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# A Context Aware Recommender System for Creativity Support Tools

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**Abstract:** The development of methods that can enhance the creativity process is becoming a continuous necessity. Through the years several researchers modelled and defined creativity focusing to the psychological aspect of the topic. More recent researchers approach creativity as a computerized process by simulating it within creativity support tools (CST). This article supports that usage of context aware recommender system, in creativity support tools and more specifically, collaborative creativity support tools (CCST) can enhance creativity process. In this work we focus on the development of a context awareness recommender system and look into how such a system can be useful for the creativity process, through preliminary evaluation results in regards to its usefulness and usability.

**Keywords**: Context Awareness, Creativity, Creativity Support tools, Context Awareness Recommender System
**Categories:** L.1.0, L.2.0, L.3.0, L.6.2, H.3.1

## 1 Introduction

Choi et al. [Choi, 06] define a recommender system as the system which recommends an appropriate product or service after learning the customer's tendency and desire. The recommender systems tend to use information that is collected from the user's actions or the user's profile in order to produce recommendations. In other words the recommendation outcomes of a recommender system are depending on the context. The context in that case consists of two types. The first is the context of creativity which is defined according to the creativity process phase, the user's input during the creativity process and the context information that already exists from previous creativity sessions. The second type is the context that characterizes the active users in a creativity process session. In that case the context is the set of information that surrounds the user. This context information is the collection of parameters from the user's profile that influences the creativity process. Examples of this information are the user preferences, knowledge background, expertise, etc. The perception of this information as contextual entities, in combination with the information processing through a computational method for the production of meaningful recommendations comprises a context aware recommender system. Meanwhile, Context Awareness has been an active area of research in the last years. Through the definitions for context given by [Schilit, 94] [Chen, 00] [Dey, 01] and [ Hartmann, 08], *"context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application including the user and applications themselves"*. In this work, we attempt to model the context of Collaborative Creativity Support Tools (CCST) by defining and describing the most important contextual entities and their role in the creative process.

The application area of the proposed recommender system is Creativity. Creativity is the process by which innovative ideas, concepts and products are being created. More formally, creativity is "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" [Tsatsou, 09]. Various techniques have been realized to facilitate the creativity process. These techniques are called creativity techniques. Nowadays, more than 170 known creativity techniques exist. Such techniques are often implemented within certain software tools called creativity support tools. Creativity support tools can provide guidance and facilitate the creativity process for the users by monitoring the process and the produced results [Schilit, 94]. They are used to simulate the creativity process using procedural patterns defined by specific creativity techniques and create environments which guide the user to become more creative.

The multidimensional perspective of creativity reveals the need to examine creativity and its several models in the existing literature [Cougar, 95] [Sternberg, 99] [Shneiderman, 00]. The study of creativity aims to identify factors that can be considered as context, as well as to the acknowledgment of the creativity process as a sequence of steps. The outcomes of our work suggest that context awareness can indeed be applied in each step of the creativity process.

The creativity process can be enhanced by stimulating user's creativity. [Tintarev, 07] recognises Effectiveness and Efficiency as two of the advantages of using a recommender system for the enhancement of the creativity process. The current work aims to facilitate the creativity process through the use of a context aware recommender system in a CCST, which is designed and developed based on semantic web technologies[1]. With the knowledge of the context of the creative actions, the system becomes able to produce recommendations for the end user, while it is aware of the current context, based on the user's input. The recommendations are in respect to relevant users for collaboration, resources and educational material, ideas from previous creativity sessions and solutions of projects relevant to the problem currently investigated. Through the analysis of creativity, the contextual elements of creativity are identified. The consideration of those elements as the conceptual entities of the creative process leads to the design of an ontology which is part of the overall architecture of the recommender system. This ontology is built over the Topic Maps

[1] Semantic Web is a group of technologies that aim to enable machines to understand the meaning of information on the World Wide Web. This meaning of information is called "semantics". Tim Berners-Lee defines the Semantic Web as "a web of data that can be processed directly and indirectly by machines."

technology which is supported by Tolog Topic Maps Query Engine (http://www.ontopia.net/topicmaps/materials/tolog.html) for the information retrieval. Based on the aforementioned, we have built a context aware recommender system.

The system uses a utility-based recommendation technique. Utility based recommendations rely their recommendations on the outcomes of a function called Utility Function, which calculates how appropriate, or otherwise "fit", is the current object for the particular user. If the score of the function for a particular object is high, then the object is recommended to the user. Among the many well known and widely used recommendation techniques (Collaborative filtering, Content-based filtering, Knowledge-based recommendation technique, Utility-based recommendation technique etc.), we chose to use the Utility-based technique as the most appropriate solution to be applied within a CCST tool. This technique does not rely on people's ratings about a product/item/object such as Collaborative filtering and Content-based filtering. Rather, it may provide recommendations based on arbitrary situation oriented parameters, which makes it very flexible and thus effective for our case. Burke [Burke, 02] provides a comparison of the most well known recommendation techniques, summarizing the pos and cons of each one. He states that a benefit of the utility approach is that it can incorporate many different factors that contribute to the value of a product, which may also have extremely idiosyncratic utility, e.g. the time factor: how soon something can be delivered may matter very much to a user facing a deadline. Thus, utility functions enable us to take into consideration for our recommendations various parameters which other techniques are not able to provide. Of course, as with any technique, there are a number of disadvantages in using the Utility-based recommendation technique, such as the complexity of constructing the most appropriate and efficient Utility Function to provide good recommendations. For further reading about recommendation techniques, the reader is referred to [Burke, 02]. We provide a detail description of our Utility Function in section 5. We also discuss the system architecture, the factors that it uses for reasoning about the context, as well as the recommendation types it produces as outcomes.

In particular, in the full text document in each section we elaborate on the following: In section 2 we discuss the related work regarding context awareness, creativity and recommender systems; in section 3 we briefly describe the idSpace CCST in which the recommender system was developed, in section 4 we present the contextual elements of creativity and their representation as a topic map ontology schema; in section 5 we present the context awareness recommender system, its architecture, the system's work process as well as the reasoning method it uses and section 6 describes a use case scenario for better understanding of the recommender system's use; Finally in section 7 we describe the recommender system's evaluation and we elaborate the evaluation results. The article closes with the conclusions and the future work in section 8.

## 2 Related Work

Context awareness in computer science could be defined as the recognition of the user's environment parameters, which will subsequently act as impulse that activates the corresponding function. Schilit *et al.* [Schilit, 94] attempted to define context by specifying three categories: computing context, user context and physical context.

[Chen, 00] extended this definition by adding the time context element. The definitions given by [Chen, 00] and [Schilit, 94] have a common limitation: they do not specifically state the boundaries for considering information as context or not [Hartmann, 08]. Context aware recommender systems concerned researchers extensively. Adomavicius [Adomavicius, 05] identifies two approaches for the recommendation systems content based and collaborative recommendations. Park [Park, 06] proposes a context aware recommendation system which uses Bayesian networks and the Utility theory for the recommendation of appropriate music with respect to the context. Mehdi [Mehdi, 10] presents a recommender system which collects information from user's web searches for the improvement of content on visited pages. Very few work relating recommender systems to creativity can be found in the literature but several resources about creativity and the modelling of creativity process can be found.

The second constructive part of this work is creativity which can be used in many disciplines. Many have attempted to allocate a meaning to the creative process and its potential outcomes. Plucker [Plucker, 04] defines 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. Hewett et al. support that creativity is the development of a novel product that has some value to the individual and to a social group. Cougar [Cougar, 95] perceives creativity at three levels: as discovery method through the idea generation, as invention with the development of ideas, and as innovation with the transformation of ideas into services [Karapides, 05]. Atman [Atman, 03] and Schneiderman [Shneiderman, 00] conceptualize creativity as a sequence of steps with variants. Simulating the creativity steps along with applying creativity techniques produce the software tools known as Creativity Support Tools (CST). In [Plucker,, 04] creativity process perceived as a two stages process: "preparation" and "ideation". This two-stage process highlights the steps of creativity defined in [Shneiderman, 00] in a more concrete way. This grouping of the steps into the two stages facilitates the specification of each step's context attributes and therefore their grouping in "primary" and "secondary" entities, following the transformation proposed by [Sternberg, 99]. This transformation has actual value for the design of context awareness ontology.

Tsatsou *et al.* [Tsatsou, 09] propose a hybrid recommendation system which combines ontological knowledge with content-extracted linguistic information. In a more domain specific application, [Shen, 05] and [Simon, 03] propose a recommender system in a learning platform which aims to the facilitation in finding resources and learning material. In the same way, an e-commerce recommender system aims to stimulate the curiosity of the user to view products that belongs in the area of his interests. Research work presented by [Tintarev, 07], presents seven advantages of the usage of recommender systems. The usage of a recommender system for the enhancement of creative process highlights two of the advantages identified by [Tintarev, 07]: Effectiveness and efficiency. The work presented in [Sielis, 09] proved the luck of context awareness and particularly the absence of recommender systems, from the most known creativity support tools.

Regarding knowledge dissemination and distribution at the workplace, many studies have shown that interpersonal help seeking is the most important strategy of how people acquire knowledge at their workplaces. Kump *et al.* [Kump, 10] presented the APOSDLE People Recommender Service, a service based on an underlying domain model and on the APOSDLE User Model to support interpersonal help seeking at the workplace. Similarly, Sie *et al.* [Sie, 10] recommend knowledgeable persons for creativity and networked innovation based on user profiles, position in the organization, power relationships and creativity. It is a utility-based recommendation approach.

The current article describes a recommender system which has been developed for the examination of the impact regarding the usefulness and the usability that such a system in a collaborative creativity support tool, has. With this work we examine how the usage of a recommender system influences the creativity process by its integration within a Collaborative Creativity Support Tool (CCST) and more specifically the idSpace platform.

## 3 The IdSpace Platform

IdSpace is a web based collaborative platform which provides an environment in which ideas in different stages of development from different people are made continuously available to everyone concerned. It does so by offering a means for entering and modelling different views on innovative ideas. Its use is related to the enhancement of a creativity process by providing modular guidance and advice scenarios that can be adapted and applied by the users. It also includes tools to articulate, process and store new ideas resulting from the elaboration of ideas from related creativity sessions.

The idSpace platform allows individual as well as distributed collaboration on the creation and co-construction of ideas. The central concept of the platform is the *idea* as a standalone, first-class semantic entity. Such entities are used for reference purposes whenever a new refinement into a different viewpoint or model is created. Links between the idea entities and their refinements are also used for navigation, exploration as well as context-aware recommendation purposes. Therefore idSpace actually covers two notions of space:

- Technical – as it is a space which integrates pedagogical approaches and tools to support innovation and creativity.
- Semantic – as it preserves semantic networks of ideas and their refinements.

The platform enables the collaboration between users across different locations. IdSpace platform achieves that by using web technologies as a foundation and a mix of visual as well as text based editing aids. All these are designed in a way that requires no knowledge of semantics. In addition, the user doesn't have to be familiar with the structure and principles of creative processes, with the exception of the moderator who defines the parameters of a creativity project.

Creative processes are all about the generation of new ideas and associations between them. This idea generation always takes place in an environment of existing knowledge and competences, harbored by the participants of the creative process. This vision of a creative process contains all the elements that are associated with semantics, namely knowledge, competences, people, ideas and associations. That is the reason why the idSpace platform was based on a semantic approach.

In the idSpace platform, semantics, by means of Topic Maps technology, tie all the elements of the creative process together. Pedagogical strategies, creativity techniques, process phases and problem domain information are tied together to provide an integral ontology of the creative process and its ingredients. Ideas, solutions, resources, user profiles and group composition are also tied with the use of Topic Maps technology. Therefore idSpace platform is built using Topic Maps technology and in particular by using the Ontopia Knowledge Suite and Morpheus' Kamala as the development framework tools. Kamala is a tool used for capturing, sharing, representing and integrating knowledge, which is also used as an ontology management environment. Kamala is built on Topic Maps technology and is used on top of the OKS.

Liferay is a collaboration portal. Its portal technology is used as a container for the idSpace modules. The overall architecture of the idSpace platform is depicted in figure 1.

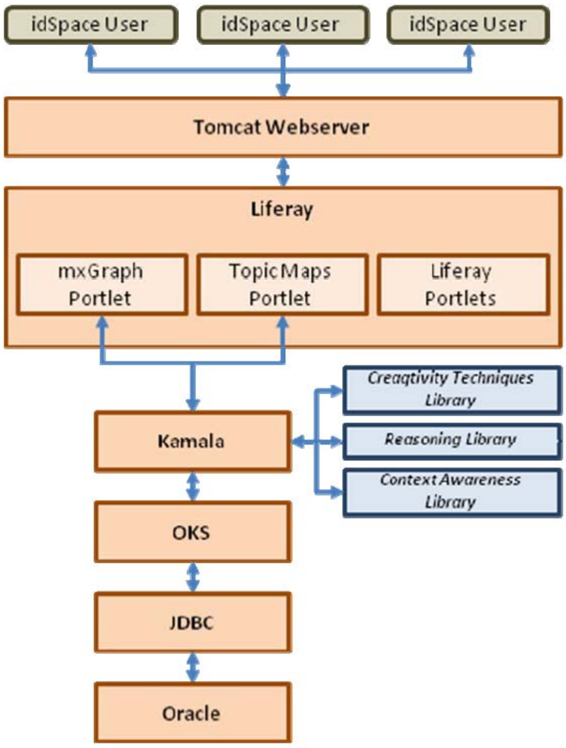


*Figure 1: Top level Architecture of IdSpace platform*

As shown from the system architecture, a Context Awareness library has been developed as a partial library of the platform. The Context Awareness library offers a set of functions regarding recommendations, that are used in the idSpace platform. These functions provide recommendations to users, either automatically (the user does not ask for them), or manually (the user asks for recommendations). The current work focuses on the comprehensive description of the recommender system that has been developed for the idSpace platform

## 4 Contextual Elements for Creativity

From the existing studies in the area of creativity, it is possible to identify the context of creativity. From the definition given for creativity, the significance of the user (or group of users), social environment and task as contextual elements in formulating a creativity process is transparent. Each one of these elements constitutes information and includes attributes that can be perceived as individual entities. The combination of these entities builds the overall context of the creativity process.

### 4.1 Description of Contextual Elements

We consider the following entities as the “primary” [Sielis, 09] context entities. A description for each “primary” context entity is given as follows:

**User:** This may include someone’s competences, preferences, etc. This information defines the profile of a user. This profile can for example be used in creating balanced teams or in establishing the qualification to perform a task. User modeling follows an approach of standard based modeling suggested in [Hartmann, 08] based on combination of open specifications for learner profiles such as IEEE PAPI and IMS LIP where the user’s learning activities are recorded in her performance and portfolios. User modeling is mainly used to formulate a profile. The profile defines the user’s role in the creative process and thereby the context in which someone functions. The context for the user in idspace platform is a combination of the user’s actions, attributes as well as their associations with the other context entities that are subsets of the contextual elements. For example a user portfolio in idSpace depends on the performance, since the user’s performance is defined based on the ideas generated or elaborated. At the same time the participation of a user in a creative session, collaborative or individual, depends on user’s competences, knowledge background or social background.

**Social Environment:** The social background of the users and the social environment in which the learning takes place. This possibly includes information such as group composition, roles played in the group, etc. The generation of an idea is usually an individual process followed by knowledge transfer to other people, or knowledge received by others. The collaborative process is often used as an internal process in team-groups, companies or organizations. Therefore the conceptualization of Social Environment in terms of the idSpace project, demands the formulation of the appropriate associations between other entities in regards to the social background of the user. The social background of a user can be constructed based on her knowledge background, in domain specific subjects/areas, the social role, the expertise and social attributes such as the language and the location. The importance of the Social Environment in idSpace platform as a context element is traced in its necessity for the formulation of social groups and the assignment of social roles to the participants. The social role and the social background of a user constitute important context factors that influence the final recommendation of a user for her participation in a team’s creative session.

**System:** This may include information such as the software or platform used at a given time. The idSpace platform strives not to be a one-size-fits-all model. Instead, mixing tools and automatically tweaking system functions should result in a platform which can be used in various settings. Some settings require a more formalized environment and other settings require an informal environment. In both cases, a creative process will be facilitated. One way to make a difference between the two options is to offer a set of concepts and associations as a starting point and delimiter for the creative session for formalized and restricted sessions and in the case of a more informal session, to offer a blank slate to be filled in by the users. The system context element can be defined by the following discrete attributes:

- Connection Speed: the connection speed influences the collaborative procedure, and is important to the proposed resources type. (E.g. multimedia, real time Skype conversations, etc.)
- Type of device accessing: The user may access the idSpace platform from a PC, PDA, and Pocket PC. The interface and supported modules of idSpace must be adapted
- 3rd Party applications: The system must search on the client's PC for the necessary 3rd Party applications which are used in idSpace and if they are not installed, the idSpace must propose Links for Download (e.g. Skype)
- Operating System Used: Different plug-ins and 3rd party applications compatible with the OS.

**Task (also referred to as 'ideation'):** Information about a task including which project it concerns, the specific activity, the objective, the owner and the stakeholders of a task. Ideation is the most important element of the creative process. The overall model of contextualization of creativity aims to facilitate successful ideation. The task can be defined through the associations of the aforementioned context elements with contextual entities which are influencing the "ideation". In regards to the idSpace project the "ideation" session depends on the selected creativity technique which supports the creative process and the creative team that includes the participants of a session. The enhancement of the creative process with the use of the context awareness of the creative process converges to the Task. The design of an ontology schema constructed by the described context elements aims to the implementation of a context aware recommender tool that will maximize effectiveness of innovation through its recommendations.

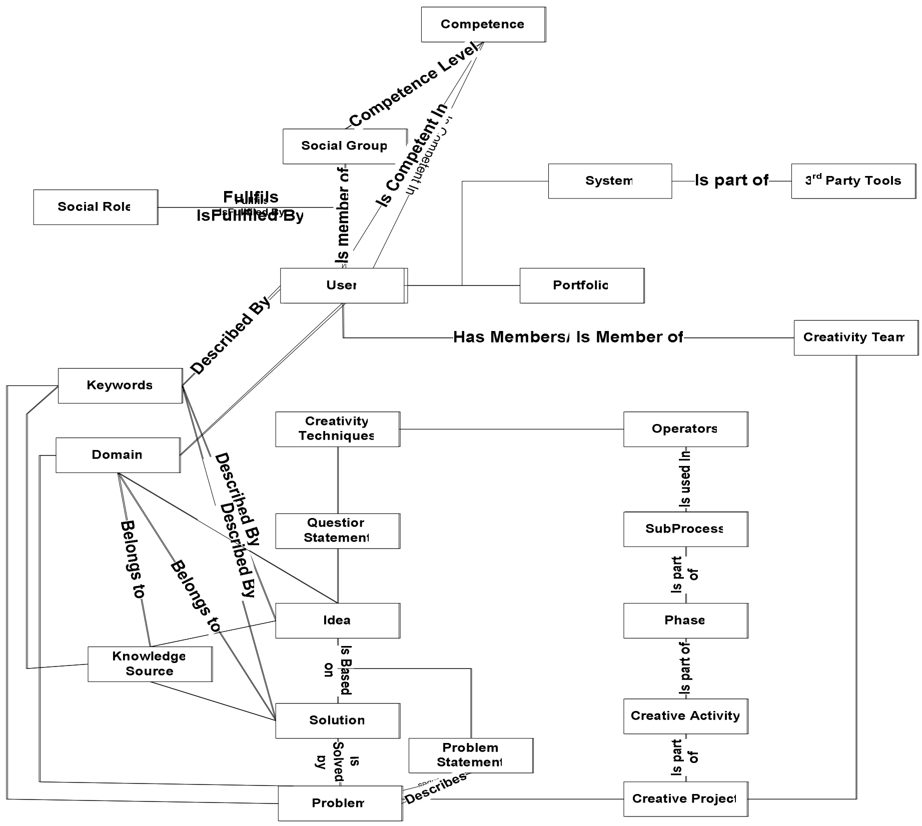


*Figure 2: Topic Map Ontology for idSpace*

Figure 2 depicts the designed ontology for the idSpace platform. In addition to the aforementioned contextual elements, it is important to formalize two more context entities, “Keywords” and “Domains”. In figure 2 the importance of these two context entities can be realized by noticing the several semantic association types they have.

**Keywords**: is an entity used to semantically describe and characterize other entities. For example, a user may be characterized as “programmer” or “doctor”, while an idea may be characterized as “SOS” or “Theoretical”.

**Domains:** is an entity used to provide the field(s) to which the entity belongs. For example, a user that holds a PhD in Human Computer Interaction may have “HCI” as his domain.

## 5 The Context Aware Recommender System

The current work refers to the implementation of a Context Awareness Recommender system as a module of a collaborative creativity support tool. The system is used for the generation of recommendations (e.g. people to collaborate with, relevant resources, relevant ideas, related projects etc.) during the creativity process within the idSpace platform. The aim of the aforementioned recommendations is to offer the user the ability to learn and become more creative by collaborating with experts, access relevant resources or elaborate ideas from previous related creativity sessions. By the development of this recommender system and its integration within idSpace, this work aims to investigate whether context awareness can enhance the creativity of the end user within a CCST. However, for testing purposes, the system can also operate as a black box application, as long as it is provided with the appropriate data.

The context awareness recommender system is designed based on the concepts of creativity as they were defined in section 4. The contextual elements are analyzed into several contextual entities that influence or stimulate the creativity of a user. For the design of the contextual model of the creativity process, the recommender system is supported by the ontology schema of figure 2. The ontology is designed using Topic Maps technology supported by the Tolog query engine under the Ontopia Knowledge Suite (OKS http://www.ontopia.net).

The ontology depicts associations between contextual entities such as ideas, resources, and users which are the constructive parts of the creativity process. Therefore, the use of semantics within the contextual meta-model for creativity constitutes a flexible method for storing and representing data monitored during the creativity process.

### 5.1 System Architecture

The context awareness recommender system described in this work acts as an *implicit* context awareness recommender system, in the aspect that it needs input from the user to function. It provides recommendations upon user’s demand or automatically; either way, the recommendations are based on data the user has inputted and are relevant to the context of the project. The user is able to select among a number of recommendation types, which are made available according to the phase of the creativity process that is active at the given time. For example, during the phase of formatting a creativity group, the “recommendation of users” is enabled. After selecting the preferred recommendation type, the user has the option to provide additional input in the form of keywords to facilitate the recommendation process. The recommender system calculates the recommendations based on the data in the topic map regarding the project and the additional keywords provided by the user, if any.

The four recommendation types supported by the recommender system are: Recommendation of users, Recommendation of resources, Recommendation of solutions, and Recommendation of ideas.

Each recommendation type is developed as an individual software package, which may be triggered by a central module, the Context Manager (figure 3). Each software package contains a Wrapper and an Adaptation Manager. The software packages together constitute a portlet situated among the Liferay portlets (figure 3).

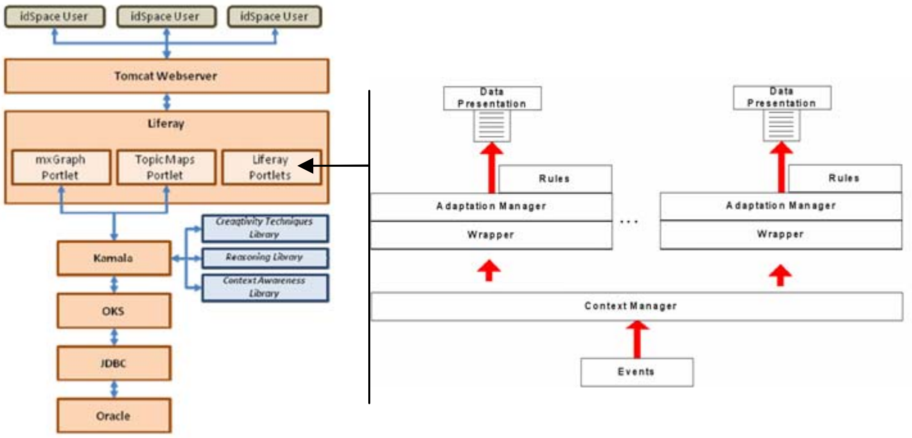


*Figure 3: Context Aware Recommender System Architecture`*

The Context Manager takes into account the actions made by the user, his input and the phase of the process that the recommender system is triggered at, to determine the type of the recommendations. Based on the recommendation type, it activates the corresponding Wrapper responsible for that type.

The reasoning method used, relies on the semantics. It is based, on one hand, on the keywords given as input by the user upon requesting recommendations and on the other hand on the keywords and domains that describe the current session. The latter data are provided by the moderator during the "project creation" phase and are considered to characterize the entire project. By using the aforementioned dataset, the Wrapper queries the topic map to find all entities of the requested type that are associated with this dataset. The wrapped data are then forwarded to the Adaptation Manager, which is, responsible for making adaptation decisions according to the refined context. More particular, in the Adaptation Manager the context information is retrieved, based on the predefined context factors, and the overall wrapped data are filtered. The filtered context data are parsed according to the adaptation method, ranked and finally presented to the end user as ranked recommendations.

### 5.2 System Work Process

The recommender system may provide recommendations on demand, or automatically. In the first case, the user specifies the type of recommendations she/he would like to receive among the available types and gives the necessary input that the system needs to provide the recommendations. In the second case, the recommender system automatically generates recommendations based on (a) the phase in which the creativity process is at that time and (b) on previous user input.

When a new project is created in the CCST, the user has to define/enter as initial data some keywords and domain(s). The keywords characterize the problem to be solved and the domains delimit it. These data are saved in the topic map so that the recommender system can use them as predefined input to compute recommendations.

Thus, when a user needs to be provided with any type of recommendations, the recommender system will consider these predefined data, along with any additional keywords the user may want to add. In the case of automatic recommendations, the recommender system will provide recommendations based entirely on the initial input of the user.

In addition to the above, the recommender system gives the user the possibility to receive even more tailored recommendations, according to his/her own preferences, by specifying which recommendation type factors are considered more important and to what extent. This is done by applying weights to factors. One weight applies to each factor, determining the factor's relevance, or in other words significance in the recommendation. The user can choose among three possible values: "high relevance", "medium relevance" and "low relevance". Each value corresponds to the level of significance of each factor to the final recommendation and affects the final ranking of that recommendation. More detailed review of factors and weights is given in section 6.3.

### 5.3 Reasoning Method

Each recommendation type's software package receives all necessary input from the topic map and the user, computes the recommendations and presents them to the user. The packages, although providing recommendations of different type each, were designed based on the same structure, the same architecture and the same reasoning method. Each recommendation type has the following characteristics:

- Its recommendations are based on a set of factors. Each factor utilizes one or more ontology entities, such as keywords, domains and problem statements (figure 2) to determine a set of recommendations.
- Each recommendation x is being evaluated in regards to a factor i by using a Fitness Function $f_i(x)$. The Fitness Function shows how relevant a recommendation is in respect to a factor.
- We introduce weights to allow end users to specify the importance of each factor, according to their personal preferences. One weight $W_i$ applies to each factor i, determining the factor's relevance, or in other words significance in the recommendation. The user can choose among three possible values: "high relevance", "medium relevance" or "low relevance".
- The Relevance Function R(x) [Kakousis, 08] is an equation of contextual factors and relevance weights that computes the relevance score of each recommendation, based on which their rank of appearance is determined:

$$R(x)= \frac{W_1 * f_1(x) + W_2 * f_2(x) + W_3 * f_3(x) + \dots W_N * f_N(x)}{\sum (W_i) * N}$$

where N: number of Factors and W: weights with values 1 (low importance), 2 (medium importance) or 3 (high importance)

| **Recommendation type** | **Factors** |
|---|---|
| Recommendation of users | Related keywords<br>Related domains<br>User's previous work<br>User's competences<br>User's user role<br>User's social role |
| Recommendation of resources | Related keywords<br>Related domains<br>Related Problems<br>Related Solutions<br>Related Ideas |
| Recommendation of Solutions | Related Keywords<br>Related Domains<br>Related Problem Statements<br>Related Problems |
| Recommendation of Ideas | Related Keywords<br>Related Domains<br>Related Problems<br>Related Solutions<br>Related Resources<br>User's Competence |

*Table 1: Set of factors for each recommendation type*

As said, each recommendation type is based on a set of factors. These factors are ontology entity types, for example “keywords”, “problems”, “domains”, etc. Depending on the recommendation type, the recommender system examines all instances within the appropriate entity types and measures their relevance to the given problem to be solved, in order to opine which are the most relevant to be recommended. The relevance is being measured by using ontology associations. If an instance of such an entity type is highly associated with the current idSpace session, then it is highly recommended by the recommender system. The instance and the current idSpace session are highly associated if they have a number of common keywords and domains. The more common data they have, the more associated they are considered to be.

For example, let's consider the recommendation of users. In this type of recommendation, the factors that play a role are: related keywords, related domains, user's previous work, user's competences, user's user role and user's social role. For each of these factors a fitness function exists that indicates how relevant that factor is to the overall recommendation. For the purposes of this example let's consider only the keywords and domain factors with weights 3 and 2 respectively for two different users, user A and user B. The fitness functions for these factors indicate the percentage of common keywords and domains that these users have with the current project. Thus, the more common data a user has with the project, the higher the fitness will be, resulting in a higher score in the Relevance Function R(x). Let's suppose that the project has 10 keywords and 4 domains and that the number of common data user A has with the project is 4 keywords and 1 domain and user B 3 keywords and 2 domains. The fitness functions for the keywords ($f_{key}$) and the domains ($f_{domain}$) will be:

$$f_{key\_userA} = 40\% \text{ or } 0.4$$
$$f_{domain\_userA} = 25\% \text{ or } 0.25$$
$$f_{key\_userB} = 30\% \text{ or } 0.3$$
$$f_{domain\_userB} = 50\% \text{ or } 0.5$$

The relevance function will be:

User A: $$R(x) = \frac{3 * 0.4 + 2 * 0.25}{5*2} = 0.17$$

User B: $$R(x) = \frac{3 * 0.3 + 2 * 0.5}{5*2} = 0.19$$

The result is that user B is more relevant to the project than user A, and thus the recommender system will recommend user B.

The above was a simplified example of how the recommender system functions in principle. In reality, more complex factors contribute to the Relevance Function with different weights.

## 6 A Use Case Scenario

The work presented in this paper refers to the context awareness recommender system designed for the idSpace platform. IdSpace supports the creativity process through a sequence of phases. It supports collaborative as well as individual creative sessions. The importance of a context awareness recommender system during the process is located to the facilitation of the user's actions at each phase of the process in the platform. Consider the following use case scenario:

> A large scale company is specialized in aircraft design. The company is consisted of several branches, many of them being located in the US and several others in Europe. The stakeholders of the company in the US want the company to get involved into a large funded program for "the design of friendly to the environment transportation means". Therefore, the company assigns to the engineering department in Europe the design of an innovative aircraft prototype which will be able to reduce the use of fuels by at least 10%. Had they achieved this, the company would be the pioneer in the design of environment friendly airplanes, managing a great financial gain. The engineering team in Paris, after an assiduous study on how they would achieve this task, they produced a chart representing all the scientific domain fields that are related to the achievement of the innovative airplane prototype. The chart included airplane design, aerodynamic fluids, energy related fields, novel lightweight materials etc. Therefore the project leader, a man by the name of Joe, should find the most suitable experts of each scientific field among all

company branches, who would be able to contribute to the project with new ideas. Therefore, he needs to organize a team of experts from various domains that are currently working in his company to work on this project. Formulating a team is not an easy task, since hundreds of people work for the company in many different branches in many different countries and in various fields. Joe will need to work with a multidisciplinary expert group, the company's best of the best, to ensure that the outcomes of this project will be the anticipated. Through creativity sessions, he expects to hear different opinions and thoughts, initiate fruitful discussions, collect valuable resources and eventually select the best solution for the task at hand. Joe decides to use the idSpace platform to collaborate. He enters the platform as *"moderator"* and creates a new idSpace project with title *"Novel aircraft design for reduced fuel consumption"*.

The first task is to prepare the project by carefully stating the problem to be solved and defining any keywords related to the project, along with the domains that the project belongs to. As Joe types related keywords and domains, the system displays all pre-entered content (keywords or domains respectively), making it easy for him to select a keyword or domain that suits him. Of course, he can enter a new value to the system, if the desired one does not exist in the system's repository. To help Joe with the problem stating procedure, the system's context awareness recommender system will provide Joe with solutions of past projects that are most relevant to the current project, so that Joe gets informed of the related work in his company and how this work had been accomplished. This will help him clarify what needs to be done further by his current project and consequently assist him in choosing a good, solid problem statement.

Proceeding to the second task, he needs to formulate the expert group of users to collaborate with during the creativity session. He thinks that explicitly searching one by one his colleagues' profiles to find those with most expertise in every related to the project domain to collaborate with would be time consuming, so he decides to use the idSpace platform's recommender system to get recommendations for users. The system automatically recommends 5 people to Joe, but prior to selecting any one of them he checks out their profiles and decides that the last two recommended users in the list are not so relevant to the subject. He selects only the top three users in the list and uses again the recommender system by inputting additional keywords and domains that he thinks are relevant. The recommender system takes into account the problem's parameters as well as Joe's criteria to recommend more people. This time, Joe selects all 5 recommended experts.

After forming the experts group, Joe is ready to start the collaborative creative session. The 8 experts along with Joe already have a common ground in respect to the current problem to be solved and are now working on the ideation screen of the idSpace platform, trying to form ideas suitable to be used as solutions for the problem. At this point, the recommender system automatically provides recommendations of relevant to the topic ideas formulated in past projects, as well as relevant resources. However, these recommendations do not seem to be inspiring enough and the group is having some difficulty on finding new ideas. Joe suggests using explicitly the recommender system to get more specialized in regards to the project idea recommendations. The group enters to the recommender system additional keywords believed to have some relevance to the project, as well as additional domains that could possibly be related to certain aspects of the given problem. While observing the recommended ideas, the group gets inspired from an idea formulated in a project 3 years ago and as a result, Joe formulates a very promising new idea on the ideation graph. In addition, 2 users in the group that are experts in light materials noticed that a recommended pdf file that was suggested by the system as a resource recommendation could be relevant and decides to further study it.

By using the idSpace and more particularly the recommender system the group has clearly discovered the correct path that leads to a good solution for the problem at hand. In the next ideation sessions, the experts in the group continue to use the recommender system by feeding it more appropriate input to find even more relevant ideas and recourses.

One day, a member of the user group, expert in aerodynamic issues, was reported heavily sick and that he would be absent from all subsequent creativity sessions of the project. Joe could feel frustrated because this is the most critical moment of the project, approaching to the solution of the problem, but he is not. He asks explicitly from the recommender system to help by recommending the most suitable persons to fill in for the place. Since by now all information related to the project has already been defined and inputted to the system, the recommender system has much information to process along with the specific criteria inputted by Joe, like finding someone who is expert in the domain of aerodynamics particularly. The recommender system proposes 5 persons, all experts in the desired field, so Joe easily chooses one. The newcomer catches up easily with the rest of the team by examining all information in the idSpace project and eventually, through the creativity sessions, a promising solution arises and Joe decides to successfully terminate the project.

The example above depicts the usefulness of a recommender system in a creativity support tool and more specifically in a collaborative one. In the example described, if Joe wasn't able to use the recommender system he would not be able to easily find people to collaborate with, he would spend time in searching for resources to study and no inspiration stimuli would be offered to him during the ideation process. In the next section we show the usefulness of our recommender system by presenting the results of an evaluation session.

## 7 Evaluation

The context awareness recommender system was evaluated in regards to its usefulness and usability. For the evaluation, 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 for the context awareness recommender system of the idSpace platform. Eight of them were female and three were male. Four of them were working as professional programmers, one as an IT officer and one as a Programmer/Analyst. More than half of them had experience in creativity sessions and more specifically, they mentioned that they were familiar with the brainstorming creativity technique.

The objective of the evaluation was mainly focused on the investigation of the recommender system's usefulness and usability. For the session the participants were asked to work on a creative project called "Classification of Learning Activities". The project was prepared specifically for the evaluation session and it was containing data relevant to the topic of classifying learning activities into the project's repository. In addition, it was ensured that enough data existed in the platform's repository, so that the recommender system would be able to demonstrate itself and provide recommendations.

The participants were asked to complete three tasks during the evaluation and fill a *post-task questionnaire* for each task. After creating a profile, users were asked to login as moderators (additional user rights) and use the recommender system for completing the following three tasks:[2]

**Task 1**: "Use the Context Awareness Recommender System to receive recommendations on solutions to related problems. You want to find out whether there existed similar problems and how they were solved, to use that knowledge and perhaps build on that".

**Task 2:** "Use the Context Awareness Recommender System to receive recommendations on suitable users to add to your team. Suitable users are users who have expertise related to the problem you want to solve".

**Task 3:** "Use the Context Awareness Recommender System to receive recommendations on ideas that may be useful/relevant for solving the particular problem. Ideas are used to build up a solution". The post-task questionnaire included 4 7-level Likert items and was taken from [Lewis, 95]:

- Overall, I am satisfied with the ease of completing this task
- Overall, I am satisfied with the amount of time it took to complete the task
- Overall, I am satisfied with the support information (recommender system's explanation guidelines, documentation) when completing the task
- The presented recommendations were useful

The results have shown that the mean for answers in Task 1 was 5.14, for Task 2 it was 5.11 and for Task 3 it was 4.86. The average standard deviation was 1.54 for Task 1 answers, 1.86 for Task 2 answers and 1.63 for Task 3 answers. Task 3 had the lowest mean, probably because the recommender system had a small delay in presenting the results and users sometimes had to refresh the page to avoid this. In general, the satisfaction regarding the recommendation results was close to 5. Task 1 was the highest because the recommender system, by recommending solutions, significantly helped the users to better understand the current problem they were working on. Moreover, through the recommendation of other existing related projects' solutions, users could more easily understand what the expected outcome of the current project was, and by that, formulate the problem more clearly in their minds.

[2] The resources recommendation type was not evaluated because at the time of the evaluation it had not yet been integrated into the idSpace platform.

After completing the tasks and the post-task questionnaire the participants were asked to fill a *post-test questionnaire*. The questionnaire, retrieved from [Davis, 89] and adjusted accordingly, included six 7-level Likert items and was designed to test the Perceived Usefulness and the Perceived Ease of Use. A summary of the results is presented in Tables 2 and 3.

| **Question** | **Mean** | **Standard deviation** |
|---|---|---|
| Using the context aware recommender system through the Creativity Support Tool would enable me to accomplish creativity tasks more quickly | 4,91 | 1,35 |
| Using the context aware recommender system through the Creativity Support Tool would improve my performance in solving a problem | 5,33 | 1,44 |
| Using the context aware recommender system through the Creativity Support Tool in a creativity task would increase my productivity | 5,42 | 1,38 |
| Using the context aware recommender system through the Creativity Support Tool would enhance my effectiveness during solving a problem | 5,66 | 1,23 |
| Using the context aware recommender system through the Creativity Support Tool would make it easier to solve a problem. | 5,08 | 1,56 |
| I would find the context aware recommender system through the Creativity Support Tool useful for the task of solving a problem | 5,5 | 1,51 |

*Table 2: Perceived Usefulness - post-test questionnaire & results*

| **Question** | **Mean** | **Standard deviation** |
|---|---|---|
| Learning to operate the context aware recommender system through the Creativity Support Tool would be easy for me | 5,17 | 1,53 |
| I would find it easy to get the context aware recommender system through the Creativity Support Tool to recommend me what I want it to recommend me | 4,92 | 1,38 |
| My interaction with the context aware recommender system through the Creativity Support Tool would be clear and understandable. | 4,92 | 1,78 |
| I would find the context aware recommender system through the Creativity Support Tool to be flexible to interact with. | 4,83 | 2,08 |
| It would be easy for me to become skilful at using the context aware recommender system through the Creativity Support Tool. | 5,16 | 1,9 |
| I would find the context aware recommender system through the Creativity Support Tool easy to use | 5,08 | 1,51 |

*Table 3: Perceived ease of use - post-test questionnaire & results*

Based on the results above, both quantitative and qualitative, we can see that the participants' opinions about how they perceived the usefulness and the ease of use both of the individual tasks, as well as the recommender system as a whole, were generally positive.

It is worth pointing out that the highest means occurred in the questions that had to do with the recommender system's usefulness for effectively solving a problem during the creative process. The lowest means were observed in questions that had to do with the recommender system's interface (the interaction with it). Therefore, the context awareness recommender system's significance in a creativity support tool such as the idSpace platform has been indeed confirmed by users.

The evaluation results depicted the positive eye by which participants had seen the recommender system. The questionnaires showed that most participants seemed to agree that the recommendations were useful and meaningful, as well as easy to get most of the times. Most of them seemed to be pleased with the recommender system's usefulness for effectively solving a problem during the creative process. Among all 3 recommendation types, the recommendation of related past project's solutions were perceived by participants as the most helpful and inspiring, since they provoked their thinking in helping them to better understand the current problem they were working on, clearly state it and formulate potential ways to solve it.

The recommendation of users, perceived by participants as the second most helpful recommendation type, offered them relevant users to collaborate with. Some participant's oral comments about recommending users stated that it was a significant help to have a system recommending the most relevant to the active problem users, because it saves time and effort from explicitly searching one by one other user profiles and comparing parameters to find the most competent for the current project.
Last but not least, the ideas recommendations during the "ideation session", triggered participants to be more creative, thus effective, even though they sometimes reported problems with the user interface.

## 8 Conclusions and Future Work

The current work supports that the existence of context awareness functionality within creativity support tools can enhance the creativity process. During the creativity process, the recommendations of resources, people to collaborate with, ideas and solutions from previous "ideation" sessions can stimulate user's creativity. Through the recommendations, the user will be able to find the appropriate people for collaboration and elaborate past knowledge to solve new problems.

In this work we attempted to identify the contextual elements that play a significant role in creativity. Based on these contextual elements, creativity was modelled into an ontology schema. Next, based on the schema and the overall study of creativity, we defined the contextual creativity factors that can produce recommendations in each phase of the creativity process. Based on these factors a context awareness recommender system was designed, implemented, intergraded into a CCST, the idSpace platform and evaluated through the platform.

In general, the evaluation results indicated that the recommender system could provide meaningful recommendations based on the context. These recommendations appeared to be very effective in promoting user's creativity within a CCST, such as the one used in this work.

The preliminary evaluation results acknowledged from the current work, regarding the usefulness and usability of the presented context aware recommender system in CCST, constitute evidence that the uses of recommender systems in CCSTs can influence creativity process positively. The future work will be focused on larger evaluation experiments which will aim to monitor the impact of the context aware recommender systems to the users´ creativity ability. This will be achieved with the use of the presented recommender system in combination with creativity metrics.

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