Designing Collaborative Learning Sessions that Promote Creative Problem Solving Using Design Patterns

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Abstract

Solving problems is considered as a very important learning activity in formal educational settings concerning all grades of education from primary to tertiary education. Students' engagement in problem solving activities helps them to acquire not only knowledge and skills on a subject domain but also useful attitudes such as thinking, flexibility, creativity, and productivity which are very important to real life. As a result numerous problem solving models and creativity techniques, mostly collaborative ones, have been proposed for aiding students solve problems. These models specify the steps of a systematic process of solution-building for a given problem description. One main open research question is "how can students learn how to apply a problem solving model"? Research has demonstrated the potential of collaborative learning sessions for enhancing young children's cognitive development and learning. The scope of this paper is to show how collaborative learning flow patterns (CLFP) can help teachers to design effective interactive learning scenarios based on well defined strategies such as Jigsaw, TPS and others that can help students learn apply problem solving models and at the same time acquire higher-order thinking skills. It is argued that CLFPs are a designer friendly way to portray the coordination and the sequencing of tasks during the learning process as well as the rationale behind them. We will present a CLFP of a collaborative problem solving strategy called e-ARMA in an attempt to explain the added value of the use of CLFPs for designing learning sessions that foster the acquisition of creative problem solving skills.

Keywords

Creative problem solving techniques, design patterns, CSCL

Introduction

Creativity is being seen as a "universal attribute, suggesting a need for greater creativity in order to both survive as well as thrive in the twenty-first century" (Craft, 2006). Finding a creative or innovative solution to a problem is often a collaborative achievement. Coordinated action of all team members is required in order to construct an innovative solution to a problem, making maximal use of the collective creative power of all team members. More than 90 creativity techniques have been proposed such as TRIZ, SCAMPER, Six Hats, 5W1H (http://www.mycoted.com/Category:Creativity_Techniques). All techniques try to steer thought processes and help the individual or the group to find a structured approach to answer questions, to see problems in their entirety, generate new ideas and to reach to faster and better decisions. They specify the steps of a systematic process of solution-building for a given problem description. This process includes the steps and their order via which one can define problem, generate and propose alternative solutions, predict the consequences of each alternative, evaluate and select the best alternative.

One crucial and open question is how students can be creative? It is not enough to focus on helping learners understand the principles of a given creativity technique and on making them better able to effectively and

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efficiently apply it in real practice. Fostering creativity is increasingly seen as a key direction and focus for pedagogic approaches from nursery education, through the compulsory years to higher education and work based environments (Glor, 1998). According to Amabile's study (1996) individual creativity can be mediated by the group and can be supported by the social environment and management. Support of collaborative inventive and creative thinking and problem solving has to deal with intensive interaction and collaboration of participants and evolving artifacts during exploration.

Literature on use of explicit, dedicated pedagogical strategies to enhance of creative problem solving is relatively scarce (Baruah and Paulus, 2008). The most well known strategies, which have been proposed to help groups and individuals to collaboratively find creative solutions to given problems, are Pyramid, Jigsaw, TPS and few others (Bitter-Rijpkema, et al 2002; Paulus & Brown, 2003).

The goal of this paper is to introduce the idea of blending a problem solving model with collaborative learning methods in order to effectively design learning sessions that will promote collaborative learning, knowledge sharing and creative thinking. Thus the e-ARMA learning strategy will be shown as an example of such attempt. eARMA is a strategy for helping learners understand the problem solving process as well as for fostering the ability to regulate their thinking when solving problems in computer supported collaborative learning settings. eARMA is based on Stenberg's problem solving model (Lazakidou & Retalis, 2010).

Designers (particularly novice ones) need guidance, advices and support in order to produce effective designs. On the one hand guidance and advice need to be based on solid research and empirical findings. On the other hand, they should not be is too prescriptive, or based on a single model, since they won't help designers to create innovative designs, suited to their particular context, that make the most of new and evolving technology. Design patterns is an effective medium for offering non prescriptive guidance to designers. Thus, the eARMA strategy, which has been applied with positive results in real classroom environments, will be presented via a collaborative learning flow design pattern (CLFP). It has been proved that eARMA CFFP helps teachers learn how and when to use it.Moreover, since there are several collaborative learning and creativity strategies, a novice designers may face difficulties in selecting the most appropriate one. In this paper, we also present a set of criteria that can aid an educational designers choose the most appropriate strategy for his/her educational context.

The paper is structured as follows: the idea of using design patterns, and mainly the CLFPs, for aiding novice educational designers will be shown. In the appendix the CLFP of the eARMA strategy will be presented. Then, the way to help designers choose when to use a specific strategy or select from a set of candidate strategies will be discussed. A set of selection criteria will be presented. It will be shown that CLFPs contain the information based on which novice designers can judge whether they can use it for their specific context or not. The paper ends with future research ideas.

Helping novice designers create collaborative learning scenarios – The notion of collaborative learning flow design patterns

In order to help designers in creating learning scenarios, strategies need to be described in a designer friendly way. According to Goodyear (2005) and Hernández Leo et al. (2006) pedagogical strategies can be described via design patterns which is a user friendly way to illustrate them. As a consequence various pedagogical design patterns can be found in the literature. Recently, creativity techniques have also been described via design patterns and especially via the specific type of design patterns called flow design patterns (Georgiakakis & Retalis, 2009). The term "flow pattern", and more specifically the term "collaborative learning flow pattern (CLFP)", was originally coined by Hernández Leo et al. (2006) to portray coordination and sequencing of tasks of a learning process. Thus, the CLFP define the sequence of the tasks that the technique dictates as well as other elements needed for the various tasks, such as the duration of a task, the use of a particular tool for a given task and so on.

A CLFP is an attempt to illustrate and disseminate the "best design practices" with respect to a problem or class of problems, to share the experience, to transfer knowledge from experts to novices designers. These resources are richer than guidelines or scripts because they contain well justifiable solutions and examples to design problems as well as the rationale behind these solutions (Goodyear at al, 2004). CLFP's are all about reusability, which seems to be the keyword in achieving an economy of scale for developing affordable and effective CSCL learning scenarios (Garzotto & Retalis, 2009).

The structure of a CLPF includes elements such as design problem's description, the related context and a documented solution suggestion for this problem with concrete examples. This specific has been proven useful and fully understandable by practitioners. Actually, the proposed format slightly differs from the one proposed by Hernandez-Leo et al (2005). It contains an additional element which is called "variations". This element contains ideas for alterations of aspects of the proposed solution when specific circumstances occur

An example of the eARMA CLFP is shown in appendix A. According to the eARMA strategy, the collaboration process plays a vital role; it operates as a means to help students proceed from the passive to the active state of thinking. According to the eARMA, a learner can develop his/her creative problem-solving skills through a learning process comprosed of the following phases:

- observation of an exemplary problem solving process using Stenberg's 6 steps model
- collaboration in a group of 4 to solve a similar problem
- collaboration in a group of 2 to further practice the model of problem solving and
- semi-guidance to advance the adoption of exemplary model of problem solving.

During problem solving activities learners are expected to apply the Sternberg's model of six steps (Sternberg, 2003) which are: problem identification, definition of problem, constructing a strategy, organizing information, allocation of resources, monitoring and evaluating problem solving. During the "collaboration of four" phase each step of Sternberg's model is performed by a different member of the group by turn. When learners are called to work in pairs, they play two roles: the observer and the active problem solver. The observer monitors the way the active problem solver applies and intervenes whenever the problem solver does something wrong or faces difficulties.

As it can be easily seen the eARMA CLFP description is much richer from a collaborative learning. A script describes only the way learners have to collaborate: task distribution or roles, sequencing, turn taking rules, deliverables, etc. (Kollar et al., 2006). A CLFP of a specific strategy description contains all the above as well as information about the rationale and the context of its use. This information is very useful because it can help an educational designer to choose the most appropriate strategy or when to use it.

Choosing the appropriate strategy

Taking for granted the variety of collaborative problem solving strategies, an educational designer (especially a novice one) needs help in choosing the most appropriate strategy for a specific context. The choice should be based on criteria such as the type of learning objectives need to be accomplished, the complexity of implementing a strategy, etc. Hernández-Leo et al. (2006) have identified characteristics of collaborative learning strategies that can help practitioners select the most appropriate strategy. These characteristics are:

- Learning objectives. An example TAPPS strategy can help in accomplishing the procedural objective of "promoting analytical reasoning skills".
- Types of problems that are best served with the strategies. For example, Jigsaw is most appropriate when a problem to be solved is "complex and can be easily divided into sections or independent sub-problems".
- Complexity or risk in terms of collaborative learning experienced needed. For example Jigsaw is complex and is probably more appropriate for experienced participants.

Also, the creativity strategies can be categorised by a number of criteria that belong to contextual factors (idspaceD2.1, 2009). These criteria are:

- Physical Requirements: The technique has physical requirements
- Emotions: A technique depends on the emotions of the users
- Complex: Complex shows if a technique is considered being complex
- Interactive: Interactive shows if the technique contains interactive elements

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Taking into consideration the aforementioned ideas, we propose that each strategy should be characterized using the following criteria in order that a novice educational designer can easily choose the most appropriate one to his/her educational context. The criteria are the following:

complexity: low|high

- type-of-problem: closed|open
- physical-requirements: yes|no
- emotions-dependent: yes|no
- interactive: low|high
- supporting-action: exporation|combination|transformation|evaluation // characterization by Boden
- distance: short|long // the distance between an given input and the possibly resulting idea
- moderator: yes|no
- expert_participants: yes|no

As an example eARMA strategy can be characterised using the above mentioned criteria as follows:

- complexity: high
- type-of-problem: closed
- physical-requirements: no
- emotions-dependent: no
- interactive: high
- supporting-action: exporation, combination, evaluation
- distance: short
- moderator: no
- expert_participants: yes|no

More elaborated description of these selection criteria can be found in (idspaceD2.1, 2008). Each CFLP could contain meta-data which can help the practitioners easily understand whether a sparticular strategy fits well to the given context/problem under investigation or not.

Concluding remarks

This paper presented the idea of using collaborative learning flow patterns (CLFP) as media for guiding novice educational designers in creating collaborative learning scenarios via which learners can acquire creative problem solving skills. The example of the eARMA CLFP has been given in order to help the reader get a better idea of how rich the description of a strategy can be when the CLFP format is being used. Also, criteria for categorising these strategies, which are based on findings of research studies in the areas of computer supported collaborative learning and groupwork, have been presented. The next steps are to present these criteria in a computable form and build a rule-based recommendation tool. This tool needs to be tested by practitioners and experts in learning design in order to validate both the criteria as well as the recommendation engine.

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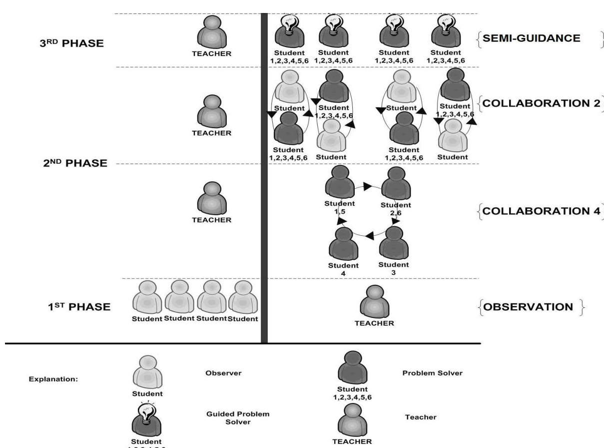
Appendix 1. e-ARMA CLPF (Collaborative Learning Flow Design Pattern)

Element	Explanation	
Name	e-ARMA	
Context	In everyday life people are asked to solve problems effectively. They are also called to solve problems in collaboration with peer. The problem solving process is not always obvious and sometimes people have to struggle for finding out how to reach to the best solution. Moreover, typical problems are not mere routine applications of formulae but real-life problems. For example, a mother who desires she and her daughter to lose weight needs to create a diet menu that will respect their different nutrition needs and habits. In order to solve such problems, learners are required to develop skills that concern monitoring their thinking process, recognizing how close they are in relation to their goals, evaluating the outcomes of their solving process, and adjusting their solving actions/plans. In primary and secondary schools the acquisition of problem solving skills is of great priority. The usual teaching approach which advocates the repetitive practice at problem solving, can help learners gain routine expertise, may develop speed and accuracy at routine problem solving, but fail to develop the ability to reflect on what they do or to adapt to solving new problems in a	

<table>
<tr><td></td><td>flexible manner. However, a process-based teaching approach can aid learners develop problem solving skills as well as trigger learners' awareness of their own thinking processes (Brown, 1987). Also, by organizing collaborative problem solving sessions in the spirit of proactive cooperation and shared effort that can lead to better, more creative and effective solutions as well as shared knowledge construction. Learners' interaction toward a common goal often tends to regulate each other's actions resulting to the solution of difficult problems that learners might not be able solve when working independently.</td></tr>
<tr><td>Problem</td><td>How can a teacher help learners acquire individual problem solving skills, but also increase the collaborative attitude?</td></tr>
<tr><td>Solution</td><td>Use eARMA which is a strategy for helping learners understand the problem solving process as well as for fostering the ability to regulate their thinking when solving problems in collaborative settings.
eARMA includes three phases :
1st Phase: Observation
2nd Phase: Collaboration
3rd Phase: Semi-Guidance
A solver after having performed the problem solving tasks of the three phases, she can reach to the level of autonomous problem solving.
During each phase a problem solving model which consists of well defined steps is being utilized (e.g. problem definition, relevance to past problems, etc.). eARMA suggests the use of Sternberg's problem solving model.
The main idea behind the eARMA strategy is that it provides problem solvers with adequate opportunities to help them learn how to solve a problem following a series of well specified steps and in a discourse with peers. Gradual removal of the collaborative learning opportunities occurs taking into account children's increasing mastery of the problem-solving strategy as well as their self regulation skills.</td></tr>
<tr><td>Actors and actions</td><td>The phases of eARMA is shown graphically below:



During the first phase (observation) a learner observes a problem solving model [DISPLAY SOLUTION] and how it is implemented during the problem solving process. For example, a teacher, who plays the role of an expert solver, can make explicit her thinking tasks when applying the Sternberg's problem solving model (Sternberg, 2003) that includes seven steps:

<u>Identification of the problem</u>
<u>Definition of the problem</u>
<u>Constructing a strategy</u>
<u>Organizing information</u>
</td></tr>
</table>

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	5. <u>Allocation of resources</u> 6. <u>Monitoring the solving process</u> 7. <u>Evaluating the solving process and outcome</u> During the second phase (*collaboration of four* and *collaboration in dyads*) learners try to mimic the observed problem solving process in quite similar problems. Each learner is responsible for a step. Peer learners watch how a team member performs a step and either accept the proposed actions or discuss other possible actions. The goal is that all group members share responsibility for the actions of each step irrespective if a specific learner had the duty to perform the specific actions of a step. In the collaboration of two learners solve at least two similar problems alternating the roles of active and passive solver. As an active solver they solve the problem based on the observed problem solving process. As a passive solver they observe their partner to solve the problem maintaining the right to ask, object, disagree and propose different answers. The third phase (*semi-guidance*) includes an individual problem solving process where learners have to find solution to problems by following the steps of the problem solving model in the way they have taught. All collaborative learning actions can take place in a computer supported collaborative learning environment where a problem solving space is either shared among the group members or isolated allowing some space for individual thinking [SHARED COLLABORATIVE SPACE]. Also, WELL CHOSEN RESOURCES such as a video of a problem solving process, mathematical formulae, etc. need to be given to the learners in order to utilize them during the problem solving process.
Types of Tasks	Various types of problems, especially from science education domain can be solved using the eARMA strategy. It is recommended that all problems solved during all phases of the e-ARMA can be a wrapped around a story. For example, a story about nutrition consisting of various mathematical problems such as calories, energy, fats etc. can be used. The first phase of eARMA focuses on learners' observation of how a typical problem is solved by a teacher according to the problem solving model that teacher selects. For example, Sternberg's model consists of 7 steps. In order a learner effectively perform a step, she can answer to a set of questions. More specifically, STEP 1. <u>Identification of the problem:</u> Have I solved a similar problem before? STEP 2. <u>Definition of the problem</u>: Are there any key points which could help me? How is the specific problem connected to what we have been taught? Which of the persons could I be in order to participate in this problem? STEP 3. <u>Constructing a strategy</u>: Why do I choose this strategy? When should I choose a strategy like this? What would happen if I chose another way of solving the problem? Is there any? How could I use the related theory I've been taught? How would I be certain of the accuracy of my procedure? What would be that thing that would make me choose x way instead of z method? STEP 4. <u>Organizing information:</u> Should I make an illustration of the problem or tables in order to avoid any misunderstanding? How would the related formulas be useful in my problem? STEP 5. <u>Allocation of resources:</u> How would I manage the available time? At which point should I intensify my concentration and my efforts to make up for my weaknesses? How am I sure that I have exploited correct the available resources? STEP 6. <u>Monitoring the process</u>: To what extent does the initial process of my plan differ from the way I continue? How would I improve the allocated solving phases? Why did I make this mistake? STEP 7. <u>Evaluating the process</u>: Why did I choose x instead of z method? When would I choose z way? In what way could I use this

	problem in solving other problems? How useful would this problem be in my daily life? What was the message of this problem? After observation, learners [FORM GROUPS] of 4-6 learners (homogeneous or heterogeneous groups) and ask to collaboratively solve problems in a cyclical turn of discourse. This means that each learner undertakes the duty to perform a step and give answers to the questions of the relevant step. While a learner gives answers to the questions of a step, the peer learners can intervene and provide modifications or additions. It is recommended that during the second phase, learners are exposed to more than one problem in order that learners change roles in the problem solving process. The problems should be a bit more difficult. Every group of four divides into two groups of two where each member alternates the role of active and passive role of problem solver in two problems. After that task learners accept guidance (namely, the steps are given in a learning material form) about the problem solving steps of the model and they are asked to solve a new problem according to the guidance. Finally, they are ready to solve the problem without any help.
Examples – Known uses	eARMA has been effectively applied to primary and secondary schools. A typical example is the following. In terms of maths problem solving in 5th grade of primary school, a set of ten story-problems had been created (Lazakidou & Retalis, 2009). Every story included mathematical problems concerning the topic of diet (nutrition, malnutrition, genetically modified foods, eating disorders etc.). An example of a problem-story "Tom's mother suffers from anorexia and she weights 42 k. She needs to take 800 calories every day to increase her weight up to 44 k. in two months. What combination of food could she make in order to cover the necessity of 800 calories every day?" Using the Synergo tool, a synchronous computer supported collaborative concept mapping tool which also allows learners to chat while shared, the various collaborative tasks of the eARMA strategy for helping learners acquire self-regulated problem solving skills in Mathematics, has been performed.
Variations	Instead of the Sternberg's model a teacher may select the IDEAL problem solving model (Bransford & Stein, 1984). It includes five steps according to which: 1. Identify the problem 2. Define the problem through thinking about it and sorting out the relevant information 3. Explore solutions through looking at alternatives, brainstorming, and checking out different points of view 4. Act on the strategies 5. Look back and evaluate the effects of your activity Otherwise, there are other problem solving models that a teacher may select one of them depending on the type/domain of problems need to be solved. The collaborative phase of the e-ARMA strategy can be a mixture of phases from other collaborative strategies. For instance, instead of having each group working alone, one may select that learners, who share similar roles such as those of the identifier (of the problem space), organizer (of the given data) explorer (of the potential strategies), and evaluator (of the problem solving process), can collaborate like Jigsaw strategy suggests. This variation is needed when problems are quite complex, the solvers are not expert and groups are not in a competitive mode.
Related Patterns	DISPLAY SOLUTION, WELL CHOSEN RESOURCES, FORM GROUPS, SHARED COLLABORATIVE SPACE
References	Bransford, J.D., & Stein, B.S. (1983). *The IDEAL problem solver: A guide for improving thinking, learning and creativity*. NY: W.H.Freeman. Brown, A. L. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 65-116). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

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