

## Developing Initial Collaborative e-Learning Environments

Su-Ju Lu\*

*This paper is to propose a learning theory based approach for the design of initial collaborative e-learning environment. This approach attempts to provide a reasonable connection of theoretical perspectives on learning with e-tools, so as to consider technology as well as learning contexts as a whole in the development of e-learning environment. This approach emphasizes the identification of design requirements driven from key attributes that are distilled from learning theories. A functional description of collaborative e-learning environments is modeled and represented in terms of a combination of selected building blocks, in which the space of potential concepts is determined. One contribution of this paper is the development of an embodiment process to derive potential physical descriptions representing e-learning environments. To explore the solution space, a range of potential concept is generated to prevent overlooking valuable concepts. These concepts are then evaluated to select an appropriate one that meets all or most of the design requirements. An example is used to demonstrate the use of the proposed approach in developing a prototype in collaborative learning. The evolution of this environment is a need for continuous improvement based on the approach.*

**Keywords:** *e-learning, learning theories, design approach, collaborative learning environments, building blocks*

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## 開發數位式合作學習環境之雛型探究

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本文旨在開發一套結合學習理論為基礎的合作式數位學習環境之設計方法，將理論上的學習需求與現階段的數位學習技術做一完整的連結，使數位學習環境發展時，能同時將理論上的合作學習概念與數位技術做一整體的考量。此設計方法強調合作式數位學習環境的核心功能需求，應該經由學習理論中推演而得。在功能設計規劃部分，選擇以合作學習理論上的需求，做為該數位學習環境之構成元件，藉由此構成元件，進一步組合與建置該數位學習環境的雛型。本文的貢獻在於透過具體化的程序，將合作學習理論抽象概念上的設計需求，轉換為實質的設計方案。此程序首先著重在設計需求選項之確認，對可能的選項做一評選，經過評估並確認滿足理論上的學習需求，以避免忽略具有價值的設計需求。最後藉由建構一合作式數位學習環境為範例，說明本設計方法的實際應用程序，與呈現該環境的雛型，透過持續性的改善，可延續性的精進此合作式之數位學習環境。

**關鍵詞：**數位學習、學習理論、設計方法、合作學習、構成元件

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# Developing Initial Collaborative e-Learning Environments

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## 1. Introduction

The design requirements of e-learning environments were often based on the intuitive beliefs of designers with little support from relevant learning research or theories (Hannafin & Hooper, 1989; Park & Hannafin, 1993; Spiro, Feltovich, Jacobson, & Coulson, 1991). This way of designing was subjective and eliminated the possibility of enhancing learning from the use of technologies in teaching and learning (Wild & Quinn, 1998). It has been suggested that a better approach is to synergize learning theories and technical advances so as to increase the opportunity of effective learning in e-learning environments (Presnell, Ramesh, & Browne, 1999; Deubel, 2003). A handful of guidelines or models for enhancing instruction and teaching have been proposed to identify how learners think, learn, and develop knowledge based on various learning schools (e.g., behaviourism, cognitivism, and constructivism) (Duffy & Jonassen, 1992; Park & Hannafin, 1993; Willis, 1995; Dick, Carey, & Carey, 2001; Hannafin, 1997; Hannafin & Land, 1997; Carr-Chellman & Duschatel, 2000). One design perspective for the development of the e-learning environment is to distill design requirements from these learning experiences. Although the same or similar aspects have been addressed in some instances, there is no agreement on common practices or approaches.

So far, at least three approaches have been used for support. The first approach is called the “tool-kit” approach, in which computation tools are developed to assist designers to understand, select, and decide the use of technical tools or appropriate learning activities in respect to certain theoretical learning requirements. The features of a certain e-tool, its potential applications, constraints, etc., are provided by means of the consultation with such “tool-kits”. An initial attempt of developing such a “tool-kit” is as Media Advisor (Conole & Oliver, 2002), in which the features, costs, potential applications, and design constraints of a variety of tools (such as audio cassette, bulletin board, etc.) are displayed in a template.

The limitation of the “tool-kit” approach is that the descriptions of input requirements and their respective answers reflect the individual beliefs of the “tool-kit” developer. A further enhancement for this approach could be to develop a set of “universal” terminologies for both theoretical learning requirements and learning activities to be used as standard languages when consulting with “tool-kits”.

The second approach is called the “prescriptive modeling approach”. A few pedagogical models were introduced to navigate and inform the use of a certain learning technology practice. Examples include Salmon (2000), who proposed a “five stage e-moderating model of teaching and learning online through computer mediated conferencing”. Wenger (1998) and Snyder, Wenger, and Briggs (2004) offered and utilized the model of “communities of practice”. These models offer a structured and paced approach for teaching and learning in the initial development of e-learning environments with the limitation of following certain preconceived e-learning requirements (Lisewski & Joyce, 2003).

The third approach is called the “learning attribute modeling approach”. This approach attempts to reasonably embody e-learning environments from a set of abstract descriptions distilled from a class of learning theories so as to identify common characteristics, pedagogical focus, and potential e-learning strategies. One example following this approach is proposed by Conole, Dyke, Oliver, and Seale (2004) in which similar learning theories can be clustered for a certain group with a certain level of learning attributes (the six attributes were identified, such as “individual” or “social”). These learning attributes were used to identify the similarity between learning theories. Similarly, learning activities with the use of a certain e-learning tool (such as online chat in the brainstorming activity) can be characterized with the abstract learning attributes. The approach proposed by Conole et al. provides a reasonable way to identify learning attributes among learning theories as well as among e-learning activities.

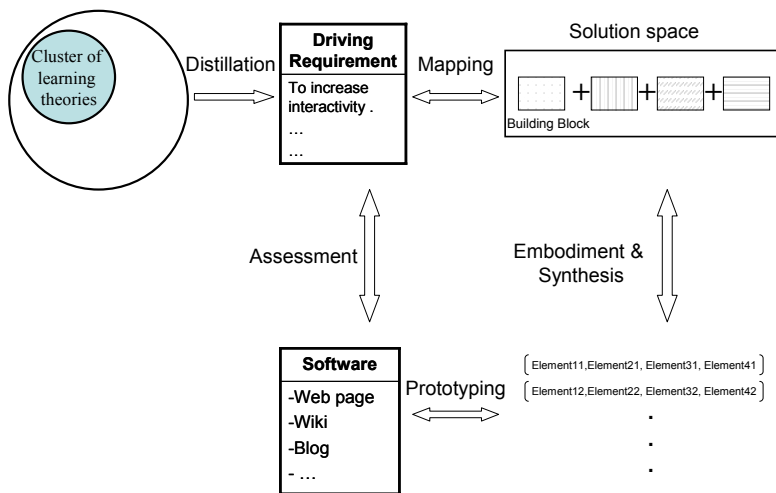
The approach proposed in this paper is to develop a “rational” connection between the requirement space (i.e., theoretical learning theories) and its solution space (i.e., the potential e-learning platforms) with the emphasis upon design phases and the tactics available for each phase. This approach combines the use of three approaches mention in the previous page. This approach involves multiple paced design phases, starting with the cluster of learning

theories, followed by the development of driving requirements, and thus eventually transforms these requirements to their potential “embodied” concepts selecting from a set of multimedia tools (e.g., email, web page, on-line chat) integrated with certain learning activities. This design approach could make the initial design of e-learning systems more manageable and traceable, and explore a wide solution space in a meaningful way. The rest of this paper is structured to address the overall approach, to detail each design phase within the approach, and to provide an example of system prototype developed based upon this approach.

## **2. The Approach**

To increase the chance of effective learning, this approach is proposed to synergize of learning theories and e-tools to develop an e-learning environment. The e-learning environment is the one that considers the kitting together of contents, learning activities, learning community, and e-tools to develop a learning experience in this environment. The strategy to implement this approach is to: 1) develop an e-learning environment focusing on learning context rather than learning content; 2) include learning theories into design requirements; 3) use these “abstract” requirements as a major driver to determine elements that comprise of the “embodied” environment. This strategy enhances designers to consider the development of e-learning environment both from the aspect of information technology as well as learning contexts. The implementation of such synergism involves five major processes. The first process starts with clustering learning theories to group a set of learning theories that have certain common attributes. Having identified a tree of attributes, these are distilled to become driving requirements for design. The second process is to identify a set of building blocks (can be represented in terms of block diagrams). These building blocks are used to represent elements of functional requirements, performance requirements, or other requirements for the e-learning environment. Combination of these building blocks represents the functional concepts of the e-learning environment. The third process is the process by which concepts are synthesized based on the designated solution domain (derived from the second process). The underlying behaviors of these concepts are used to compare with the driving requirements to determine whether these concepts are “rationally” mapped into the requirements. The fourth process

involves further development of concepts to eventually become a prototype of e-learning environment. This prototype is thus used to support teaching and learning. The final process is to analyze the learning experiences in the use of the prototype and to identify future improvement on the prototype. Two major reasons make the final process necessary. First, the mapping from the requirement domain into solution domain creates variances that require continuous improvement. Second, because of the differences in types and characters of digital contents and communities, when knitting together of digital contents and communities with the use of learning activities, it often derive various unique learning experiences in which some of the experiences might be derived for a need for future improvements. A conceptual description of this approach is shown in Figure 1. Highlights of these processes are described below.



**Figure 1 The approach for the initial design of e-learning**

## 2.1 Cluster of Learning Theories

This process reviews a variety of learning theories, and identifies attributes from each learning theory, and thus groups the theories that have similar or the same attributes. The purpose of cluster of learning theories is to investigate relevant theories in a meaningful way. This process helps to identify the distance of similarity among learning theories. One benefit from this process is to enhance understanding by comparing the attributes among a

set of learning theories. One of the most common methods of clustering learning theories is to establish a list of attributes. Each attribute is used to characterize and represent a specific class of learning theories. Example of establishing a list of attribute can be shown in the works of Conole et al. (2004). There are three branches in the tree, each branch has two values. According to Conole et al.'s classification, the attributes for any learning theory has the "values" with the combinations of these six components. Each group of learning theories falls into a (x, y, z) value of modeling representation. Each axis has two components, for instance, in the x axis, there are two values, i.e., "reflection" and "non-reflection". All theories have one or two "values", "reflection" or/and "non-reflection" in the x axis, so is in the y axis and z axis. In general, each theory based on Conole et al.'s approach has a mapped "values" representing in terms of a cartisan representation.

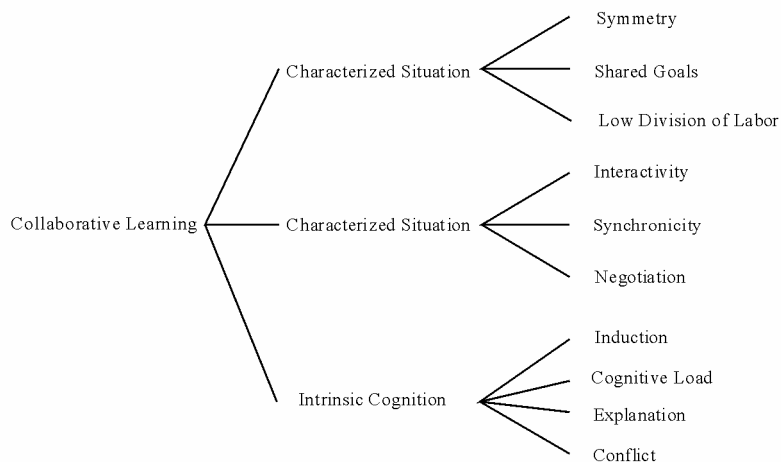
## **2.2 Identify driving requirements from an attribute tree**

Once a certain cluster of learning theories is identified, these theories are then distilled to establish a tree of attributes. The established tree is used to characterize the cluster of learning theories. One or some of the attributes will be taken for designing. The example of cluster learning theories falling into the area of collaborative learning is shown in Figure 2. The attribute tree can be represented in terms of more than one layer, for example, the attribute tree in the figure has two layers. Usually, more layers in each tree stand for finer granularity that can be identified from the cluster.

The size of learning theories in a certain cluster if using a attribute tree is dependent upon which layer in the attribute tree is selected for grouping. The selection of a certain layer in the attribute tree depends upon how detail the designer would choose to identify the characters of the embodied solution that are likely to have the potentials with the mapped attribute.

Having clustered the learning theories and distilled an attribute tree characterizing them, this process is to identify driving requirements in consideration with the attributes. One common format representing each requirement is in terms of "to verb noun" where "verb" express how the designer would like to manipulate the "noun", and "noun" stands

for or represents one of the attributes identified in the tree. Table 1 shows an example of potential driving requirements distilled from the cluster of collaborative learning theories. Attributes and notes in the table are summarized from Dillenbourg (1999). The requirements in Table 1 are derived with the use of the attribute tree in Figure 2. Three major requirements are identified: 1) to design situation that has strong collaboration character; 2) to increase the probability of interaction during learning; 3) to develop learning mechanisms that are more intrinsically collaborative. Take the driving requirement of “to design situation that can be characterized with collaboration” as an example, three attributes are considered, i.e., symmetry, shared goals, and low division. Therefore, if designing learning in the e-learning environment with this requirement, these three attributes are used as a basis to depend upon whether a certain learning situation is appropriate. Each requirement can be further divided into sub-requirements until it is understood to a certain level of clarity. For instance, the requirement “to enable the interaction in a timely manner” can be further divided into three sub-requirements as shown in Figure 3. The driving requirements represent the major characteristics that the designer wants to grasp from a certain cluster of learning theories.



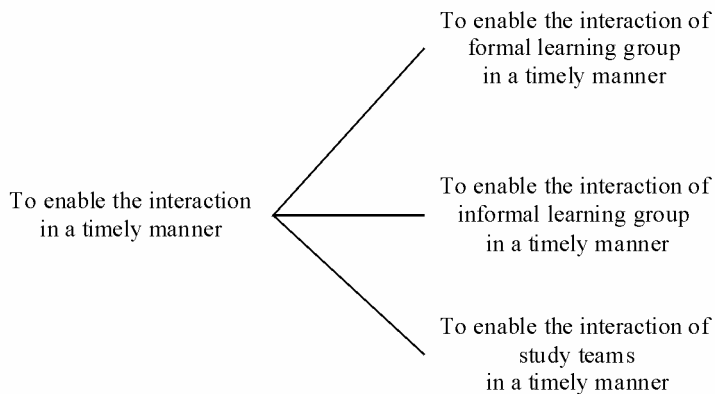
**Figure 2 An attribute tree distilled to represent collaborating learning theories**



**Table 1 Summary of driving requirements for initial collaborative design, and how they link to the attributes distilled from collaborative learning**

Driving Requirements	Division of Driving Requirements	Attributes	Notes
To design situation that has strong collaboration character.	to develop symmetrical situations rather than asymmetrical situations	symmetry	The situation with respect to the level of actions (control, coordination), or the level of expertise (tutoring, teaching, coaching, etc.)
	to provide teams with the same level of knowledge and share with common goals.	shared goals	The situation that has common goals for a certain task or activity.
	to provide low division of labor	low division of labor	The situation with less split of the work.
To increase the probability of interaction during learning	To increase the degree of interactivity among peers	interactivity	The degree of interactivity among peers is not defined by the frequency of interactions, but by the extent to which these interactions influence the peers' cognitive process.
	To enable the interaction in a timely manner	synchronicity	The distinguish between synchronous communication and asynchronous communication is dependent upon the learning tasks selected for peers interaction in certain type of communications (e.g., chat, or email).
	To allow to argue, justify, and attempt to convince for certain learning tasks	negotiation	

Driving Requirements	Division of Driving Requirements	Attributes	Notes
To develop learning mechanisms that are more intrinsically collaborative	To use inductive process to enhance understanding in representation	induction	
	To increase/reduce cognitive load to enhance understanding/regulation	cognitive load	
	To use explanation in social situation	(Self-) explanation	
	To enhance social interaction by means of conflicting statements	conflict	



**Figure 3 A division of driving requirement into smaller driving requirements**

The granularity of a certain driving requirement depends upon how detail the designer wants to address or can address. Usually, the granularity must be small enough to identify the potential mapping e-tools and learning activities.

In summary, the driving requirements with the designated attributes are used in this approach to derive an e-learning environment with the underlying features that are close to these desired attributes.

### 2.3 Develop building blocks representing solution domain

Having identified driving requirements, this process is to develop building blocks that can be composed to represent concepts in the solution domain. Building blocks focus on what a component in the solution domain must do to produce the required function. Building blocks represent functional views of solution in the areas of system functions, tasks or actions to be performed, and system performance (how well does it have to be done).

Two types of building blocks are considered in this paper. One is called driving building blocks that is the building block directly contributes the operational behaviors that are required from the driving requirements. The second is called non-driving building blocks that is related to other aspects of design requirements, such as requirements for security, management, user support, standards, etc. An e-learning environment is developed with the combination of driving building blocks as well as non-driving building blocks.

#### Representation of design requirement in terms of building blocks

The relationship between the requirement and the building blocks can be written as follows: requirement =  $f$  (building block 1... building block  $n$ ), where  $n$  is equivalent to 1 to the natural number larger than 1. In words, this expresses “requirement is a function of one or more building blocks”. Graphically, this relationship can be shown in Figure 4. Combination of building blocks is to fulfill or map to a certain requirement. Each building block from the solution perspective represents a sub-solution space. In this paper, combinations of the four driving building blocks are used to map into the driving requirements. This is to say, all the potential concepts derived from the four driving building blocks are the possible embodiments of the driving requirements. Whether a certain requirement mapped to one or combination of building blocks depends upon the granularity of the requirement. For example, if the requirement is to “enable the interaction of study teams in a timely manner”, the mapped building block is a one-to-one relationship, i.e., the building block of “Interaction”; however, if the requirement is to “enhance negotiation for certain learning tasks”, the mapped building block is the synergy of the four driving building blocks. A complete concept (i.e., an e-learning environment) is derived

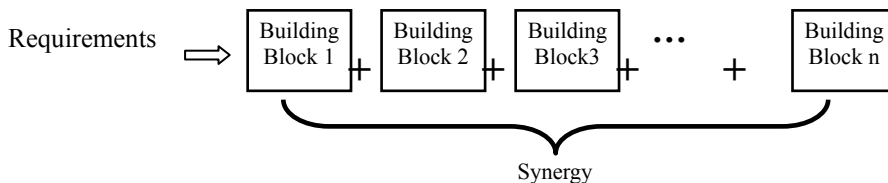
from the combination of driving building blocks and non-driving building blocks.

### Relationship between building block and embodied element

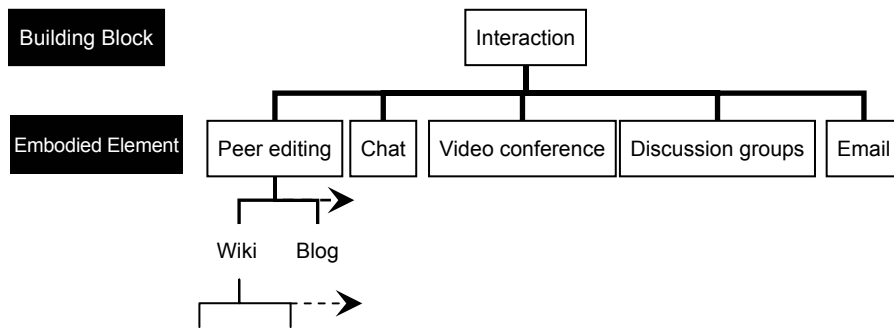
Each building block has a set of embodied elements. The relationship between building block and embodied elements is that building block is the “parent” of embodied elements. Embodied elements are the potential embodiments of a building block. Each embodied element shares the functional aspect of its parent plus additional behavior, such as the embodied element of “Chat” has the behavior that allows for conversational interaction. Building block is the functional view of a solution component, while embodied element is the physical view of a building block. Graphically, this relationship can be explained in a tree-like representation, as shown in Figure 5.

Each embodied element is the generalization of a class of e-learning tools (e.g., all sorts of email applications) to prevent too many existing tools to be explored at one time. Four driving building blocks are identified in this paper as shown in Table 2, which are called “Interaction” “Learning Task”, “Learning Content” and “Content Presentation” respectively. These driving building blocks are developed with respect to e-learning tools, learning activities, learning contents, and representation of contents.

Examples of non-driving building blocks are considered with the development of a system prototype, which are in the aspects of learning review and assessment, document management, and the support of learning. The definition of each building block and its potential embodied elements are shown in Table 3.



**Figure 4 The relationship between driving requirements and building blocks**



**Figure 5 The relationship between a building block and its embodied elements**

**Table 2 Driving building block and its potential embodied elements**

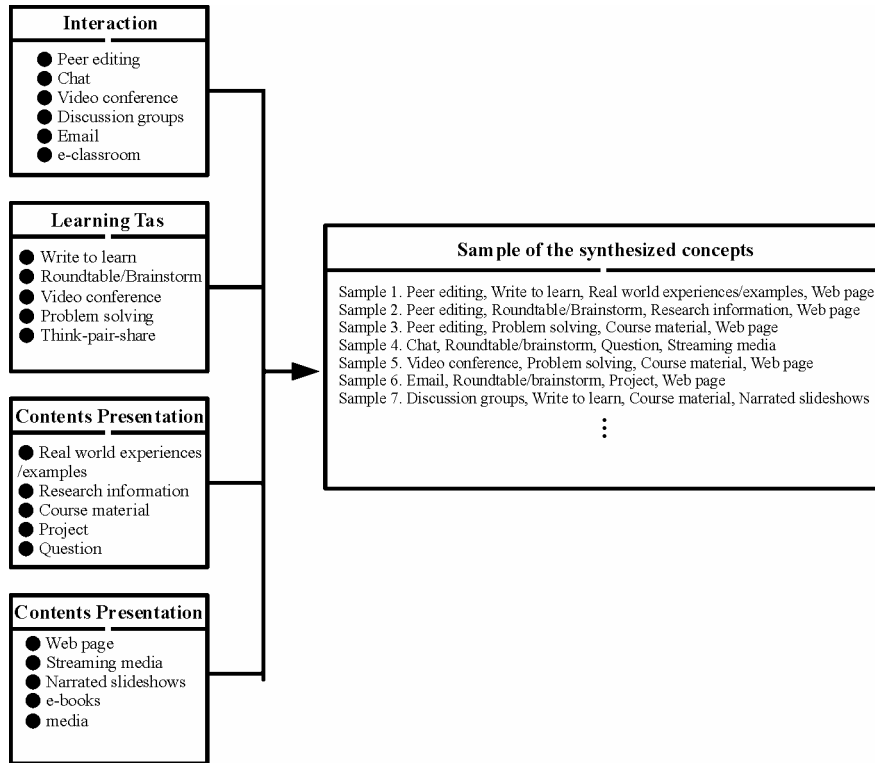
Driving Building blocks	Definition	Potential embodied elements
Interaction	The system function to exchange synchronous or asynchronous.	<ul style="list-style-type: none"> <li>● Peer editing</li> <li>● Chat</li> <li>● Video conference</li> <li>● Discussion groups</li> <li>● Email</li> <li>● e-classroom</li> </ul>
Learning Task	Activities to be performed in a group of selected people.	<ul style="list-style-type: none"> <li>● Write to learn</li> <li>● Roundtable / brainstorm</li> <li>● Problem solving</li> <li>● Think-pair-share</li> </ul>
Learning Content	Course materials to be used in the activities.	<ul style="list-style-type: none"> <li>● Real world experiences / examples</li> <li>● Research information</li> <li>● Course material</li> <li>● Project</li> <li>● Question</li> </ul>
Content Presentation	The system function to display course materials	<ul style="list-style-type: none"> <li>● Web page</li> <li>● Streaming media</li> <li>● Narrated slideshows</li> <li>● e-books</li> <li>● media</li> </ul>

**Table 3 Non-Driving building block and its potential embodied elements**

<b>Non-Driving Building blocks</b>	<b>Definition</b>	<b>Potential embodied elements (not a comprehensive list)</b>
Regulate and Learning	The system function to monitor interactions and collect learning assessment	<ul style="list-style-type: none"> <li>● Teacher's evaluation</li> <li>● Peer review</li> <li>● Self assessment</li> </ul>
Document Management	The system function to regulate learning and manage learning content	<ul style="list-style-type: none"> <li>● Resource library</li> <li>● Version tracking and control</li> <li>● Permission-based access</li> </ul>
Support Learning	The system function to help, answer relevant questions and enhance learning	<ul style="list-style-type: none"> <li>● Online help</li> <li>● Sandbox</li> <li>● FAQs</li> </ul>

## 2.4 Synthesis of embodied elements to build design concepts

This process is to synthesize building elements in terms of design concepts characterizing most of the driving requirements. The focus of this process is to explore all the potential concepts that meet most of the driving requirements. All the concepts in the space are derived from exhausting all possible combinations among the elements of each driving building block, as shown in Figure 6. A synthesized concept by knitting together of embodied elements represents a certain e-learning environment that has its specific context. The representing context of each synthesized concept is evaluated to determine whether they meet all or most of the driving requirements. This process ensures the critical context of the learning environment is considered first, before considering other requirements from techniques, managements, constraints, etc. The critical context in this approach is the result from the synthesis of embodied elements. The rules of evaluation are based upon whether the combination of elements within each building block has the attributes from driving requirements. In general, synthesis of a list of embodied elements should contain two kinds of steps: generating a range of combinations (to prevent overlooking valuable learning contexts), and evaluating/selecting these soon enough (to restrict the concepts that are meaningful based on the driving requirements).



**Figure 6 Synthesized concepts in the solution space comprised of the four driving building blocks**

### Exploration of solution domain

The ideal situation to explore the solution domain is to exhaustively search of all the potential concepts that can be synthesized in the solution domain, and thus evaluate these concepts upon the requirements, and find out an optimized once to develop the e-learning environment. However, the number of all the potential concepts can be manually impossible to search and evaluate. Before a computational tool can be developed to support this task, a search strategy is required to identify most likely concepts manually. To conduct an possible search and evaluation, the strategy used in this paper is to identify the most critical requirement from the driving requirements first, and select one or two embodied elements of the driving building block that are represented as the mapped embodiments.

For example, if the embodied element of “peer editing” is the critical requirement and is selected first, the synthesized concepts based on the embodied element (i.e., peer editing) are generated with the consideration of all potential embodied elements for the rest of the building blocks of “Learning Task”, “Learning Content”, and “Content Presentation”, and these generated concepts are evaluated to meet the rest of driving requirements. If the embodied element of “Question” is first selected to meet the critical requirement, the synthesized concepts are generated to consider all possible embodied elements in the “Interaction”, “Learning Task”, and “Content Presentation”.

Another method of linking driving requirements and its potential physical solution is the use of “tool-kit” or “case-based” approach. The “case-based” approach is to collect and analyze a set of past e-learning environments to identify the contexts and distill their underlying attributes. To find out some of the e-learning environments, the driving requirements are matched against the cases in the database, and similar cases are retrieved. The retrieved cases are used to suggest a concept.

### **3. Development of an e-learning environment**

The design requirement used for the prototype is to develop a platform for the undergraduate and graduate students in the university to enhance “write to learn” capability based on the collaborative learning theory. The requirement is to provide an environment to establish teams toward formal learning groups to complete a specific task, such as write a report, carry out a project, or prepare a position paper. These groups need to complete their work in the learning environment in a single class session or a class session over several weeks. The critical driving requirement is distilled as “to enable the interaction of formal learning group in a timely manner” for the learning tasks related to peers editing.

As addressed in Section 2.4, synthesized concepts were generated first and thus evaluated. The concepts selected for further development are the ones with the embodied elements, i.e., “peer editing” and “write to learning” in the building blocks of “Interaction” and “Learning Task” respectively. The difference between these concepts is that their potential embodied elements in the “Learning Content” and “Content Presentation” building blocks. Peers editing is the major collaboration tool currently selected in this paper.



Two families of e-tools are considered for use to detail the embodied elements in the selected concepts with the required functionality of “Peer editing”. Wikis<sup>1</sup> are selected with the following reasons: 1) it supports the functional requirement of peer editing; 2) it allows users to manipulate (i.e., edit, create, and modify) information for all allowable pages in the hypertext environment which support “write to learn” element; 3) most of the embodied elements in the “learning content” and “content presentation” can be developed in Wikis; 4) web page presentation is provided. Users are not required to understand HTML, Java applets, or other web page editing language. This might reduce the difficulties for those with less computer skills to manipulate in the hypertext environment.

The strategy of selecting any existing e-tool for the development of e-learning environment is to compare families of e-learning tools first, select one which meets most of the functional elements among the selected synthesized concepts. Once a certain family is selected, some of the e-learning tools within this family are further selected. This strategy allows designer to first explore and select families that are widely different, and thus select an existing e-learning tool within the selected family.

Once the Wikis family is selected, Mediawiki is selected with the following reasons: 1) Mediawiki supports multi-lingual (including Chinese) HMI; 2) Plug-in applications, such as the function of opinion polls, can be inserted into the platform to enhance the systems capabilities and provide additional functionalities to meet the need of embodied elements; 3) users’ manipulation can be recorded in the “history” function which allow data extraction to analyze users behavior in terms of contents input, frequencies, time spent, etc. Note that selecting Mediawiki is considered with embodied elements in the non-driving building blocks, apart from the elements in the driving building blocks.

### 3.1 Detailing embodied elements in the e-learning environment

The platform is to develop a foundation to exploit a computer-supported collaboration

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<sup>1</sup> There are more than 100 wiki engines used in many communities. This original idea was derived by Ward Cunningham (Leuf & Cunningham, 2001) in 1995, when he was looking for a means that can be used to collect common programming tasks from a group of programming developers and allow them to modify information displayed on the wiki page. At that time, the idea was to simply use web browser to modify each wiki page.

that enhances learning by means of peer editing. Another purpose of this platform is to experiment some pedagogic models to investigate further improvements. Other means such as voice (including chat), video, or others that support collaboration is not considered here. Courses with regard to the aspect of collaborative learning are taught in the use of this platform for undergraduate students in the Department of Plastic Design and for graduate students in Graduate School of Toy and Game Design, National Taipei University of Education, Taiwan. The current prototype platform is based on MediaWiki engine (Ebersbach, Glaser, & Heigl, 2005), with the use of MySQL database (Williams & Lane, 2004) for data storage. To modify this platform if necessary, it requires PHP programming skills (Williams & Lane, 2004). Otherwise, no programming language background is needed. The system architecture is shown in Figure 7. Highlights of the functionalities in the e-learning environment are as follows:

### **Peer Editing Area**

This area provides to meet parts of functional requirements for peer editing. Results of the editing is presented with hypertext environment. Anybody can create or edit this environment concurrently. The group assignments are edited and completed in this working environment. Cognitive activities are conducted in terms of reviewing, writing, modifying the content. Collaborative learning context here is conducted in accordance with the instructional process, internal rules inside each team, as well as completing the assignment in this area. Following this learning context, team members are allowed to construct their own understandings as well as to develop team skills. This is to create an environment to allow users (including learners, instructors, and system administrator) actively participating learning, supporting information display, sharing, and exchanging information.

A fairly easy editing grammar was designed, featured in Mediawiki, to allow users to enter ideas or information online. The environment for peers editing is shown in Figure 8. When any user clicks the “edit” button on the upper right corner, the web page will pop out as shown in Figure 9. The text area displayed in the scrolled page will allow users to edit, modify, increase, and link to other Mediawiki page, or link web pages in the internet.

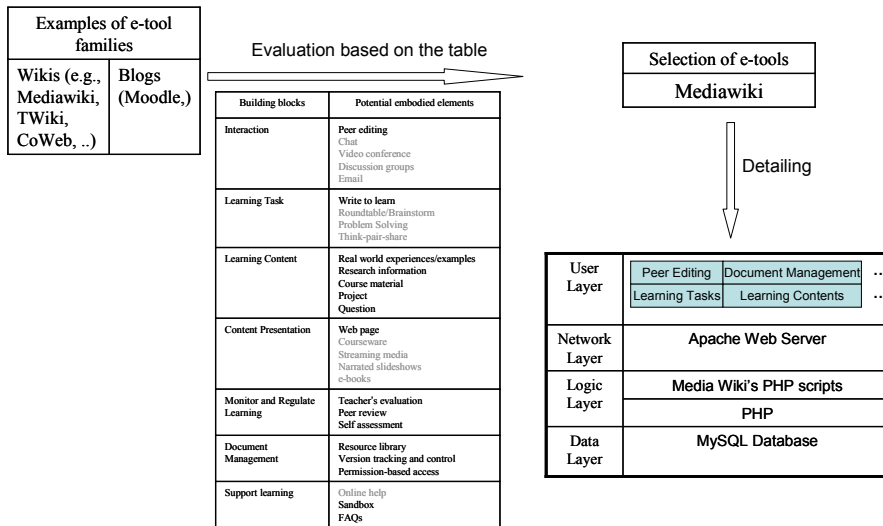


Figure 7 System functionality, potential embodied element, and building block



Figure 8 A snapshot of peers editing environment.



Figure 9 The web page display based on the editing information shown in Figure 6.

## Learning Tasks Area

This area provides users to meet parts of the embodied element “write to learning” with various learning contents (e.g., questions and research information). This is to structure collaborative learning tasks to increase the changes of enhancing collaborative learning. Lesson learned and experiences derived from the use of these learning tasks can be used to modify and enhance them. Two main learning activities are currently proposed (Millis & Cottell, 1998)

(1) Questions for short answers: this is to design collaborative learning activities on having students with short writings from a variety of assignments (such as to reason about and conclude data, to explain a concept or the assigned reading, to raise a list of questions, or to comment on certain instances). All students are grouped with the same or similar size (2-6 people are considered). Each student is first asked to provide a short answer. All the answers in each group or pair are discussed, selected, modified, or finalized.

(2) Peer Review: students are asked to review and comment on each other’s paper. Review can be happened for drafts, “nearly final”, or final papers. For longer papers, the

author can direct reviewers to a specific section or question..

Before conducting learning activities, two areas need to be considered. The first is to prepare for collaborative learning tasks. This includes the introduction of collaborative learning and the benefit of collaborative learning, decides and groups the size of each team, proposes learning procedures for better learning control of class procedures, describes goals of the course and Q&A on grading, and describes tasks for learning activities. The second is to guide students on how to conduct collaborative learning (to enhance learning mechanisms that are more collaborative). This includes the described objectives (include academic and social skills) of the tasks and required knowledge to reach these tasks, proposes guidance to conduct collaborative learning activities, determines criteria for success, and provides directions for learning behavior. The particular emphasis on the proposed guidance is to use writing as a method for collaborative learning activities.

### **Learning Content & Learning Presentation Area**

This area creates an environment allowing users (including learners, instructors, and system administrator) to actively explore and catch the necessary information of courses. The forms of courses can be: 1) a slide show in which picture files are sequenced in a meaningful and interactive manner with the support of music and text to present specific messages or contents. Commercial software, such as PowerPoint, Adobe Photoshop and Macromedia Flash can be used to support this platform; 2) hypermedia presentation: each web page is composed of texts, videos, pictures, voice, hyper links and other media formats. Hypermedia presentation is the extension of hyperlinked text and hypertexts. Learning content shown in Figure 8 describes a project regarding designer styles and their applications. Learning presentation is made with texts, diagrams and picture files.

### **Monitor and Regulate Learning Area**

This area collects or records data or information (e.g., learner's response, and learner's operational procedures) involving in learners' behavior, thinking process so as to evaluating learning and interaction. The data or information collected include the learners' evaluation, outcomes from the assignment, and change records. Opinion poll allows users to evaluate self learning progress, assess team performance and others team's work product. The

analysis of these can be used for many purposes including providing learning direction, identification areas (such as course design) of strengths and weakness for future enhancement, identification of learner's interest and specialty that can be used as reference when students consider future career. Change records are one of the major data sources to be analyzed for further improvement. This research relies largely on this feature, i.e., "history" inherited from the functions of Mediawiki. The types of data collecting for analysis are such as content differences (what is the discrepancy between the latest web page and its previous one), history (tracing back to the previous web pages), information contributors (who enters the information), and time of editing (when is the information entered). Further process of these data (e.g., filtering, counting or fusing) can help to summarize the potential learning behaviors. One example of the change record is shown in Figure 10, the snapshot of the "history" page.

### **Document Management Area**

This area is to provide a function for online course management: to serve as a general learning management purpose for course planning and scheduling, registration, tracking of courses taken by learners, assignments, and resource management. A number of learning management systems provides the functions of online course managements. Hill (2001) investigated how to select appropriate learning management systems. More advanced functions not considered here such as to support the sequence of courses to be taken and learning speed based on students' previous performance, and to support the suggestions for future career selection based on students learning performance and courses taken.



Figure 10 A snapshot of records shown all the changes

#### 4. Discussion and Conclusion

This approach involves in abstract descriptions of requirements that can be “rationally” mapped into multiple phases of solution forms in which smaller granularity of elements are considered when transforming from one level of solution forms into the next detailed level, with the use of tactics such as cluster, decomposition, transformation, or others.

The example of the prototype system shown in this paper simply shows the initial effort on the development of e-learning environment with no claim of a successful result. The level of synergism is dependent upon the “quality” of the distillation process as well as the mapping process. However, the advantage of this approach is able to trace from the beginning of the design process for the distillation of driving requirements to the development of the e-learning environment. Any functionality inside this environment can be traced back and identified which building block or driving requirement has been involved. This type of traceability allows designers to systematically identify design changes or further improvements on the environment whenever she/he experiences a need

to change design requirements or the mapping process.

The process of designing used in this approach, from requirements, conceptual design, moving to embodiment design, and then completed in detailed design is common in many researches in the domain of engineering design, such as works done by Pahl and Beitz (1996), Pugh (1991) and Ulrich and Eppinger (1995). Moreover, some tactics or methods could be borrowed from these researches to meaningfully link, map, or transform abstract descriptions (e.g., to represent learning theories or models) into physical e-learning environment, which is worthwhile for further investigation.

To summarize, this paper proposes an approach for designing of e-learning environments. This approach is based on the assertion that the development of an effective e-learning platform is not only beneficial from increasing advance in information and communication technology, but also from a collection of pedagogies and theories derived from previous research. This approach considers design as evolutionary, starting from distilling driving requirements from learning theories, gradually evolving the development of design concepts in the interim process, and thus eventually embodying these concepts into e-learning environments. This approach can be considered as the development of meaningful relationships among these learning theories as well as the design of e-learning environments. The driving requirements used in this paper as an input for the design of e-learning environments are used as a means to synergize e-learning and their respective learning theories. Four building blocks in the environments are considered as the major ones for effective e-learning, which are learning activities, the associated e-learning tools, learning contents, and content presentation. These four areas are considered concurrently to increase the opportunity of conducting an effective learning in the environments.

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