Empirical Investigations on Community Building and Collaborative Work inside a LMS using Proactive Computing

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Abstract: Today learning is becoming more of a social process; traditional e-learning platforms like Learning Management Systems (LMSs) need to rapidly evolve in order to offer users not only conventional learning tools but also a flexible environment to collaborate and share ideas. Current LMSs are difficult to use, collaboration and interaction is limited within courses and they lack the option for customization to allow users a personalized learning environment. In order to satisfy the increasing needs of learners, Communities of Practice (CoPs) were automatically and dynamically developed on our local LMS, Moodle™, with the help of Proactive Computing. During the summer semester at the University of Luxembourg, we recorded and observed how communities were created, how they evolved over time and what role they played in facilitating the learning process. Our findings support our hypotheses that integrating social aspects into a LMS makes learning more accessible, captivating and personalized.

Introduction

LMSs had a major influence on how teachers taught and how learners learned over the past 20 years. They continue to represent a very hot topic in IT as many universities and colleges across the world use LMSs for delivering educational content to their users. Recently, many people consider that learning to be more of a social process and many educators are using social learning platforms such as *Edmodo* or social networking software like *Elgg* for addressing the growing needs of their learners.

With the increasing popularity of networking platforms like *Facebook*, *Twitter*, *Google Plus* or *LinkedIn*, there have been numerous attempts to use similar tools in education. The main arguments are that these tools would enhance the online collaborative learning process and that it will allow their users to build and maintain stronger relationships with one another.

It is essential that LMSs either change their approach on how to deliver educational content to their users or they adapt to the newest trends by including more social features such as internal ratings and reviews for courses, events and resources, a friendship system which would allow students to build powerful networks. The purpose of this study was to extend the functionalities of the LMS with the help of new technologies, i.e. Proactive Computing, and to integrate new ways of creating, developing and managing learning communities as part of an online course.

But why integrate social features inside a LMS when the majority of students have a *Facebook* account? One answer is that social platforms like *Facebook* have many problems with fake accounts, this accounted for more than 5% of the total number of registered accounts (Facebook, 2012). This decreases the level of trust among users and discourages users to branch out from their circle of friends.

In this study, students used a unique account with their real names for logging into the local Moodle™ platform, for accessing their online course, for enrolling in their exams and for uploading their online assignments. This is one of the main reasons for choosing Moodle™ for this study. Another reason is that students do not possess the rights for adding resources like wikis, forums and chats or other content into their courses as they have limited permissions. This only allows students to be trained by their teachers, and limits their knowledge to the given materials. The final reason for using this platform was that it could easily be extended with the help of blocks and plug-ins, without modifying its source code.

Platforms like *Facebook* or *Twitter* are an ideal place for social learning which can be defined as learning by conversation, observation or by questioning. But social learning is more concentrated on the individual's needs and that is why we consider CoPs to be more suited for collaborative work. They are more focused on enlarging and distributing the knowledge of a group, as opposed to a single person (Farry, 2011). Inside a CoP, people are learning by collaborating, exchanging and sharing information. CoPs or virtual communities of practice (VCoPs) represent a particular form of CoPs developed and maintained using the Internet.

Moodle™ offers the possibility of grouping students inside a course, but this procedure has to be done manually by the teacher or by an administrator. This can easily be done if the number of participants is small, but it rapidly becomes time consuming when there are many students. Moreover, students cannot build their own communities or knowledge networks inside a course, which is important, because they have limited capabilities on the LMS. Students cannot discover other students from other semesters or from other study programs with the same particular interests in various fields because they are limited to knowing only the participants of their own courses. This is where Proactive Computing would come as a solution for the LMS.

Proactive Computing was first described as new computational method opposite to reactive computing (Tennenhouse, 2000). Being proactive implies the idea of a software system to be aware of the different contexts that may occur, more precisely predict certain situations, understand new events, predict user's behavioral patterns and generate new possibilities for improving the user's experience. Having a higher level of awareness leads to more intelligent decisions that will change the system in the favor of its users.

A concrete example of how a proactive LMS behaves is the ability it has to detect when multiple students from different disciplines try to access online resources that are not related to their study programs or courses and then, if certain conditions are met (like having enough students with the same interest) the system would propose a community where the participants could exchange materials, read multiple documents and articles, and start discussions on the topic that they are interested in. The benefits of Proactive Computing inside the LMS would be the creation of an intelligent communication mechanism between the system and the users for guiding, helping and assisting them in their online activities.

Literature Review

Communities of Practice

Wenger defined CoPs as "groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger, 2002). Chalmers and Keown (2006) claim that the success of an online community of practice depends on the online space in which the users interact. Interacting regularly inside a CoP is very important from an educational point of view for the users as it may include actions like requests for information, problem solving, discussion development and knowledge mapping (Wenger, 2006). The actual knowledge of a CoP can be built from the tacit knowledge of individuals through the exchange of new ideas and new insights, through mediation and with collaborative effort (Hartnell-Young, 2006; Wenger *et al.*, 2002).

A successful example of creating communities inside a LMS is provided by Waltonen-Moore *et al.* (2006) as a study case that focused on the participants enrolled in a course for educators at a Midwestern University in the United States. An interactive and well-connected learning community was established even though the participants did not know each other in the beginning of the five-week course. Five main stages for group development were identified by examining the essential characteristics of posting discussions inside the LMS.

Proactive Computing

Tennenhouse (2000) described Proactive Computing as a new mode of operation. It was considered a solution for problems that were limiting the expansion of computing systems (Pering *et al.*, 2003). Rhodes and Starner (1996) proposed 3 techniques for handling automated tasks: perform a task only when it is particularly requested, wait in the background and only act when needed and run continuously. Maybe the most substantial characteristics of proactive systems, elaborated by Oulasvirta and Salovaara (2004), are that they carry out tasks on behalf of the users regardless if the users are performing request-driven or event-driven interactions and secondly, that they act on their own initiative, without any specific instruction coming from the users. This kind of computation is applied to mobile devices (Gellersen *et al.*, 2008), for traffic control systems (Guo *et al.*, 2010), in healthcare systems (Jurik and Weawer, 2008) and in many other sectors.

Proactive LMS

Previous work shows that Proactive Computing can successfully be applied to a LMS. In (Coronado and Zampunieris, 2008; Coronado and Zampunieris, 2010; Shirnin *et al.*, 2013) the assignment system of Moodle™ was improved as a consequence of running proactive scenarios and meta-scenarios. Student activity regarding their assignments was monitored and inactive students were detected by the proactive system. In this case, the LMS was able to send notifications by mail both to the inactive students and to their teachers. Another major benefit of using Proactive Computing was that the students were continuously assisted and guided by online messages for completing their assignments, for interacting inside the e-learning platform and for actively participating in their online courses.

These earlier studies proved that one of the core features of a LMS, the assignment system, could be successfully enhanced by using Proactive Computing and that assisting the students with their online assignments had a significant impact on the students' final grades.

Social Awareness Systems

Context or situation awareness is a major research topic in areas like transportation, aviation, navigation and air traffic control. Another type of context aware system is given by social aware systems that use their sensors and their capacity of analyzing data to take smart actions. In 2000, a group of researchers tried to define and understand what is a social aware system and how does it behaves (Caselles *et al.*, 2000). They divided awareness into 2 types: superficial and non-superficial. The non-superficial awareness was considered more important as it was described as the process of understanding the individuals and their actions. Finally, they arrive at the conclusion that social awareness requires trust and the absence of fear, meaning that users that are using social awareness systems should have a certain level of trust otherwise their behavior would affect the other members.

Coates (2005) describes social awareness software as "*software which supports, extends, or derives added value from, human social behavior*". Social awareness systems are systems that are capable of helping connected individuals or groups of people to be aware of different activities, interests and situations (Andersen *et al.*, 2006). More recent studies include the creation of a framework for the development of social awareness systems (Ibanez *et al.*, 2009). This framework was designed to ease the authors' investigations on how to include information to close friends into a person's work environment.

Social Networking Systems (SNSs) and LMSs

Previous discussions argue that courses inside a LMS are focusing too much on simply delivering content to its users (Blackall, 2005; Ozkan and McKenzie, 2008). The authors argued that social networking, as an emerging technology, could be applied in education because it represents an important factor on how we know and understand things.

Recently, in the e-learning research community, many efforts have been made to integrate SNSs with e-learning systems (Rožac *et al.*, 2012; Rodrigues *et al.*, 2011; Du *et al.*, 2013). In the first study (Rožac *et al.*, 2012), the successful integration of a SNS, i.e. *Facebook*, with a multimedia based LMs, i.e. *Coome*, was done as a possible solution for increasing the level of interaction and engagement of the students. The second study investigated, during a period of 4 months how students and teachers would collaborate inside a hybrid e-learning environment using specific social networking tools (Rodrigues, 2011). The importance of this study was to observe and analyze the different types of interactions that would support and maintain multiple styles of learning.

Du *et al.* (2013) propose an e-learning collaborative and interactive platform that integrates social software inside the LMS. One of the benefits of having such a platform is that it is able to provide a personalized space for each user where users could read information coming from their groups and circles of friends. The key feature of the whole model is a filtering mechanism that would process the information coming from the user's knowledge network and social network. Creating groups, as part of a course on the LMS, would encourage the process of active learning, and would better support the interaction between the participants, and increase online participation in the platform.

Research Questions and Hypotheses

This study aimed to establish the extent to which users of a LMS would benefit from having social features inside their e-learning platform (RQ1), which properties of learning software should be improved in order to have proactive characteristics (RQ2) and if organizing students into various OCoPs would have a positive impact on how students interact, learn and collaborate inside a LMS (RQ3).

For addressing the questions above, three hypotheses were developed:

H1. Social features support CoPs and increase the student engagement inside a LMS.

H2. The e-learning platform is aware of different situations and can adapt to the user's need through Proactive Computing.

H3. Community building based on multiple themes allows a better interaction, creates well-defined knowledge networks and stimulates the learning process of the students.

The Experiment

The study was conducted during the second half of a summer semester as an online experiment at the university using the local LMS, i.e. Moodle™. For testing and assessing the three hypotheses an intelligent engine was used (Zampunieris, 2006) that executed proactive rules. With the help of these rules, the eligible users were enrolled by the Proactive System inside a specialized course and inside the first type of CoPs based on the study programs of the users. Two resources were added at level of the course, containing a user manual and a detailed description of the whole project. A set of three communication tools, including a forum, a chat and a folder, were generated when each CoP was created. After the first successful login of each participant, two new types of CoPs were proposed through a question box specifically built for the graphical user interface (GUI) of Moodle™. New CoPs and their resources were only generated if there were minimum three participants willing to join these groups. Two Moodle™ blocks called "Social Groups" and "Coaching Messages" were developed and used on the clients' GUI for sending messages and notifications from the Proactive System to the users, for displaying the list of CoPs together with their level of activity and for alerting users of new events inside their communities.

Participants

A total of 2404 individual participants were included in the tests, but only 1088 were selected for the enrolment in the course which contained the first set of communities due to the fact that they were only assigned in the "student" role in their other courses. A particular case was given by the PhD students that represented a large percentage of the total number of unregistered users. They have multiple roles on the Moodle™ platform like "teacher" or "manager". The main reason for only selecting students for eligibility to participate in the experiments on Moodle™ was the assumption that students would feel more comfortable in sharing experiences, course materials and projects between one another without having teachers or assistants monitoring their activity and actions. The participants were divided into two main categories: *engaged students* and *uncommitted students*. *Engaged students* refers to the students whom accepted being a part of at least one other community, and voluntarily joined the newly formed groups, while *uncommitted students* refers to the students that were automatically placed in their study-based CoPs but did not want to take part of any other community.

Procedures and Analysis / Data Collection and Analysis

Data was continuously collected during the experiments by both the LMS and the proactive scenarios and meta-scenarios. Additional data was also gathered because some important data could not be registered in the LMS' database. For example, actions like *delete a coaching message*, *view a coaching message* and *leave a community*, which were specific to the two Moodle™ blocks used in the experiment, were recorded in another database specifically created for information about the communities of practice and their members.

Analyzing the data was done in two main phases. The first phase consisted of a step-by-step process of examining the data for making local decisions such as creating or ending the life cycle of a community. This continuous process of evaluating the data was an outcome of using Proactive Computing. It was necessary for sustaining the second hypothesis (H2) and for answering the second research question (Q2). The second phase, which happened at the end of the experiment, included gathering relevant data about the communities, the interactions that took place inside the communities and the resources that were used by the participants.

Measures

Quantitative measures were taken for supporting the first hypothesis (H1). For evaluating the activity of the participants from the moment they were enrolled in their communities, it was taken into account that their actions related to the three main resources that were provided, i.e. the forum, the chat and the folder. Operations such as *Add Discussion*, *Add Post*, *Update Discussion*, *Update Post*, *View Discussion*, *View Post* were considered for the forum, *Report*, *Talk*, *Update* and *View* for the chat and *Edit*, *Update* and *View* for the folder. The activity inside the groups was measured during three weeks before and after launching the experiments. These periods were considered very relevant because they were situated in the middle of the semester and did not include weeks where the activity would be influenced by external factors like the beginning and end of the semester when student traffic is highest in the e-learning platforms.

The secondary hypothesis (H2) was mainly evaluated with reference to proactive procedures which determined which participants remained and actively took part in their CoPs until the end of the semester. These procedures included notifications, reminders and messages sent by the proactive LMS to the participants in order to encourage them to participate actively in their CoPs. These procedures also informed students about new posts and new resources, and gave them guidance within their social environment.

The last hypothesis (H3) was verified by investigating quantitatively and qualitatively communities in terms of collaborative work regarding learning practices, knowledge networks and particular interests. It was also considered how many CoPs of each type were initialized and how many were waiting to be created.

Results and Discussions

A total number of 3618 actions were recorded for the three main tools provided inside each CoP, i.e. the forum (46.6%), the chat (35.2%) and the folder (18.2%). The forum was by far the most used tool in all three categories of social groups, see [Table 1]. *Viewing Forum Posts* and *Viewing Discussion* represented more than 96% of the total activity in the forums. These results show that students were more reluctant to add or update a post or discussion, and would rather participate as observers. The *Folder* and *Chat* tools were rarely used by the participants considering the number of participants and the time period. One explanation for the lack of activity is the structure and the design of these tools. For example, the *Chat* is designed as more of a chat room, a place where students can participate in discussions at any time. To use the *Chat*, students had to be online simultaneously which is quite improbable for communities with few members. Also, discussions between students were not saved by the LMS, so each time the chat had no remaining participants, the LMS would remove all the conversations. This explains the difference between *conversing* (87 recorded actions) and *viewing* the chat rooms (904 recorded actions). *Adding* and *Editing* content of the folder in each community, with a total of 30 actions, was significantly less used opposed to other operations like *viewing* the resources of a certain folder which recorded more than 600 actions.

Types of CoPs	Forum						Chat				Folder		
	Add discussion	Add post	Update	Update post	View discussion	View post	Report	Talk	Update	View	Edit	Update	View
City-based	7	8	2	6	98	196	35	9	14	127	7	2	86
Country-based	9	8	2	6	135	263	46	27	14	163	9	2	107
Study-based	7	7	1	4	254	675	166	51	9	614	8	2	432
Total	23	23	5	16	487	1134	247	87	37	904	24	6	625
	1688						1275				655		

Table 1 - Results of resource usage inside CoPs from all the different categories

Out of the three main categories of CoPs the study-based communities had the highest number of activity. In the study-based CoPs, the LMS recorded a total of 948 actions concerning the *Forum*, 442 concerning the *Folder* and 840 concerning the *Chat*. This came as a consequence of having five times more participants in the study-based CoPs than in the city-based or country-based CoPs. The registered number of activities showed a small difference in favor of country-based CoPs compared to city-based CoPs. One argument is that people participating in the country-based CoPs found it much easier to express themselves in their native language. A relevant example is given by the community of students coming from Portugal, which represented one of the most active social communities in the study. All the forum posts and replies were written in Portuguese, as seen in [Figure 1], which shows a clear desire of students to communicate in their native tongue.

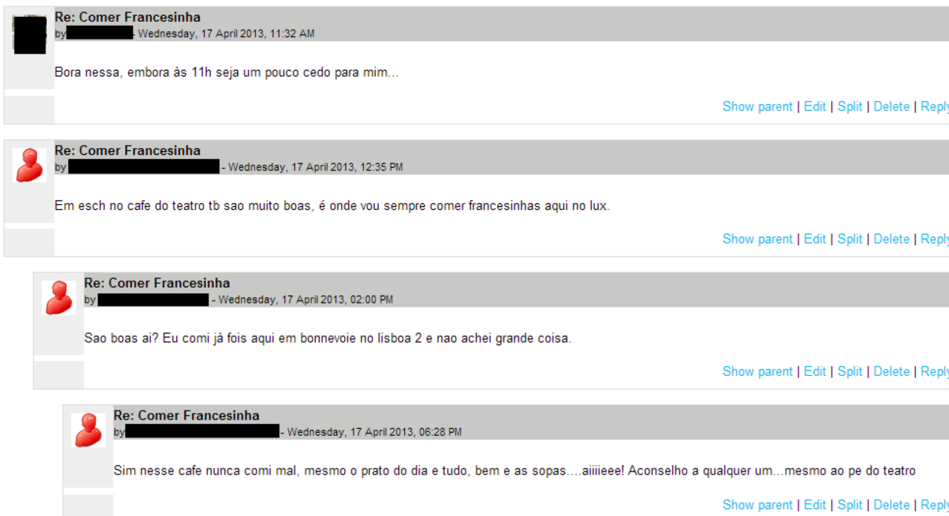

Figure 1 - Example of a forum discussion in the Portuguese community

Measurements, presented in [Table 2], indicate that the average login actions per week, of both engaged and uncommitted students, increased in the first three weeks after the launch of the experiments. The rise in the case of the engaged students (21.1%) was similar to the one in case of the uncommitted students (23.3%). If an engaged student logged into his/her Moodle™ account, 3.5 times per week on average before the start of the experiment, than after the start of the experiment this average reached 4.3 logins per week. For the uncommitted users, the average went from 1.67 to 2.03 login actions.

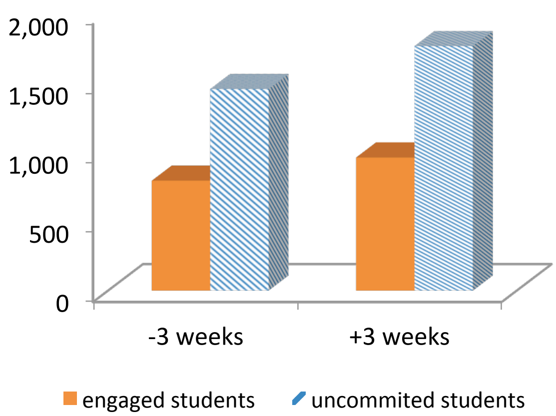

Figure 2: Statistics containing number of logins

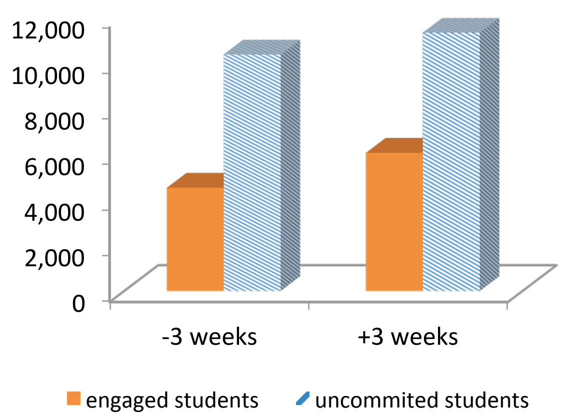

Figure 3: Statistics containing overall activities inside the LMS without logins

In [Figure 3], a similar increase as the one in [Figure 2] can be noticed for all the activities performed by the students within the LMS except their successful login actions. These activities included actions completed by the students inside their courses regarding assignments, grades and other resources and actions done at the level of the LMS including checking the calendar for important dates, upcoming course events and updates for discussions. The recorded activities show an increase of 32.0% in the 3-week period after the launch of the experiment for the students that took an active part inside the CoPs and an increase of 10.7% for the uncommitted students.

The results indicate that inserting more opportunities to socialize as part of a course into a LMS have a positive effect on the online engagement of the students, which supports the first hypothesis (H1) and which confirms expectations about the first research question (RQ1).

In [Table 2], it was observed that the number of students that preferred to remain in the groups is quite high compared to the number of students who decided to leave their social groups, especially for the engaged students. The number of students who decided to leave their groups in the time interval of 4 weeks constitutes 9.1%, 0.37% and 25.6% of all the enrolled members in study-program CoPs, city-based CoPs, and respectively country-based CoPs. This demonstrates that students were quite satisfied with their communities and preferred to remain inside these communities. One reason for this outcome could be that students were alerted when the system detected relevant activities inside their CoPs such as new forum posts or discussions, new resources that were added to folders or when new chats or discussion took place. Students were also informed when their CoPs were inactive for more than 3 days, meaning that there was no action detected by the system inside the CoPs. During the experiments a total of 5913 reminders, hints and notifications were generated for all the 1088 students, meaning an average of 9.2 messages per user per week. Under the Proactive analysis lens, Proactive Computing was used for constantly analyzing the situation inside the CoPs and for deciding whether to send either a notification, reminder or hint.

Types of CoPs	Number of students that left his/her community	Number of students that stayed in his/her community
City-based	9	98
Country-based	6	159
Study-based	222	866

Table 2 - Membership count for each social group category

Proactive Computing was designed to serve multiple purposes for the CoPs like keeping users informed and motivated inside their CoPs, extending the CoPs by constantly adding useful content that would benefit the entire community and propose new CoPs based on the interests of the users. For example, if multiple users read articles related to a certain topic or field, the LMS would detect and create an additional CoP for the users with the same interests.

The proactive rules created 23 CoPs based on the student's programs of the study. This number represents the number of distinct Bachelors and Masters Programs of study available. These programs offer courses in disciplines such as: Computer Science, Physics, Biology, Medicine, Pharmacy, Telecommunications, Mechanics, Environmental Sciences, Electrical Engineering and Mathematics.

Joining country-based CoPs presented more interest than joining city-based groups, as 196 students accepted to participate in the first type of CoPs and 155 in the second type of CoPs. The 10 CoPs of students focused on the country of origin included: Luxembourg (103 members), France (12), Germany (10), Portugal (10), Belgium (8), Iran (5), Afghanistan (5), Romania (4), India (4) and Russia (4). From the 12 CoPs focused on the student's city of residence the largest one had 60 members and was called Luxembourg-Ville.

From the beginning of the experiment, there was a small chance of not being able to create some of the country-based CoPs due to the fact that there were some cases of only 1 or 2 students originating from that particular country. These communities contained students coming from countries with a very small population or from countries that were a great distance from the University. This same case applied to the *Cities of Residence group*, where 24 students were unable to join a community.

A relevant example of collaborative work was given in the community of students that were enrolled in different semesters of the Bachelor in Informatics program. A forum discussion was started by a student (S1) enrolled in the first semester for obtaining information that would help him solve one of the assignments related to one of his courses, i.e. "Programming 1". A student (S2) from the third year, fifth semester, and two students (S3 and S4) from the first year, first semester, of the Bachelor in Informatics participated in the discussion. General and specific solutions, including an algorithm in pseudocode, were provided for answering to the question asked by S1. The conversation is displayed below in Figure 4.

S1: "Hi guys, I have been looking for a solution to implement the AutoPlay of my game but i have a little problem. I can't really see how can I make my autopilot execute the commands since the Command class is supposed to read from the keyboard input. Can someone maybe guide me through it just to have an idea? Thank you."

S2: "You only start the robot with keyboard input and afterwards it's running on itself."

S3: "I suppose you're waiting user input via a scanner, right? Then, you get this string, and send it to the parser that will handle it with Command class. So, what you can do, in pseudocode:

```
String input = null;
if(botIsActive) {
    input = botReactionToSomeEvent();
} else {
    input = scanner.nextLine();
}
```

(and then you process the string with the Parser and Command class)

In your bot class, you need of course a method botReactionToSomeEvent() that will return a String corresponding to command needed for the current event (I don't know your game, but something like: "use itemX" or "go east")".

S4: "You can also look up java.awt.Robot documentation. There is a method to simulate keypress."

S3: "But still be careful with that, as it needs low level access to ressources like keyboard (or mouse btw), and some OS don't allow that. The problem is also that it needs to focus on the right window, in our case the console, but by default, the Robot class focus on the awt window, which is not existing if you're not using the awt GUI. So yes, it's possible to use this class, but quite hard (we tried, we failed :D)"

S2: "Guys you overcomplicate the thing you don't need any keyboard input at all. You have a command "bot" and the bot starts to visit every room by exploring the map."

Figure 4 - Forum discussion inside a CoP

Another example was provided by three students from the same CoP, see Figure 5. They decided to share their project for the "Programming 2" course with the other members. In their message, they indicated that they would benefit if others students would collaborate with them to finding errors or to share suggestions.

Student: "Hi guys, I uploaded the game we developed for Programming 2 project under CubeEscape folder. Feel free to test it, and please report if you find any bugs, or if you have any suggestions. (You can access the files from this message - upper right corner - or from the BINFO social group folder). Bye"

Figure 5 - Forum post inside a CoP

Participants demonstrated they were ready to engage in deep discussions with people that they did not know and shared their knowledge with the entire community, which increased their social network, and benefited the other members in the group who were only viewing these interactions, while using their real names. The participants realized the benefits of sharing resources and having constructive conversations with other students who were a part of their communities. Efficient knowledge networks were formed and supported inside the CoPs through regular interaction between their members, e.g. the community of the Bachelor in Informatics students.

Conclusion

In conclusion, concepts from emerging technologies and theories like Proactive Computing, Social Computing and Communities of Practice were applied to a LMS. These empirical investigations clearly demonstrate that the limitations of a LMS can be overcome, and the LMS can be transformed into an intelligent and aware system. The key contribution demonstrates that including social features inside the LMS and creating OCoPs as part of a course enable different collaborative learning techniques. With the help of proactive scenarios and meta-scenarios, Moodle™ was able to actively seek out and analyze information about the CoPs and their members, and make decisions based on this information without an explicit command from any user or administrator.

The expectations about the first hypothesis were confirmed by the results, which show that employing social features as part of a student's courses increased the level of online student engagement. It is also likely that this could positively influence a student's performance when completing online assignments and tasks. The second hypothesis was not fully measured and more specific actions need to be implemented for measuring, with the help of Proactive Computing, the positive benefits of OCoPs and by applying them inside the LMS. Future efforts will focus on how to make activities more engaging inside CoPs, on how to add valuable content to expand the general knowledge inside CoPs, and on how to make CoPs more attractive in order to increase user participation. Creating a variety of communities offers students the possibility of creating well-defined, knowledge-based networks and social networks inside the OCoPs. Arranging students into CoPs to exchange information, express new ideas and to observe one another's work led to collective solutions for various problems and questions; it also stimulated the learning process of these students, thus confirming the third hypothesis, and answering the third research question.

CoPs require space to expand and need time to evolve in order to reach a mature phase. Social barriers need to be broken by their members whom do not know one another, and without physical presence, but reaching this level of comfort within an academic LMS will take some time. The evolution of CoPs inside e-learning platforms should continue to be observed and investigated. Future work should also include a proactive mechanism capable of motivating the users inside the CoPs. The integration of CoPs should not be limited to a single specialized course, but rather as part of all courses inside a LMS. Finally, more focus should be placed upon the correlation between the engaged students that get socially involved in the LMS and the student's academic performance in that course.

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