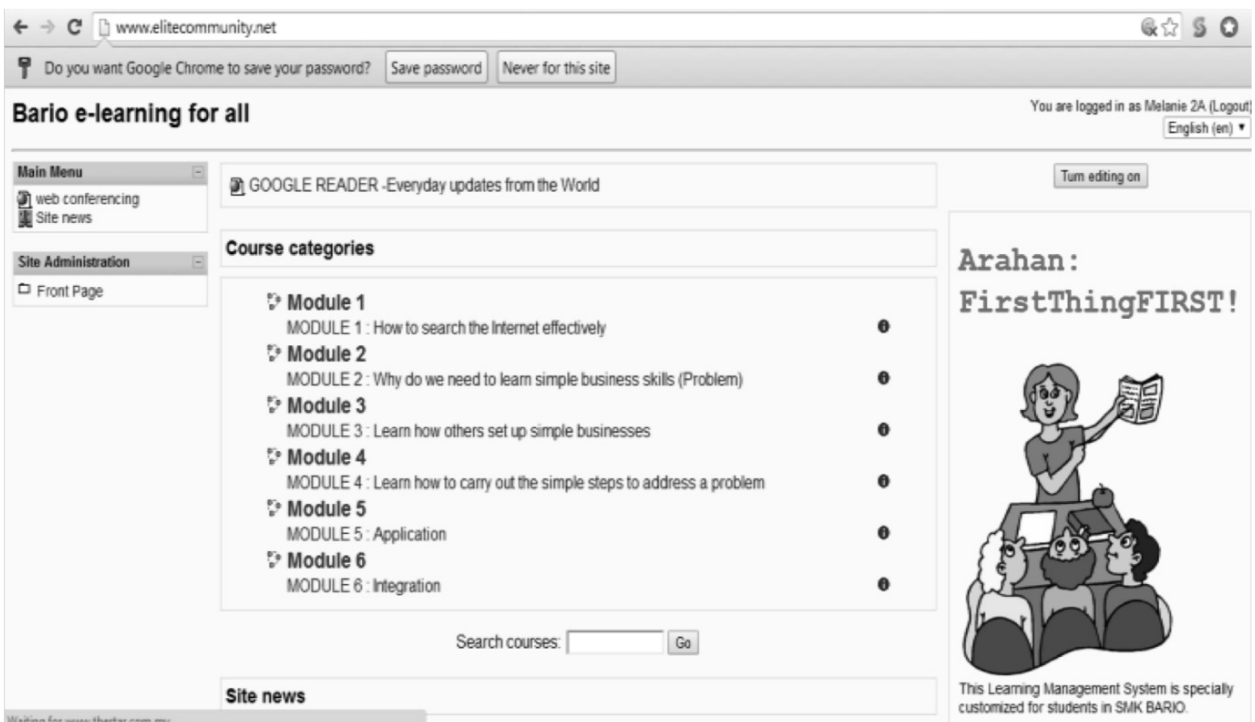


Figure 18. Student's login page

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	Class 2A	Class 2B
Paper-based	3.25	1.65
Blended learning	3.75	3.10

Table 10. Overall mean results compiled from two tests generated by using SPSS

material repository can be centrally placed at the Exabyte web hosting provider. The three components can be networked to facilitate communication among these three components. Figure 17 illustrated the architecture as following:

Demonstration

A user can log in to KM-e-learning system on login page (see Figure 18). User can view their document by folder or search the module by type in key word. They can participate in the learning activities by following the HTA or concept maps for interaction activities.

Methodology

The research aimed to evaluate the effectiveness of the KM-e-learning system's educational intervention. Hence, the authors used the quasi-experiment similar to Panko's (2007) study, with a pre-post-test and a delayed post-test. The authors compared two types of treatments, that is, paper-based vs. blended learning in the first study and blended learning (hints vs. non- hints-based scaffolding).

In order to produce the customized *learning materials*, the authors identified the students' profiles. The authors conducted a pre-test aimed at assessing their Internet skill level and to investigate their level of Internet search engine skills. The group of 38 learners (aged 14-15 years old) was heterogeneous and was pre-assigned to different classes according to their academic results in school. Class Form 2A had better school results than Class 2B.

In the first test, that is, paper-based vs. blended learning, the instructor taught the six modules in the class and then the students used the e-learning system to brainstorm and discuss. The second test compared between Web hint-based and non-hint-based learning, whereby the instructor became the facilitator by providing minimal hints to the students as and when required. The facilitator provided hints by monitoring the students' work progress. As students showed the ability to move up to the next level in Bloom's taxonomy, the facilitator faded out hints gradually. These two tests were conducted for both Group

2A and 2B students in their classrooms and computer laboratory respectively. The tests were developed based on reviewed literature from Kanninen (2009); Educause (2003) and Kapp (2005). Post-tests were conducted at the end of the e-Learning programme. Questions were similar to those of the pre-test.

The analysis tool was the Statistical Package for the Social Sciences; SPSS version 18.0. The authors used Independent sample t-test to compare Group 2A and 2B's performance on their ICT skills. For the first test, the authors expected Group 2A would achieve more through blended learning. For the second test, the two groups of students were expected to be able to use the e-learning system with minimal help. In order to measure learning effectiveness, the authors deployed Bloom's taxonomy, which has six developmental levels pertaining to the acquisition of knowledge and of intellectual analysis and skills: knowledge, comprehension, application, analysis, synthesis, and evaluation.

Data presentation, analysis and discussion

In the following subsections, the authors present the findings and discussion.

In order to find out the students' ICT skill level by conducting a pre-test to measure the effectiveness of Cognitive-engineering-derived KM approach to blended learning. This pre-test was based on the customized *instructional design of learning activities, especially role-playing and design of learning content*. For paper-based learning, Group 2A's mean was almost twice that of Group 2B. These results suggest that class 2A had better basic Internet search skills than Group 2B. Furthermore, there was a significant difference in the scores for Group A ($M=3.25, SD=1.57$) and Group B ($M=1.65, SD=0.99$) conditions; $t(24.1)=3.55, p =0.002$."

After some basic tutorials were conducted and blended with some online practical exercise, the authors found that for *blended learning* (Tables 10 and 11), the mean value increased from 3.25 to 3.75 for Class 2A and for class 2B, the mean value increased from 1.65 to 3.10. The number of questions answered correctly for Class 2A was 43, much higher than Class 2B's 22 (see Table 12).

	Class	N	Mean	Std. Deviation	Std. Error Mean
Paper-based	2A	16	3.25	1.571	.393
	2B	20	1.65	.988	.221
Blended learning	2A	16	3.75	1.438	.359
	2B	20	3.10	1.119	.250

Table 11. Learning performance before and after introducing the e-learning system

Innovative Hint-Scaffolded KM E-learning Framework To Increase Meaningful Learning And Multi-Dimensional Thinking

Paper-based vs. Blended learning	
Class 2A (16 students)	Class 2B (20 students)
43	22

Table 12. Number of questions answered correctly (paper vs. blended learning)

	Class 2A	Class 2B
Hint-based	3.16	3.73
Non -hint-based	3.72	3.28

Table 14. Mean results (hints vs. non-hints)

	Levene's Test for Equality of Variances	t-test for Equality of Means								
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
DV_Before	Equal variances assumed	7.677	.009	3.732	34	.001	1.600	.429	.729	2.471
	Equal variances not assumed			3.551	24.096	.002	1.600	.451	.670	2.530
DV_After	Equal variances assumed	1.413	.243	1.526	34	.136	.650	.426	-.215	1.515
	Equal variances not assumed			1.484	27.896	.149	.650	.438	-.247	1.547

Table 13. Independent sample t-test: to show students' ICT skills performance

From the independent sample t-test, The authors found that there was a significant difference in the pre-test scores for group A (M=3.25, SD=1.57) and group B (M=1.65, SD=0.99) conditions; $t(24.1)=3.55$, $p = 0.002$. However, in the post-test, there was no significant difference between group A and group B; $t(34)=1.53$, $p = 0.136$ (see Table 13). This indicated that blended learning narrowed the gap between the two groups. This is a positive indication because during the *face-to face sessions*, students were given pre-defined options *a, b, c* and *d* to choose the best answers from. In the blended session, students could Google search from the Web. This increased the number of options to choose the best answers from if they did not know the questions' keywords and how to refine the scope while searching on the Internet. The increased number of options added cognitive load. Hence, the post-test was actually more difficult than the pre-test. However, the mean for class 2B (students who performed weaker in the pre-test) increased by 0.5.

The effectiveness of blended learning with and without hints

The authors wanted to find out the effect of *designing hint-based teaching-learning strategies to scaffold learning*. After six months, the authors conducted blended

learning, with and without hints for the same group of students. This time, the authors introduced the KM-e-learning system to the groups. In order to gather both qualitative and quantitative data on improvements in their IT skills, the tests consisted of both objective and subjective questions. The main concern here was to help the students to reflect on what they had learnt in the last six months.

From Table 14 and Table 15, the mean score for Class 2A without hints was 3.72 (SD=1.59) and for Class 2B was 3.28 (SD=1.57) conditions; $t(34) = 0.84$, $p = 0.41$. Class 2A performed better than Class 2B for blended learning without hints by a difference of 0.44. Class 2B had one extra hour compared to Class 2A due to logistics and the school's internal scheduling. Hence, The authors were pleasantly surprised that Class 2A's performance was commendable and that there was not much difference in terms of the number of questions answered correctly (see Table 16) and that there was no significant difference compared with Class 2B (see Table 17).

Innovative Hint-Scaffolded KM E-learning Framework To Increase Meaningful Learning And Multi-Dimensional Thinking

	class	N	Mean	Std. Deviation	Std. Error Mean
Hint-based (Before)	1	16	3.16	1.5992	.3998
	2	20	3.73	1.5259	.3412
Non-hint-based (after)	1	16	3.72	1.5913	.3978
	2	20	3.28	1.5684	.3507

Table 15. Mean comparison for blended learning (hint-based vs. non-hint-based)

Non-Hint-based vs. hint-based	
Class 2A (16 students)	Class 2B (20 students)
54	60

Table 16. Number of questions answered correctly (non-hints vs. hints)

	Levene's Test for Equality of Variances	t-test for Equality of Means								
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
OBJ & SUB_1 (Before)	Equal variances assumed	.032	.860	-1.088	34	.284	-.5688	.5228	-1.6312	.4937
	Equal variances not assumed			-1.082	31.581	.287	-.5688	.5256	-1.6399	.5024
OBJ & SUB_2 (after)	Equal variances assumed	.001	.982	.838	34	.408	.4438	.5295	-.6322	1.5197
	Equal variances not assumed			.837	32.078	.409	.4438	.5303	-.6364	1.5239

Table 17. Comparison results by using t-test for students' performance

Class 2A (16 Students)		Bloom's taxonomy	Class 2B (20 Students)	
Paper based vs. blended learning (offline)	Non hint based vs. hint based (online)		Paper based vs. blended learning (offline)	Non hint based vs. hint based (online)
10	14	Knowledge	5	18
-	-	Comprehension	-	-
14	14	Application	4	7
8	13	Analysis	6	18
-		Synthesis	-	-
11	13	Evaluation	7	17
43	54	Total	22	60

Table 18. The number of questions answered correctly by these two classes.

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Instructional Design	Instructional method	Observation
Merrill's First Principles Of Instruction: <i>The task / problem</i>	Role playing	Role playing engaged students to assume greater responsibility over the process of role playing and challenged the learners to think and reflect about significant facts in the learning activities instead of memorizing them. This innovative learning activity linked learning to learners' environment with customized rural settings.
Merrill's First Principles Of Instruction: <i>The activation principle</i>	Role playing	Hints/pointers characterizing each role were given in order to guide learners to think from a product, pricing, place and personal relationships perspective. Learners integrated the knowledge elaborated in this phase with the core knowledge they identified during Knowledge Identification (KI).
Merrill's First Principles Of Instruction: <i>The demonstration principle</i>	Wiki	The learners integrated and consolidated what they have learnt during KI and Knowledge Acquisition (KA). Throughout the Wiki session, students were encouraged to filter and to consider multiple perspectives when posting their views. The instructor provided hints or questioned their assumptions when necessary. Through wikis, the learners obtained constructive feedback from the instructors to be on the right track.
Merrill's First Principles Of Instruction: <i>The application principle</i>	KWL Table Concept Map	Learners organized the knowledge acquired and shared by using KWL table and concept mapping in their discussions.

Table 19. The overall mapping for students' progress and improvement

To measure multidimensional thinking, the authors used Bloom's taxonomy. The results are indicated in Table 18. In terms of quality of answers, the authors provide a detailed breakdown of the types of questions answered correctly based on Bloom's taxonomy. In a comparison between paper-based and hint/non-hint-based learning, Table 13 indicates that class 2A answered almost twice the number of questions correctly for the analysis category. This was a pleasant surprise considering that Class 2A had one hour less (*the school timetable arrangement*) than Class 2B. It was also interesting to note that Class 2B showed improvement in all categories, most notably in terms of the knowledge, analysis and evaluation categories where the number of questions answered correctly was more than twice that when they were learning via the paper-based mode.

From the collected data in Table 18, Class 2A and Class 2B showed great improvement in recalling correct data and information (*knowledge level*). In the blended learning (with and without hints) session, Class 2A and Class 2B were able to use a concept in a new situation and applied (*application level*) what was learned in the classroom into novel situations in the e-learning system

where they integrated ICT skills into setting up an online business. They separated the concepts into categories and post questions to forums and wiki to discuss and analysed (*Analysis level*) the completed issues by breaking down the problems into place, products, price and promotion. After evaluating (*Evaluation level*) they compiled discussions and after acquiring some hints from the facilitator, were able to make judgments by selecting the most effective solution to set up their own online business (see table 19).

The findings from this study indicated that the design factors, that is, KM processes, e-learning Principles and HFE, successfully inculcated multidimensional thinking. The authors' contributions towards the promotion of sustainable online learning are in four aspects: (i) *instructional design of learning activities, especially role-playing* (ii) *design of learning content* (iii) *design of hint-based teaching-learning strategies to scaffold learning* and (iv) *design of technology-enhanced collaborative learning*.

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Conclusion

The findings (Tables 10-19 (notably Table 18)), indicated that our design framework and principles helped both classes, especially class 2B students to improve in all categories based on Bloom's taxonomy. Both groups of students were able to filter and consider multiple perspectives to choose the best options to solve the problems, represent the problem in more ways than one by clarifying goals through the KWL, examining assumptions by helping them to think critically and helping them to formulate abstract concepts by quickly changing focus and goals as the situation require and able to post questions about complicated and complex issues in open class discussions/forum/wikis (see Figure 8). They learned to share and to discuss when the problems were raised by posting questions about complicated and complex issues in the open class discussion. Members of the groups were interacting constructively to evaluate evidence posted and found from the Web, to come out with refined information to accomplish the task given. Learning was meaningful.

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