Encouraging thinking processes as a foundation of learning design within LAMS: Context free design patterns and e-communication support

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This paper focuses on the encouragement of students' thinking processes as a main aim of learning design within LAMS. To this end, specific design patterns in the form of sequences of learning activities within LAMS are proposed, together with a brief description of their theoretical background. These basic design patterns could be linked with specific tools of LAMS to help teachers use them towards the development of their students thinking processes, namely: concept formation, decision making, problem solving, inquiry based learning, composition, comprehension of learning materials, and communication. To this end, a Critical Thinking Communication Wizard (CTC-Wizard) is also proposed to be integrated within chat and forum of LAMS in order to encourage core critical thinking skills during synchronous and asynchronous communication that usually takes place in chat-rooms and forums.

Keywords: Critical thinking, design patterns, LAMS, a/synchronous communication

Introduction

Undoubtedly, networking technologies and e-learning provide many advantages in education in terms of opening the doors of the typical classrooms to a wide international context, as well as liberating learning from limitations of time and space by providing learners with flexible opportunities to learn at any time and at any place and collaborating virtually throughout the world. E-learning also provides great opportunities for teachers to upgrade the quality of their teaching by sharing good learning examples as well as re-use and improve them through a cyclic process of experience and reflection. The most recent generation of e-learning environments shifts the emphasis from the design of content to the design of learning. That entails the design of sequences of appropriate learning activities in order to provide learners with opportunities to achieve specific goals within a specific domain of knowledge (Britain & Liber, 2004; Conole & Fill, 2005). To this end, learning design-based e-learning environments seemed as promising and revolutionary contexts for the design of pedagogically sound e-learning events (Bennett, Agostinho, Lockyer, Koper & Harper, 2008). Specifically, 'learning design' has been defined (Koper & Olivier, 2004) as application of excellent pedagogical models for a specific learning objective, target group, and a specific knowledge domain. Learning design represents the learning activities that have to be performed by different persons (learners, teachers) in the context of a unit of learning (Koper, 2006). To this end, the role of design patterns is significant. Specifically, best pedagogical practices -which are context free- can be reflected on the formation of 'design patterns' which could be shared and reused across instructional contexts and essentially assist online learning. A pattern is seen as something that will not be reused directly but can assist the informed teacher to build up their own range of tasks, tools or materials that can draw on a collected body of experience (McAndrew, Goodyear, Dalziel, 2006).

LAMS (Dalziel, 2003) is an open source environment that supports learning design as it provides teachers with great opportunities in terms of: (a) easy and intuitive design of sequences of learning activities even for those who do have not any programming experience and knowledge (Cameron, 2007), (b) the ability to

'Preview' the sequences of learning activities through the lens of the learners (Cameron, 2006), (c) possibilities to take a general overview of the entire sequence of learning activities on the computer screen (Cameron, 2007), (d) possibilities for improvement of such a sequence even though it is running online in real-time, (e) possibilities for transforming a ready-made sequence of learning activities. (Thus, the role of the teacher is not reduced to the role of a traditional behavioristic practitioner (Skinner, 1968) who has to use 'learning designs' ready-made by expert learning designers), (f) possibilities of fine grained grouping and branching, (g) possibilities for adapting the sequence of learning activities according to students' previous knowledge, preferences and specific learning styles using appropriately designed questionnaires in combination with grouping and branching , (h) provision with 'well working' learning design patterns – using the Activity Planner - that could be adapted by the teachers, (i) generic 'blank' learning sequences representing 'well known' collaboration learning strategies (Kordaki and Siempos, 2009 a; http://www.lamscommunity.org/lamscentral/) which are available by members of the LAMS community. To this end, the community of learners built around LAMS could play an encouraging role for the teachers and the designers of learning activities by providing them with opportunities to exchange experience and knowledge. Finally, in the context of LAMS, different learning theories could be taken into account for the design and implementation of diverse kinds of learning activities.

However, if the role of education is to help learners become mature, rational and critical thinkers who will be able to acquire and to appropriately use knowledge in analyzing problems, search for meaning and make thoughtful decisions, then the centrality of teaching and learning within a framework that emphasizes the learners' cognitive development needs no justification (Anderson, 1983). In addition, if the goal of education is not just to prepare learners to provide 'the right answers' to pass their exams but to create autonomous democratic citizens, then, thinking as a foundation of learning design has to be considered as essential. To this end, 'learning design' is not limited to using the tools provided, forming sequences of learning activities where the learners are limited to visiting various attractive learning materials and participating in loose and general discussions performed in chat rooms and forums, but also includes the design of learning activities that could encourage the development of learners' cognitive structures. To this end, enhancing the tools of LAMS with appropriate pedagogical information regarding learning design towards critical thinking will become useful for the teachers and the designers of learning activities. Here, it is worth noting that some attempts have been made to equip LAMS with tools that could support teachers in their learning design, with regards to the development of learners' critical thinking skills. Specifically, the construction of a Critical Thinking Wizard has been proposed by Kordaki, Papadakis and Hadzilakos, (2007) that has also been implemented by Papadakis and Giglione, (2008). This wizard is attached to Q& A tool and aims to support teachers in the formation of appropriate questions that could encourage diverse core thinking skills in learners.

In line with critical thinking and learners' cognitive development, modern constructivist and social views of learning (Jonassen,1999; Vygotsky, 1974) emphasize that teaching is closely related to both; design of appropriate activities for each specific group of students as well as appropriate monitoring and intervention by the teacher during the learning process. According to these modern views, learners are in the centre of the learning process. That means that the learning tasks and activities have to be designed taking into account their previous knowledge and idiosyncratic characteristics. To this end, teaching should become an online modelling, decision making and mediation process performed by the teacher, instead of a pre-defined activity performed by remote experts in learning design. In fact, the teacher is a basic actor in the design of learning activities while her/his various interventions are necessary during the whole learning process (Wittrock, 1986).

Moreover, research in teacher education points out that prospective teachers found difficulties in developing appropriate collaborative learning activities despite the fact that they were provided with appropriate training and text based supporting materials (Kordaki, Siempos and Daradoumis, 2010). In addition, despite the fact that non experts in learning design exploited the provision of collaborative design patterns to design appropriate collaborative learning scenarios within LAMS, they failed to use these patterns in integration with strategies providing appropriate possibilities for the encouragement of students thinking dimensions such as: concept formation, decision making, comprehension, composition, problem solving, inquiry-based learning and communication (Kordaki, 2010). However, it is acknowledged that a typical teacher needs training for the formation of appropriate learning activities, lesson plans and specific interventions. In addition, it is recommended that teachers make use of both high level tools to understand learning design and easy-to-use

tools which are specialized for a particular pedagogic context (Kordaki, Papadakis & Hadzilakos, 2007; Kordaki, Siempos and Daradoumis, 2009). It is also suggested (Oliver & Littlejohn, 2006) that pedagogical practice has to be represented in an appropriate form so that teachers can easily apply, adopt, adapt, and reuse. Despite the above, tools that support synchronous and asynchronous communication towards the development of learners' cognitive skills and specific design patterns that can encourage their thinking processes within LAMS have not yet been reported.

Taking all the above into account, some leaning design patterns have been designed aiming at the encouragement of learners' critical and creative thinking processes. In addition, an e-communication editor was designed; namely, a Cognitive Skill-based Communication Wizard (CSC-Wizard) to support primary and secondary level education teachers in their attempts at learning design, and especially, at their attempts at intervention in synchronous and asynchronous discussions, with the aim to encourage students to develop core thinking skills and critical and creative thinking.

This paper is part of a wider work (Kordaki, Papadakis and Hadzilakos, 2007; Kordaki and Daradoumis, 2009a; 2009b, Kordaki, Siempos and Daradoumis, 2009; Kordaki and Siempos, 2009b; Kordaki, 2010) aiming at the enrichment of the specific tools provided by LAMS with some pedagogical information in order to scaffold teachers to design appropriate lesson plans towards the encouragement of students' thinking processes. In the following section of this paper, the rationale of the design of the proposed design patterns is reported, along with their implementation within LAMS. The rationale of the proposed CSC-Wizard is also reported together with its design for possible implementation within LAMS. The paper ends with a summary of the features proposed to be integrated within LAMS.

Proposed design patterns for the encouragement of learners' thinking processes within LAMS

The concept of critical thinking dates back to Socrates. Critical thinking cannot be precisely defined: it sometimes has been defined narrowly while other times it has been defined globally. Critical thinking has been related to the acquisition of specific core thinking skills (see next Section), but it is far more than these skills. Some researchers acknowledge that critical thinking has been defined as "reasonable, reflective thinking that is focused on deciding what to believe or do" (Ennis, 1985, p. 54). Other researchers also claimed that the goal of critical thinking is to develop people who are fair minded, objective, and committed to clarity and accuracy (Marzano, Brandt, Hughes, Jones, Presseisen, Rankin and Suhor, 1988). Critical thinking has also been related to creativity and both concepts are referred to the quality of thinking.

In this section, an attempt has been made to concentrate on essential points of thinking dimensions, presented on the framework formed by Marzano, Brandt, Hughes, Jones, Presseisen, Rankin and Suhor, (1988) and to propose specific design patterns and a computer-communication wizard that can support the development of core thinking skills as well as critical and creative thinking by the learners. The aforementioned framework has been reviewed by numerous researchers, experts, practitioners and scientific organizations and also revised several times in order to be as accurate and helpful as possible. This framework has been proposed to be fully reflected on the design of learning curricula as well as on real teaching practices for the learning of each learning subject. Five dimensions of thinking have been identified, namely: (a) thinking processes, (b) core thinking skills, (c) critical and creative thinking, (d) metacognition and (e) the relationship of content-area knowledge to thinking. These dimensions reflect the various domains of thinking but do not form taxonomy. Usually, learners use these dimensions simultaneously - that is, they use core thinking skills and processes to solve a problem of a subject domain in critical and creative ways, while at the same time monitoring themselves and taking control of their learning. Next, a brief description of basic thinking processes as well as of core thinking skills is presented followed by a proposal of how to take them into account in the formation of appropriate design patterns within LAMS as well as to encourage synchronous and asynchronous discussions towards the development of learners' core thinking skills.

Basic thinking processes and design patterns within LAMS
The following basic thinking processes have been identified (Marzano, Brandt, Hughes, Jones, Presseisen, Rankin and Suhor, 1988): (a) Concept formation, (b) Principle formation (c) Problem solving (d) Decision making (e) Scientific inquiry (f) Composition (g) Comprehension and (h) Oral discourse. Here, it is worth noting that, instead of the term 'oral discourse', the term 'communication' is used due to the fact that in e-learning courses this term is more appropriate. In the next section, a brief description of each of these processes is presented, followed by proposals of specific design patterns within LAMS appropriately designed to encourage each of these processes.

Concept formation. A concept consists of several information about one or more entities – objects, events, ideas or processes- which are organized by a person, so that, s/he is able to discriminate the particular entity or class of entities and also to relate to other entities and classes of entities (Klausmeier, 1985; p. 276). Various concept formation levels have been proposed such as; concrete and identity level, beginning classificatory level, mature classificatory and formal level. Specifically, it has been proposed (Klausmeier, 1985) that at the concrete and identity level the teacher has to provide concrete materials representing the concept in question, give it a name and provide situations where the students can recognize this concept. In the initial classificatory level, the teacher has to provide at least two examples and counter examples of the said concept and then ask students to name this concept, identify its salient attributes, form its definition as well as recognize this concept in newly encountered examples and non examples. In the mature classificatory and formal levels, the teacher has to prepare the students to recognize the related concepts to the one in question and their relationships. At these levels, learners also have to be encouraged to identify examples and non examples and to articulate the name of the concept and its salient attributes. Finally, learners have to be asked to provide a definition of the concept in question in oral and written language and receive appropriate feedback as well. Based on the aforementioned model (Klausmeier, 1985) of the concept formation levels, a design pattern was formed in order to support teachers to encourage concept formation in diverse learning subjects within LAMS. The proposed concept formation design pattern is reported bellow as a sequence of learning activities:

(a) *Introduction to the activity* (using a *notice board*)
(b) *Identification of concrete representations, name and examples of the concept in question:* Provide the learners with learning materials aiming at the visual representation of the concept in question and its label as well as examples where the students can recognize the concept. To realize this activity, the use of a *Share Resources* (SR) is suggested.
(c) *Group formation* (using the grouping tool)
(d) *Identification of salient attributes of the concept and its definition*: Present students with examples and counter examples of the concept in question -using the *SR tool*- and ask them to describe its salient attributes and its definition. The use of the *mind map* tool is considered as appropriate to represent the knowledge of each group.
(e) *Identification of related concepts and their relationships to the concept in question*: Use of *a chat & scribe/forum & scribe* (*CS/FS*) for each group to identify relative concepts to the concept in question and their relationships. Use also a *mind map* tool to represent the mind map of each group regarding the concept in question and its related concepts.
(f) P*rovision of examples and non examples of the concept in question:* Use of a *CS/FS* for each group and ask students to present their examples and non examples of the concept in question and also discuss their ideas about the different attributes of the concept that is illuminated in these examples.
(g) *Provision of written and oral exchanges regarding the concept in question*: Ask students of the whole class to express their ideas regarding the concept in question, using a *wiki* in combination with the *mind map* tool to represent the mind map of the whole class regarding the concept in question. In addition, use of the *dim-dim* videoconference tool for oral exchange of the final student ideas regarding the concept in question.

Principle formation. Principles are generalizations describing relationships between or among concepts in a discipline. Principles have been classified as: cause and effect, correlation, probability and axiomatic (Klausmeier, 1985). Here as well, the *mind map tool* could be used to help students organize concepts into principles using the previously mentioned relationships.

Problem solving. The ability to solve problems is essential in human development. In fact, any goal directed behavior can be classified as problem solving (Anderson, 1983). Problems could fall into two broad categories: well defined and ill-defined. Despite the fact that, some general problem solving processes are lists of unordered strategies, various heuristic and specific strategies have been proposed to treat problem solving (Bransford and Stein, 1984; Frederiksen, 1984). A widely used model for problem solving is the IDEAL model (Bransford and Stein, 1984) that stands for: (I) Identifying the problem (D) Defining the problem (E) Exploring strategies (A) Acting on ideas and (L) Looking for the effects. Here, a brief description of the aforementioned processes is presented and then an attempt to describe a possible realization of these processes within LAMS is demonstrated. The difference between stages (I) and (D) is that in the (I) stage students have to recognize that there are some problems related to some topic while in the (D) stage they have to define the problem in some form eg. a diagrammatic presentation. The definition of a problem is interesting because it influences the types of solutions that could be considered. During the (E) stage; students have to explore diverse solution strategies to the problem at hand. In the context of this stage, some helpful strategies are recommended (Bransford and Stein, 1984): breaking a problem into manageable sub-problems, using special cases to simplify it and working backwards; that means beginning with the goal and then gradually tracing the steps backwards. During the (A) and (L) stages the problem solver repeatedly evaluates the current state of the solution, in terms of fulfilment of the desired goals, and when it is appropriate, redirects the said problem solving strategy to other strategies (Newell and Simon, 1972). During the whole problem solving process the role of group and whole class communication is essential. A representation of the IDEAL model of problem solving process as a design pattern within LAMS should be as follows:

(a) *Description of a situation* where some problems need solution (by using a *notice board*)
(b) *Grouping* of students (using the *grouping* tool)
(c) *Identification* of the problem in the said situation by each group (using a *CS/FS*) and present their ideas to the teacher through a wiki and then he/she share these ideas to the whole class using the *SR* tool
(d) *Agreement* on the identification of the problem using a whole class discussion (using a *CS/FS*)
(e) *Definition* of the problem within small groups (using a *CS/FS*) and present their ideas to the teacher through a *wiki* and then he/she share these ideas to the whole class using the *SR* tool
(f) *Agreement* on the definition of the problem using a whole class discussion (using a *CS/FS*)
(g) *Exploration* of possible solution strategies to the problem at hand, performed within small groups. This process could be realized using the *brainstorming* collaboration strategy (using a *CS/FS*). More than one solution strategies can be acceptable.
(h) *Acting* on the solutions in order to evaluate them in terms of correctness and quality within each group (using individual *notebooks* and a *CS/FS*)
(i) *Looking for* the effects of the proposed strategies to other disciplines and to the society within each group (using a *CS/FS*)
(j) *Reporting* the solutions using a *wiki* and submitting them to the teacher and then, the sharing of these ideas to the whole class using the *SR* tool
(k) Performing *whole class discussions* (using a *CS/FS or the dim dim)* on the solutions proposed by each group and making specific points based on the reports related to (A) and (L) stages.

Decision making. This process is closely related to problem solving that is also an activity that we all engage in, many times each day. In fact, the decision maker has to invent or choose the best among alternatives, taking into account essential criteria (Wales, Nardi and Stager, 1986). To this end, a 12-step decision making process has been proposed involving four operations: state the goal, generate ideas, prepare a plan and take action. Every operation includes three steps: Identify problems (Analysis), create options (Synthesis) and select operation (Evaluation). Thus, the aforementioned 12-step decision making process is as follows:

State the goal: Identify problems in a situation (step 1), create goal options (step 2) and select the goal (step 3)
Generate ideas: Identify goal problems (step 4), create idea options (step 5) and select ideas (step 6)
Prepare a plan: Identify the new problem situation (step 7), create plan options (step 8) and select plan (step 9)
Take action: Identify plan problems (step 10), create action options (step 11) and next actions (step 12).

This 12-step process could be used as a decision making design pattern. This pattern could be proposed by the teachers to their students when they have to be involved in a decision process situation. As students can decide through the use of a chat room and a forum, this design pattern can be attached as a wizard to these communication tools within LAMS.

Scientific inquiry. This is a major thinking process that includes problem solving and decision making but its purposes emphasize explaining and predicting. Different views of scientific inquiry share common characteristics such as; describing phenomena, formulating and testing hypotheses. To this end, some general models for the process of scientific inquiry have been reported (Marzano, Brandt, Hughes, Jones, Presseisen, Rankin and Suhor, 1988). Despite the fact that it cannot be claimed that students can be taught different models of data analysis and hypothesis testing, they can practice the general scientific inquiry process through the following procedure within LAMS:

(a) *Description of a situation* -through the use of a *notice board*- where a problem needs solution
(b) *Grouping* of students (using the *grouping* tool)
(c) *Identification of the problem* (using a *CS/FS*) and presentation of the ideas to the whole class in the way mentioned in the previous section
(d) *Agreement* with the identification of the problem within the whole class (using a *CS/FSe*)
(e) *Identification of what is already known* about the problem in the group level (using a *CS/FS*) and a *mind map* tool
(f) *Generation of hypotheses and research questions*: ask students to try to create relationships with what is already known, develop a theoretical model about the problem and its solution and finally, generate a hypothesis or a research question (through brainstorming using a *whole class CS/FS*)
(g) *Design a research experiment*: ask groups to design a specific experiment to investigate the hypothesis or answer the research questions stated in the previous phase and then conduct the testing experiment and collect the appropriate data (use *CS/FS and a wiki)* .
(h) *Data analysis*: ask students to organize and analyze the data relating it to the hypotheses stated in the previous phase. Ask students to interpret the data taking into account what is already known about the problem (use of a *CS/FS* in combination with a *mind map* tool and a *wiki*),
(i) *Discussion of the data* and determination of the extent to which these data disconfirm the hypotheses stated or fully answere the research questions posed and decision if these data can be used to predict other phenomena by designing new experiments (using a *CS/FS*)
(j) Stating of *conclusions* (use of a *Survey* tool) and presentation using a chat/forum or the dim dim videoconferencing system.

Composition. This is a process towards the development of a product. Writing has been acknowledged as one of the most cognitive operations (Nickerson, 1984). According to Flower and Hayes (1981) the nature of the writing process is far from linear; it is rather an interactive, 'looped' and recursive one. They propose a model for composition writing which consists of three main processes: planning, translating and reviewing, All these processes are performed under the control of the writer as monitor (Flower and Hanes, 1981). During the planning process the writer has to set goals that drive her/him to generate new ideas and then organize these ideas. This is a cyclic process because these new ideas probably should lead the reader to generate new more complex ideas etc. The translation of ideas is the process of putting ideas into visible –written- language. Finally, the reviewing process is a planned action where the writer reads critically what has been written, evaluates the ideas and the written text and makes appropriate revisions. The writer monitors the whole writing procedure by deciding when to move from the one specific process to the other. However, the role of communication is acknowledged as essential in the planning as well as in the revising processes (Proet and Gill, 1986). Based on the above, it will be useful to provide a generic design pattern –as a help for writing- within LAMS. To this end, the following collective writing design pattern is proposed to be attached to the wiki tool:

(a) Introduction -using a *notice board- to the topic could be addressed by collective writting*
(b) Generate ideas through brainstorming (by using a *CS/FS*)
(c) Organize the ideas presented during brainstorming (using the mind map tool)
(d) Translate the ideas of the mind map to visible language (using a wiki)
(e) Read the whole text and express ideas for its revision (through the use of a *CS/FS*)
(f) Revise the whole text, using the previous wiki. All the members of the group have to be involved.

Comprehension. Comprehension is the subjective process of extracting new information from various sources, interpreting and integrating it with what is already known to generate new meaning. Such sources would be; observing a phenomenon, reading, listening to something, looking at a sign, participating in an activity etc. Various strategies have been proposed to achieve comprehension (Marzano, Brandt, Hughes, Jones, Presseisen, Rankin and Suhor, 1988). These strategies acknowledge specific actions that have to be performed before, during and after reading specific material or attending a learning event. To this end, teachers have to provide students with opportunities to: (a) preview the information in terms of its focus, organization and preliminary aspects as well as activation of their previous knowledge, motivation and purpose, before reading (b) confirm/reject predictions, clarify ideas and construct meaning for specific parts of the information at hand during reading and (c) construct meaning of the information as a whole, assess the achievement of purpose, as well as consolidate and apply learning to new situations after reading. Based on the above, the following comprehension design pattern -that could used for effective studying of learning materials within LAMS- is presented:

(a) *Introduction to the activity* of studying learning materials (using a *notice board*)
(b) Provide a summary and a mind map of the information (using the *SR tool* and the mind map)
(c) *Provide information* and learning materials to the students through the use of the *SR tool*
(d) Grouping students (using the *grouping* tool)
(e) Prepare appropriate questions to motivate students and ask students to set purposes in order to be involved in the learning activity within a *CS/FS* in combination with the Q&A tool
(f) Activate students' prior knowledge within groups using a "Rountable' method within a *CS/FS*
(g) Ask students to read the materials and submit the new ideas they found in the learning materials they accessed (use of the Q&A tool)
(h) Ask students to focus on key ideas, clarify and evaluate them (use of a *CS/FS)*
(i) Ask students to select and organize the key ideas in a mind map (using the *mind map* tool)
(j) Ask students to summarize the new ideas, construct meaning, identify gaps and try to apply them in new situations using the *wiki* tool.

Communication. This process is central to the process of making meaning. Communication is usually supported within e-learning environments synchronously and asynchronously by using the features of chat rooms and forums correspondingly. The dim dim video-conferencing system could also be used for synchronous communication. Learners and teachers can take advantage of these features, in terms of allowing diverse communications, from any place and at any time. Despite these advantages, our data suggest (Kordaki, 2010), that these features are usually used -by non experts in e-learning- just as technical tools to support loose and weak communication, mostly ignoring the development of students' core thinking skills. This is probably due to the fact that these tools are not enriched in such a way so as to provide specific support for the user (teacher/student) to design their interventions within communication settings which can encourage learners' cognitive skills. Core thinking skills are used in metacognitive reflection as well as in thinking processes which are performed in the acquisition and performance of knowledge of each content area by the learners. Needless to say, these core skills are also implied in critical and creative thinking. To this end, a CSC-Wizard is proposed to be integrated in the chat and forum of LAMS, to act as a scaffolding tool for the design of communication interventions that support the development of critical and creative thinking and core thinking skills in learners. In fact, considering the core thinking skills (TSi, i=1,…26) -mentioned in the next section- nine different groups of Communication Labels (CL) were designed. These CLs (CLTSi, i=1,…26) are dedicated to the design of twenty six types of participant communication-interventions proposed to be used in chats and forums. The aforementioned CLs have the form of appropriate 'words' which can be selected by the user (teacher/student). Each type of CL is assigned to each different core thinking skill. For example, labels CLTS5 are dedicated to the encouragement of the development of the thinking skill TS5, and so on. In fact, for each thinking skill, at least two carefully designed labels have been designed for use by the users. A possible implementation of CSC-Wizard within the chat of LAMS is shown in Figure 1.

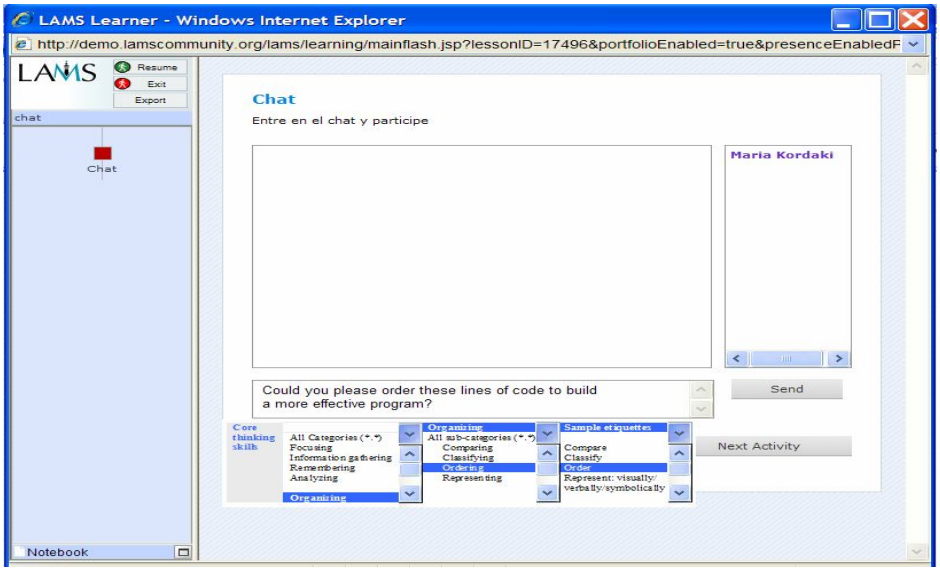

Figure 1. Integration of the CSC-Wizard within a LAMS chat room

Examples of the use of these CLs in the design of appropriate communication in terms of questions and examples could also be provided. In the following section, the aforementioned core thinking skills are briefly presented together with the proposed CLs.

C1. *Focusing skills*. Two skills are included: TS1) 'Defining problems'. That means clarifying situations that are puzzling in some way and TS2) 'Setting goals'. These skills can be used at any time during a task to clarify/ verify and also redefine one's efforts.

Proposed CLs: CLTS01: Identify/State a problem; CLTS02: Set/Propose a goal

C2. *Information gathering skills.* Skills included: TS3) 'Observing' involving obtaining information using learners' one or more senses, and TS4) 'Formulating questions' implying the focus on important information for clarification of essential issues through inquiry.

Proposed CLs: CLTS03: Observe, Focus; CLTS04: Form a question, Request

C3. *Remembering skills*. Here, fall the skills of: TS5) 'Encoding', that is the process of linking pieces of information to be stored in long-term memory, and TS6) 'Recalling' that implies the use of effective strategies to store information for easy retrieval.

Proposed CLs: CLTS05: Encode, Codify, Check; CLTS06: Recall, Retrieve, Define

C4. *Organizing skills*. Here are included the skills of: TS7) 'Comparing', that means finding similarities and differences between or among entities, TS8) 'Classifying', that is, grouping entities into categories based on some of their attitudes, TS9) 'Ordering' that implies the establishment of a criterion and the use of it to put entities in order or hierarchy, and TS10) 'Representing' that means putting information in such forms (visual, verbal, symbolic), so that the relationships of its critical elements are demonstrated in a meaningful way.

Proposed CLs: CLTS07: Compare, Contrast; CLTS08: Classify, Categorize, Qualify; CLTS09: Order, Arrange; CLTS10: Represent visually, Represent symbolically.

C5. *Analyzing skills*. Skills included in this category: TS11) 'Identifying attributes and components', that implies the analysis and recognition of the parts that constitute an entity, TS12) 'Identifying relationships and patterns' that means articulation of interrelationships among entities and recognition of the repetition of a pattern, TS13) 'Identifying main ideas' that is finding the main message or line in reasoning, and TS14) 'Identifying errors' involving the ability of detection of errors in logic and calculation procedures. These skills are crucial in the development of critical thinking.

Proposed CLs: CLTS11: Identify attributes/ components; CLTS12: Identify relationships/ patterns; CLTS13: Identify main ideas, Suggest main issues; CLTS14: Correct, Rectify.

C6. *Generating skills*. Under this category fall skills such as: TS15) 'Inferring' implying the ability to go beyond available information to identify what may be true based on learners' previous knowledge and reasoning, TS16) 'Predicting' that is the skill of anticipation of the progress and outcomes of a situation, TS17) 'Elaborating' that is improving understanding by adding relevant information and explanations.

Proposed CLs: CLTS15: Infer, Deduce, Reason; CLTS16: Predict, Estimate, Provide; CETS17: Elaborate, Process.

C7. *Integrating skills.* Two skills are included in this category: TS18) 'Summarizing' that means the learners' ability for condensing, selecting and synthesizing a cohesive statement from the data analyzed, and TS19) 'Restructuring' that is the ability of restructuring existing knowledge by incorporating new information.
Proposed CLs: CLTS18: Summarize, Conclude, Moderate; CLTS19: Restructure, Modify, Replay

C8. *Evaluating skills.* Here as well, fall the skills of: TS20) 'Establishing criteria' that implies the ability of establishing standards for judging about the value or logic of statements from both; philosophical and psychological points of view, and TS21) 'Verifying' that means confirming or proving a statement by using the criteria of evaluation established using the previously mentioned skill. *Proposed CLs*: CLTS20: Establish criteria/metrics; CLTS21: Verify, Ascertain.

Additional core cognitive skills that participate in critical thinking have been also reported (Matsagouras, 1997) such as: TS22) Separation between facts and opinions. This skill implies the learner's ability to separate their own personal opinions which are arbitrary and some times biased from some facts that can be confirmed using specific data. TS23) Implementation-Improvement. This skill implies the learner's ability to transfer the knowledge constructed -in previous stages- in similar/analogous cases. Making also improvements of the solution constructed. TS24) Knowledge organization. This skill means that the learner is capable of forming some diagrammatic visual hierarchical organization of the knowledge constructed during the data analysis and data transcendence stages of the experiment at hand. TS25) Empathy. This means the learner's ability to make sense of the other people's feelings and emotions of the situation at hand. So he/she can take a distance from a situation and accept the individual differences referring to it. TS26) Reflection. Reflection has been described as the mental process of looking back over the completed experience and performance to assess, analyze, and make connections to convert the experience into learning and to lead to new understandings and appreciations. Few people are able to convert personal experience to transferable learning, principles and models through the experience alone.
Proposed CLs: CLTS22: Differentiate facts/opinions; CLTS23: Implement, Improve; CLTS24: Organize, Structure; CLTS25: Support, Understand; CLTS26: Reflect, Think over, Acknowledge.

Summary

This paper proposed a view that emphasizes the provision of multiple aims -in terms of tools and learning design patterns in the form of blank sequences of learning activities- for the encouragement of students' thinking processes during their learning within LAMS. In fact, it was considered that providing tools in not enough for the teachers to appropriately design learning activities for their students towards the development of their thinking processes, namely: concept formation, decision making, comprehension of learning materials, composition, problem solving, inquiry based learning and communication. It was claimed that teachers needed specific support in order to appropriately use the tools provided. Specifically, the aforementioned design patterns could be linked with specific tools of LAMS to help teachers to use them effectively. To this end, a Critical Thinking Communication Wizard (CTC-Wizard) is also proposed to be integrated within chat and forum of LAMS in order to help teachers/students in the encouragement of core critical thinking skills during synchronous and asynchronous communication. Field research is needed, however, in order to investigate the impact of these design patterns and of the aforementioned CTC-Wizard on the quality of learning designs performed by the teachers, as well as on student learning taking place within the context of these patterns and communication supporting facilities.

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