Design of a Multi-interface Creativity Support Tool for the Enhancement of the Creativity Process

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Abstract. This work examines the influence of the different working environments during the execution of a creativity process. The selection factor used for the decision is each user's learning style. For the examination of how this is perceived by the users and to test how this influences the creativity process within a Creativity Support Tool a prototype has been developed. The paper describes the prototype as well as its pilot testing by a group of users.

Keywords: Learning Styles, Creativity, Creativity Support Tools, Context.

1 Introduction

Creativity Support Tools (CSTs) are designed to facilitate users in generating innovative ideas related to existing open problems, or to new problems that appear on the scene. In the existing literature, we can find CST design approaches that simulate the creativity while supporting some of the most known Creativity Techniques, like brainstorming. The research interest in the plurality of these approaches focuses on finding methods that process the content, and use AI techniques to produce innovative ideas or creative outcomes automatically. The current work attempts to examine the creativity process from a different point of view, and this is, the examination of how different interfaces and different types of interactions influence the user's creativity effort during the creativity process.

Creativity is an ability carried by all people, but the level of creativity that each person has is different. Levels of creativity depend on how the person's creativity has been cultivated and amplified. Plucker and Beghetto [1] define creativity as "*the interplay between ability and process by which an individual or a group produces an outcome or product that is both novel and useful as defined within some social context*". In this work we use the latter definition for the development of a multi-interface context aware CST prototype which enhances the creativity process. The proposed approach elaborates the selection of a working environment based on the user's learning style with the belief that this can enhance the user's creativity. The prototype of this work aims to examine the influence of the user's learning style as a

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decision factor for the most suitable interface that the user can work with. We also describe the design methodology used for the implementation of a context aware CST, adapted to the user's learning style.

The exploration of learning process has inspired development of a variety of learning style models and categorizations. Kolb's learning style theory [2] proposes that learners can be classified into convergent learners, divergent learners, assimilators and accommodators. Honey and Mumford [3] present another interpretation of Kolb's theory and categorize learners into activists, pragmatists, reflectors and theorists. Gardner's Multiple Intelligences Theory [4] proposes seven intelligences: verbal, logical, visual/spatial, musical, interpersonal, intrapersonal and bodily. Felder-Silverman Learning Style Theory (FSLSM) [5] characterizes each learner according to four dimensions: active/reflective, sensing/intuitive, visual/verbal and sequential/global.

Although the learning style theories have been applied in educational environment widely, only recently researchers have started to undertake them in the computer-supported ones. The learning styles proposed by Gardner [4] in the work for Multiple Intelligence Theory and the related tests are considered as the most relevant to this work in relation to the use case scenario which is described in the following sections. Gardner proposes seven learning styles which can be simulated within a Creativity Support Tool representing a real case scenario. In our belief, for the implementation of a CST prototype which simulates a Creativity environment in a realistic way, the Gardner's tests appear to be the most simplified but at the same time accurate tests for the determination of a user's learning style.

In particular the document is organized as follows: Section 2 elaborates the motivation for the current study through a use case scenario; Section 3 describes a proposed context aware multi-interface Collaborative Creativity Support Tool (CCST); Section 4 describes the pilot testing of the prototype and finally the paper ends with the conclusions in Section 5.

2 Motivation

The perception of creativity in real life is correlated to innovation and exploration. A very common use of creativity in real life is the conversation. When two or more people exchange opinions on a subject, then this conversation consists of a creative process. Therefore, creativity is the set of ideas, opinions and conclusions that arise from stimuli that environ the participants of a creative process. In real life, stimuli are defined by the environment where a creative process is taking place. For example, if a group of people walk in the street, they will change their discussion subjects according to what they see during their walk. An artist who might see an extraordinary object will inspire her future work, while a group of scientists will use images, texts or figures to solve a difficult problem. In any of the aforementioned scenarios, the environment where the creative process takes place influences how each person perceives creativity, and how she participates in a creative process.

This study aims to explore how realistic creative processes can be supported by means of ICT and more specifically, to examine how the use of multiple interfaces during a creative process influence the creative productivity of the user. The motivation for this work emerges from the examination of the existing Creativity Support Tools from our previous work [6] from which none of the examined tools was supporting or enhancing creativity methods. The real life creative examples mentioned at the beginning of this section lead to a more precise examination of how the use of more than one interface can influence the creative ability of a person who uses a Creativity Support Tool to solve a problem or to find an innovative idea.

In the rest of this section we will present a real life scenario of a creative process that takes place in a classroom, and then we will describe how the same use case scenario can be applied with the use of a Creativity Support Tool.

2.1 Real Life Use Case Scenario

A group of 15 students attending a university course in applied mathematics are asked to solve a difficult mind-bending problem. The professor who teaches the course wants to examine the way of thinking of his students in problem solving processes. He initially describes the problem orally and asks the students to either collaborate in finding the solution or to work individually. He provides the following problem:

> *"You have a balance scale and 12 coins, 1 of which is counterfeit. The counterfeit weighs less or more than the other coins. Can you determine the counterfeit in 3 weightings, and tell if it is heavier or lighter"* [7].

Some of the students are taking notes while the professor describes the problem, and others listen carefully to the description. After the professor asks them to start working on the problem, one of the students asks him to write it on the white board, so that they can read it again and catch details that they probably missed. The professor writes the problem on the white board and asks them to work for 10 minutes on the collection of ideas related to the solution.

Six of the students start working individually and the rest of the students are working in groups of three. The professor observes the students´ working processes and their reactions. The students are working as follows:

- The students who work individually are writing their ideas for the solution methodology on a paper. For every idea they write, they review it crosschecked to the problem and either they continue writing a new one or delete the last. One of the students creates twelve paper balls and marks one of them as the fake one. He uses the paper balls as the coins referred to by the problem and he divides them into groups while he is taking notes. A third student is continuously reading the problem loudly. He makes some pauses to think and sometimes he writes some notes and diagrams. One other student is trying to solve the problem using mathematical equations and symbols.
- The three groups are working in a similar way. Their difference with the students who work individually is the fact that they collaborate with each other and they provide ideas after discussion. An interesting point is that each individual member of each group uses a different method of idea collection, similar to the students working individually. Each collects his ideas individually using either diagrams, or notes or paper balls, and when she has a good idea puts it in a common pool of ideas for discussion. In most of the cases when the group members explain ideas

for possible solutions to the other members of the group, they use different methods of demonstrating the ideas, such as design on the white-board, mathematical equations or oral speech.

When the time is over the professor asks the students to present their ideas and the problem solution, if they have one. The professor collects all ideas on the white-board and he begins an interactive conversation with the students for each methodological idea provided. Through the discussion they select the best ideas that seem closest to the solution, and they test the solution using figures and diagrams on the whiteboard.

2.2 The Use Case Scenario Using a Multi-interface Creativity Support Tool

The scenario described in sub-section 2.1 describes the case of a problem solving process that employs the use of conventional methods. In this paragraph we will attempt to adjust the same scenario into problem solving process, using a Creativity Support Tool and taking into account the different users´ learning styles. For better understanding we assume that the CST of this scenario has two different user groups with different user rights. These are the “moderators” and the “learners”.

Assumptions:

- The professor of the class belongs to the first user group which has more user privileges since he is the person who moderates the students/learners in their participation of the problem solving process.
- The students belong to the “learners” user group.
- The Creativity Support Tool we refer to is a web based Collaborative Creativity Support Tool (CCST) which can adapt the content according to the learning style that each user has.
- The CCST supports interfaces for 5 different learning styles; literal (**L**), musical (**M**), visual (**V**), interpersonal (**I**) and intrapersonal (**Intr**) [4].

The moderator uses the CCST to create a new creativity session for finding a solution for the 12 coins problem. He registers to the system and creates a new creative project by writing the problem description. After that, the moderator selects the participants/learners and he sends them an online invitation to participate in the creativity session for finding a solution for the problem. From the problem setup screen, he also defines options that reflect to the overall creativity process like “limited time=10 minutes”, “synchronous activities”, “Begin time and day”, etc.

The learners receive the invitations and they register onto the system at the defined date and time that the session is scheduled by the moderator to start. The first time the users register to the CCST, the system provides them with a learning styles questionnaire [8] which is mandatory to complete. The results of this questionnaire are saved to their profiles for the systems computations by the adaptation mechanism that the system supports. The adaptation mechanism is used for the selection of the content presentation method taking into account each learner’s learning style.

Taking into consideration the conventional case scenario from the previous sub section, the participants of the creativity session can be categorized according to their learning styles using the following pattern.

- Learners who repeat the problem loudly or ask the professor to repeat the problem description, belong to the musical learning style group.
- Learners who write the problem, take notes and write down their ideas, belong to the literal learning style group.
- Learners who design diagrams or create paper balls to experiment with, belong to the visual learning style group.
- Learners who work in groups and try to find a solution in collaboration with other learners, belong to interpersonal Learning style group.
- Learners who work individually belong to the intrapersonal learning style group.

The CCST classifies the users in the groups they belong to based on the above pattern and, with the use of a recommender system, it recommends to the users to accept the interface that corresponds to their learning style as a way to work. For the (**L**) group, the presentation of the content is text based. The problem description, the ideas surrounding the problem, tips for the user actions and all context information correlated to the problem is presented as text. The input is also text and it is supported by provision of word synonyms aiding the literal user to express an idea using the correct words. For the (**M**) group the interface contains a text to audio transformation system which offers to the learner the possibility of hearing what it is written in the screen. For the (**V**) group the problem description and the ideas provided for the problem are presented in a diagram. There is also a recommendation mechanism which provides images related to the problem and the user is able to select the images and add them in the diagram. The (**I**) group supports all the above interfaces for the users, but additionally offers the possibility for real time collaboration with other users. The collaboration method allows the synchronous collaboration between the learners as well as communication methods such as chat. The interface provided in each group member adapts the input content following the aforementioned adaptation pattern. For the (**Intr**) group the system does not allow the collaboration between the learners but it offers the learner the option to change into an (**I**) group.

When the session's time is over all ideas provided by the learners are collected into a diagram which is visible by all learners and the moderator. All learners vote on the best ideas and finally, the moderator collects the ideas with the highest scores as the problem's solution approach. With these ideas, each learner is able to understand the problem solution methodology.

3 Description of the Multi-interface CCST Prototype

In order to explore the ways in which adaptation of the working environment of a CST based on the learning styles of users who participate in a creativity session, we developed a multi interface Collaborative Creativity Support Tool prototype. The proposed prototype implementation that we present in this work consists of a simplified version of a CCST. For the aims of this work, we are using one creativity technique, brainstorming; and we implement two interfaces for two learning styles users, the literals and the visuals.

3.1 System Architecture

The prototype is a web based application, and it is designed following the three tier architecture principles. It is written in the PHP scripting language and it uses mysql as the backend database engine. It includes middle tier modules such as a synonyms suggestion mechanism, and a rule based context aware mechanism for identifying the user's actions and deciding the proper working environment and the content's adjustment to it. In particular, the system's architecture consists of three parts, the database, the application logic and the presentation. The most important part is the application logic which includes all the partial modules of the application. The modules of the application are independent sub-applications that are designed for specific system functioning. All modules are managed and triggered by the application logic part with the use of the context aware module. Each module as they are shown in Figure 1 is described in the continuation of this section.

- *Data transformation module* is the mechanism responsible for the transformation of data between the different interfaces. The existence of more than one interface presumes the existence of such a module. When data is input via an interface, this data must be available for use by other interfaces too. This is because users that belong to different learning styles groups and therefore work with different interfaces must have access to this data if they need it. Thus the transformation mechanism can recognize the type of presentation that must be used and adjust the contents in the correct form. The correct functioning of this module also depends on the database schema and the data storage structure used. The transformation mechanism contains several queries which they are adjusted in each particular case according to the interface they have to fill.
- *Interface Selector module,* in combination with the *context aware module*¸ identifies the current browsing location of an active user, and by taking into account the user's learning style, it loads the corresponding content to the interface styles and graphics to setup the interface.
- *Context aware module* tracks the user's actions and loads all the profile context information for every user. The context aware module consists of a rule based reasoning method on which the rules are determined according to the user's action, her activities and her learning style.
- *Learning styles classifier module* contains the learning styles questionnaires [8] and it is triggered the first time a user logs in to the system. The module contains also a scoring method and the necessary queries to classify the new user into a learning style group and update the user's profile.
- *Synonyms module* consists of a method of synonyms propositions, for the user, while she is typing text input to the interface. It uses an existing thesaurus [9] and with the use of ajax technology when a new word is entered into the system the synonyms suggestions appear in the screen. The user is able to select a synonym with a single click and continue the typing.

For the implementation of the prototype, some existing technologies have been used. As already mentioned at the beginning of this section, the prototype is written in PHP and mysql. The ajax prototype framework [10] is also used as well as the MobyThesaurus [9] taxonomy and the MindWeb [11] mind-map tool. The MindWeb

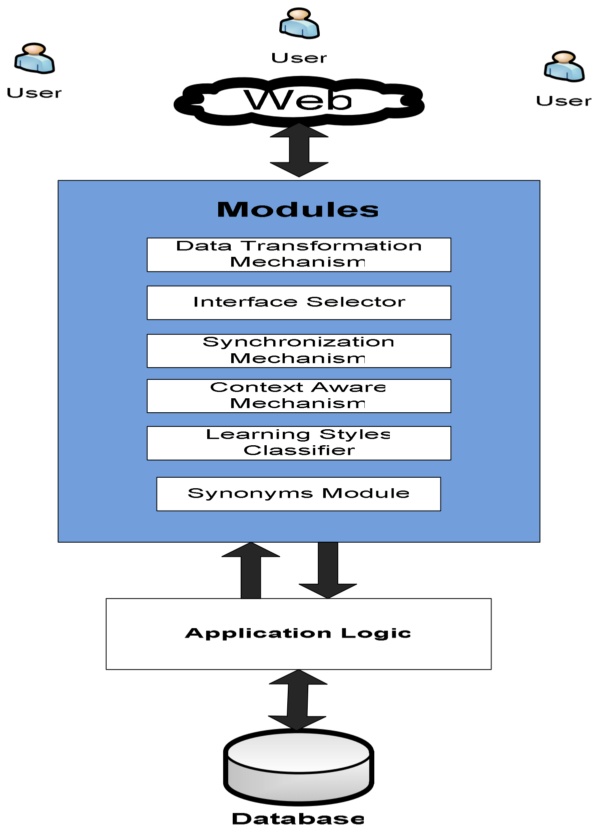

Fig. 1. System Architecture

mind map tool is modified for the purposes of this work in order to connect with the database and build its mind maps for each defined problem dynamically, on the fly. The connection with the database and the dynamic mind map build is not supported by other known mind map tools.

Due to lack of space, we provide a text based description of the implemented interfaces, rather than a set of screenshots.

- *Interface Approach for Literals***.** Users who belong to the literal learning style category are more comfortable in working with texts. They prefer to read text as well as write text. For this reason the proposed prototype supports a working environment based on text. The problem description, the ideas input from other users and the active user's ideas are presented on the screen in text form having a top to the end sequence of appearance. Literal users are also competent in selecting the proper words when describing a problem or an idea, thus the input forms of this interface are supported by a word proposition mechanism. This mechanism suggests to the user synonyms of the last entered word helping in writing well defined sentences and at the same time providing help in generating new ideas based on the suggested synonyms.

- *Interface Approach for Visuals***.** Users who belong to the visual learning style group are more comfortable in working with images. They prefer to design diagrams and create a visual effect of what they have in mind. Therefore the visual working environment is based on a mind-map diagram on which the root node is the problem description and the ideas surrounding the problem are nodes connected between each other with edges. The interface contains small icons that the user can add to the idea nodes and images that can be used as ideas. In the case of adding an image as idea, the user must also add a textual description of how the idea is related to the image regarding to the problem so this can be used by the literal working environment too.

4 Evaluation

For the pilot testing of the prototype, a group of 15 postgraduate students from the Computers Science Department of University of Cyprus with working experience in the IT sector, were asked to participate in an evaluation session and asked to register to the platform and work on a specific problem together. Six of them were female and nine were male. The purpose of this evaluation was to determine how the users perceive the use of an interface adapted to their learning style and proof that each user can work more comfortably with an interface that corresponds to the learning style they belong. For the aims of this evaluation we selected the 8 users from the overall group of 15 based on their results after they completed the learning styles test. The selected users were those who classified to the learning styles that the prototype supports, visuals and literals. Five of them were belonging to the visuals learning style group and 3 of them were literals.

Before the beginning of the evaluation all users received three common tasks to complete on the prototype, and a post task questionnaire to complete after each task. The aim of this pilot testing was the subjective assessment of the users so the 8 testers received a post test questionnaire to complete after they finish the three tasks. The three tasks given to the users were:

- *Task 1***.** Given the 12 coins problem if you think it is not well described please rewrite it in your own words using the Synonyms module.
- *Task 2***.** Provide three to five ideas for the defined problem**.**
- *Task 3.* Select the ideas that can be used as suitable solutions for the problem.

The first task aimed at the observing how helpful the synonyms module is, in describing a problem clearly and in examining how useful the module is for each learning style users.

The second task aimed at the examining how the users were able to provide new ideas by viewing ideas coming from other users in the two forms of presentation they were using. The visuals were viewing the ideas as a mind-map and the literals as a list of numbered sentences.

The third task aimed at examining how the users, literals or visuals, could manage the overall list of ideas using the two interfaces for identification of the most valuable ideas that could be used as solutions.

The post-task questionnaire included four 7-level Likert items and was taken from [12]: 1. *Overall, I am satisfied with the ease of completing this task;* 2. *Overall, I am* *satisfied with the amount of time it took to complete the task;* 3. *Overall, I am satisfied with the support information;* 4. *The interface I was working on was understandable*.

The mean value for answers in Task 1 was 5.22, for Task 2 it was 5.18 and for Task 3 it was 4.82. The third task had the lowest mean because of the difficulties faced by the literals on the selection of the accepted ideas as solutions of the problem.

The summary of the questions and the answers given by the completion of the post test questionnaire are depicted in the following table.

Table 1. Post test questionnaire summary of results

Question	Answers By Visuals	Answers By Literals
Do you think that the working interface assigned to you by the system was the suitable one for you?	All 5 users answered "yes". They believe that if they had the option to choose between the two interfaces they would choose the same interface.	One of the users answered "yes" and two answered "maybe". The users felt more comfortable working with textual representation of the content but they believe that the design needs several improvements. The structure of the presented ideas was not well organized and they would prefer to have more options to edit and change the presentation sequence for the ideas.
Did the interface facilitate you to understand the given problem?	The use of mind map helped in understanding the given problem. The use of the mind map helped in recognizing the important nodes with one look and focusing the interest at specific nodes which they contained large amount of information.	The interface helped in understanding the problem through the use of the problem refinement with the use of the synonyms module. Through this, the users managed to refine the problem using their own words.
What did you consider as weakness of the prototype?	The lack of an intelligent recommender system which would appear in the screen ideas in several forms such as images, texts or graphs. Others answered that they would like to use a drawing tool within the interface.	The ideas were presented in unstructured and the connections between new and previous ideas are not recognized. Some of the users also proposed the use of a recommender system for the recommendation of books and relevant resources to study.
What do you prefer to work with, images or text?	All users answered both, but with the flexibility to interact with images through a drawing tool.	All users answered both.

5 Conclusions

In this work we attempted to identify the learning styles as significant contextual factors for the enhancement of the creativity process. In real life creativity is an attribute that all people have. Its expression depends on the environment that people live work and act. Based on this, we examined how a different computer programming environment may influence the productivity of new ideas by a group of users. The selection of the working environment that corresponds to each user was taken based on the learning style group that each user belongs to. Through the preliminary testing results of the prototype that we presented in this work, it is obvious that the working environment based on the learning styles helps the users to feel more comfortable during a creativity session but it is also not enough. The subjective evaluation of the prototype leads to the conclusions that learning styles can be used as a decision factor for the selection of a creativity session's interface, but in some cases this can become more complex. This is a motivation for future work where more contextual factors of creativity must be found and used for the development of more successfully adapted to the users working interfaces.

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