Ergonomic Study of Existing Project-Based Learning Management System

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Abstract
We are interested in designing a Project-Based Learning Management System (PBLMS) for high school students. In this paper, we focus on the study of ergonomics of existing PBLMSs. We first analyze four different PBLMSs regarding three points: aims, functionalities and indicators. We particularly focus on the indicators and analyze their attributes: purpose(s), concept(s), data construction and visualization. Based on this analysis we discuss the utility, the usability and the acceptability of the studied systems according to their functionalities, the types of visualization and the users. We finally conclude with some directions of our future research work.

Introduction
We are interested in designing a Project-Based Learning Management System (PBLMS) for high school students, which support learners and teachers respectively in the learning and teaching process. Project-based learning is carried out under complex situations and PBLMS can help learners to build new knowledge and acquire new skills (e.g. management, communication and collaboration). More precisely, the indicators used in PBLMS aim to monitor the way of individual knowledge building. In fact, it can help participants involved in learning activities to reflect on their own behaviors, to self-regulate their activities and to improve their ability of collaboration.

The objective of our research is to design a PBLMS. We define PBLMS as a computer system that provides participants with some management tools to support and monitor the learning activities in order to solve a complex issue, problem or challenge. PBLMS is characterized by supervision functions. Examples of learning activities are collaboration, coordination and production (George et Leroux 2001). Here we should specify that PBLMS could manage various aspects of the learning processes (e.g. the way the activities are carried out, the visualization mode chosen for learners, the configuration and resources of the activity) and the project outcomes (e.g. the documents produced during/after the project and the products). Obviously, PBLMS can facilitate carrying out the project activity and enhancing the learning.

This study is based on previous works dedicated to the design of a paper prototype of PBLMS, named MESHaT (Michel et Lavoué 2011). This prototype is composed of monitoring and expertise transfer tools for tutors and learners. They could give information to monitor individual or group learning activities as well as to support the acquisition and transfer of expertise. More particularly, MESHaT provides learners and teachers with dashboards, since we think that the use of a dashboard is a key-learning objective in the context of PBL. The dashboard is a good way to strengthen learners’ metacognitive skills and to facilitate the group works, the group cohesion and the professionalism of learners by showing explicitly the consequences of their acts (Michel et Lavoué 2011).

The aim of this study is to analyze the ergonomics in PBLMS context. More precisely, we have analyzed four existing PBLMSs and proposed indicators’ features (utility, usability and acceptability). According to this analysis, we have drawn upon the strengths and weak points of the other systems. Based on these results, we propose the main lines of our future PBLMS. It should not only satisfy users’ needs as far as possible but also have suitable ergonomic user interfaces (UI) to improve learners’ collaboration.

This article proceeds in three main parts. First, the paper provides an overview of project-based learning, dashboard and indicators used in PBLMS to improve the quality of learning. In the second part, we analyze and summarize the features and indicators offered in PBLMS. In the third part, through discussion, we analyze the weaknesses of PBLMS and indicators which should be avoided in our context of work and propose the direction of our future research work.

Overview of PBLMSs Using Dashboard and Indicators

Project-Based Learning
There are many definitions of project-based learning. Harris and Katz (2000) defines it as “an instructional method that allows in-depth investigation of a topic instead of using a rigid lesson plan that directs a student down a specific path of learning outcomes or objectives”. According to Jeremic, Jovanovic and Gasevic (2009), “PBL is a teaching and learning model
that organizes learning around projects. Projects comprise complex tasks and activities that involve students in a constructive investigation that results in knowledge building.” Moursund (2007) defines project-based learning as “an individual or group activity that lasts for a defined period of time, which results in a product, a presentation or a performance”. Through these definitions, we can establish that:

- Project-based learning is learner-centered.
- Project-based learning isn’t “teacher telling”, but “learning by doing”. It is an investigation and an inquiry process.
- The project results are not known in advance, each project being unique, which is different from problem-based learning for instance.
- Project-based learning ends with a presentation or product that demonstrates learning and is assessed.

Learners can generate new knowledge and get new skills based on their previous knowledge and experiences when they carry out a project. This kind of activity can lead students to obtain and to apply skills in collaboration, communication, and self-management. Briefly, it is a good way for learners to solve practical problems in an open environment with an interdisciplinary approach.

Dashboards and Indicators Used in PBLMS

Generally speaking, a dashboard is expected to collect, summarize, and present information from multiple sources so that the user can see at once how various indicators are performing (Yigitbasisoglu et Velcu 2011). Dashboard could be considered as a container of indicators. The indicators used in PBLMSs can give information to participants involved in the learning activities. Information could concern their activity or their group activity, and could be seen during or after the learning process. Dashboard could favor cognitive or metacognitive reflection. Based on this reflection, participant can build new knowledge and skills (soft and hard) as well as they improve their learning ability.

During interactions, indicators mainly reflect three types of data: (1) the Logfiles recording learners’ actions occurring in the learning environment, (2) the products of the interactions (communication messages or documents produced during the project) (3) the data recorded by the learners themselves to describe how the activity is carry out and what they think. Compared to the first type of data, the second and third types of data are much more difficult to analyze automatically.

It is also a challenge in this research domain.

We can distinguish four main users of indicators: (1) learners, (2) teachers (3) observers and, (4) the learning environment (Dimitrakopoulou 2006). The learners mean the people who participate in the learning activities. The information supplied by the indicators help them to carry out the metacognitive process. The teachers are the persons who define a PBL activity and monitor the activity in order to uncover the features or the quality of the interactions. The observers, including the researchers and the administrators, are interesting in exploring the mode, the process or the quality of the collaboration. Finally, the learning environment can transform the information given by the indicators into a guiding message and send it to learners and teachers.

According to Dimitrakopoulou (2006), indicators have several important attributes: (1) the purpose of the indicator, (2) the output of the calculated indicator, (3) the concept of the indicator. Additionally, the data construction, which is the core of an indicator, and the visualization of the indicator, which decides the presentation style and mode, are also critical aspects.

Ergonomics Analysis of Existing PBLMS Using Indicators

In this part, we analyze four different PBLMSs. These systems seem the more relevant to our context because they not only help learners to achieve projects collaboratively, but also aim to improve the learning by displaying some indicators. Furthermore, the indicators of these systems refer to different targets (e.g. learners, teachers, observers and the learning environment), and these indicators also monitor different aspects of learning (activity process, communication, features and profiles of learners’ behaviors). We discuss the systems from three points: aims, functionalities and indicators. And for the indicators, we choose four attributes from those previously mentioned: purposes, concepts, data construction and visualization.

System Introduction

Figure 1 gives the workspace interfaces of the PBLMSs described after.

The system SYNERGO (Avouris et al. 2004) supports synchronous collaboration modeling and collaboration analysis. The main goal is to facilitate the understanding of the mechanics of collaboration. It supplies learners with a chat tool and supports them to model flow charts, concept maps, entity-relation diagrams and other semantic modeling.

The system DEGREE (Barros et Verdejo 2000) is conversation-based. The teachers can deploy projects, contribution type and conversational structure at the beginning. Then a group of learners can carry out collaborative activities which are based on conversation by proposing or replying to a proposal. The system and the indicators can improve learners’ metacognitive awareness and give them assistance.

The learning environment proposed by (Fesakis et al. 2004) is based on the ModellingSpace (ModellingSpace 2004), which has many different channels to support learners to communicate during activities. It is synchronous conversation based and the availability of all the participants is required. In collaboration, learners and teachers can exchange chat messages through a set of logical broadcast channels.

The SPLACH system (George et Leroux 2002) aims to help young learners to design and build micro-robots modeling. It incorporates asynchronous communication tools (E-mail and discussion forum), a synchronous meeting tool, and a scheduling tool in the form of a calendar for the team, which provides learners with coordination on the project, a tool to write reports during the project and, finally, specific educational robotics tools.
Synthesis and Analysis

The aforementioned approaches constitute a representative specimen of PBLMSs. All of them provide tools and functionalities for supporting and facilitating users’ (learners’ and teachers’) activities in various levels. Table 1 summarizes the main points of these PBLMSs.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Concept</th>
<th>Functionality</th>
<th>Purpose</th>
<th>Data construction</th>
<th>Visualization</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYNERGO</td>
<td>To help learners to model semantically.</td>
<td>To support synchronous collaborative modeling, monitoring and analyzing activities, communicating.</td>
<td>To monitor the learning process, to facilitate teachers and researchers to understand mechanics of collaboration.</td>
<td>Based on Logfiles storing in XML, formula is given.</td>
<td>Line charts showing number of every kind of action done by every learner, and evolution activity map interpreting evolution of actors’ activities, degree of collaboration in numeral.</td>
</tr>
<tr>
<td>DEGREE</td>
<td>To facilitate proposing or replying to a proposal.</td>
<td>To configure an activity, collaborating based on conversation, analyzing learners behavior, offering guiding.</td>
<td>To help learners to have metacognitive activities; to support teachers to monitor learners’ performance and changes.</td>
<td>Based on Logfiles, some attributes are calculated directly, others are generated by combining these attributes based on Fuzzy Logic techniques.</td>
<td>Table form listing attributes’ names and values; textual aiding messages; line chart giving the evolution of individual’s attributes’ values and interpretation.</td>
</tr>
<tr>
<td>ModellingSpace</td>
<td>To support learners to express their ideas during projects.</td>
<td>To support synchronous communication through a set of logical broadcast channels.</td>
<td>To help teachers estimating learners’ style to offer intervention when needed.</td>
<td>Based on Logfiles, collaborative action is proportional to the number of agents that were interacting and the quantity of interactions.</td>
<td>Mainly line chart which the horizontal axis represents time, the vertical scale records the amount of various variables; information is summarized by analyzing and comparing the curves.</td>
</tr>
<tr>
<td>SPLACH</td>
<td>To help to design and build micro-robots modeling.</td>
<td>To support asynchronous communication, synchronous meeting, specific robotics tool, writing reports, scheduling.</td>
<td>To help understand social relationships; to provide learners insight into their own and their colleagues’ behavior.</td>
<td>Based on Logfiles and semi-structured communicative acts (sentence openers); detailed formulas are given.</td>
<td>Line chart showing how the profiles of the users evolve in time.</td>
</tr>
</tbody>
</table>

Table 1: Main point of analyzed PBLMSs
Discussion
In this part, we highlight the lacks of the analyzed systems according to utility, usability and acceptability criteria. Based on these analyses, we propose some directions of our future work.

Utility, Usability and Acceptability Analysis

Utility Analysis of Functionality
When we read the literatures on PBLMSs, we find that most systems support collaboration only by offering communication tools (e.g. communication system based on ModellingSpace and DEGREE), for example, chat tools, discussion forums etc. Communication is one of the most important aspects during the collaboration but it is just one aspect in project-based learning. We assume that PBLMs should always offer other functionalities to teachers and learners. For example, it should supply learners with:

- Metacognitive tools to support the metacognitive learning process and to facilitate their ability of “learn how to learn”.
- Flexible configuration tools to deploy a learning activity according to different learning contexts.
- Tools for documents sharing and co-writing to help learners to co-build knowledge network.
- A scheduling tool.
- Some special and professional tools offering to learners based on the context of learning activities. For example, SPLACH provides learners specific robotics tools to support micro-robots modeling projects.

Concerning the functionalities of the indicators, most of them just provide some simple reporting analyzes of the learning process (e.g. how many learners are on line, how many messages have been sent, how many times a document has been read) and some monitoring information about the learning environment (e.g. which tasks have been done and which haven’t, whether the learning process is delay according to the project schedule). We don’t criticize that simple indicators and monitoring indicators aren’t important. The importance of these indicators cannot be estimated a priori (Dimitrakopoulou 2006). But supplying the learners and teachers only with these two types of indicators is not enough because the assistance levels of these two types are lower than guiding indicators and supervision indicators. The guiding indicators can generate some information to learners to make some reflection and changes according to the context and the practical situation of learning activity. The supervision indicators can identify whether the action that learners are doing is good or bad and give alerts to learners to draw their attentions. For example, if a learner is watching a film or talking little when he joins in a synchronous discussion, the indicators can give alert. Another lack of the indicators’ functionalities is that most of them are about the activities process; while they cannot supply the information about the content of the products of the activities (e.g. the content of a proposal, the content of communication) or the hidden thoughts (ideas or moods) recorded by learners during activities. These two types of information are very difficult to catch because it needs to recognize and analyze the textual content automatically. We think that this kind of information is as important as the analysis of the actions.

Usability Analysis of Visualization
SPLACH is considered very well because it could create a comfortable learning environment to increase the colleague mutual-understand awareness and the workspace awareness. It gives a photo of every member in the group and a “smiley” button to represent everyone’s mood, which can encourage the feelings of awareness between learners and indicate their feelings without typing any text when they participate in a synchronous meeting (George et Leroux 2001). It is important to create an environment, in which learners can be aware of the others, because it will enhance the relations between learners and shorten the distance between them. It is a good way to improve the quality of collaboration.

Many classical graphical modes are used to present the results of indicators, e.g. line chart, bar chart, table form. But most of learning environments have no textual interpretation of these indicators. So the users, especially young learners, should have a high ability to understand the content of indicators and to discover some important information. We think that the learning environments should be able to interpret the contents of graphical indicators into text form, so as to be used more widely and to give much better support to the learners. The use of metaphors could also be a good way to solve this problem perfectly (e.g. i-bee, i-tree). They could present the results of a number of indicators synchronously in a nice visual frame in an indirect mode (e.g. animation), which can have a strong effect at young learners and help them have a strong awareness of their behaviors (Dimitrakopoulou 2006).

Most indicators interfaces are designed previously and little customizable. The customizable feature has been considered in some UI design of PBLMSs (e.g. DEGREE, communication system based on ModellingSpace), but it hasn’t been considered in most of PBLMSs. Learners and teachers can’t choose the form of visualization they prefer. Moreover, customization is really an important aspect that could help (1) learners to visualize indicators in the way they like and to choose the kinds of information they really want to monitor, as well as (2) teachers to adjust the definitions and choices of parameters according to the different contexts of the learning activities. The visualization customization includes for example selecting monitoring variables, selecting the form of presentation, changing the configuration of the learning activity, selecting the time interval of information updating.

Acceptability Analysis of indicators’ User
The indicators introduced in this paper have been meant for different users: SYNERGO is used by teachers and researchers. DEGREE is used by learners, teachers and learning environment, the communication system based on ModellingSpace is used by teachers, and SPLACH is used by learners and teachers. We think that there are many indicators offered to teachers while a few are supplied to learners and learning environment. From this
point of view, we think that an appropriate PBLMS should manage user profiles and supply suitable information according to their profile. It can’t be ignored that the learning environment is a kind of indicators’ user to some extent because the information produced by some indicators can be processed deeply by learning environment and give useful information (e.g. DEGREE).

We think that the systems analyzed in our paper design the indicators offered to the learning groups well. Most of them give the evaluation about the whole group but not about each member into the group. For example, DEGREE measures the level of creativity, attitude and other attributes of the whole group, SYNERGO gives the degree of relative contribution of group, and the communication system based on ModellingSpace computes collaborative action of the group. Through close analysis, we also can discover that these indicators could present the collaboration quality of the whole group instead of only centralize all information from individuals indicators, which just show everyone’s value in one indicator.

Future Work

These systems offer us good references to construct a PBLMS which not only can satisfy users’ needs as far as possible but also has suitable ergonomic user interfaces to improve learners’ collaboration. Michel and Lavoué (2011) have described a main framework of the platform, named MESHAT. It includes different interfaces according to the learning actor: a project group, a learner or a tutor. Each interface is composed of a monitoring tool (on the form of a dashboard) in order to help the actors to have a global view of their activity and a publication tool that allow them to share their experience. Based on our analysis of the four systems, we suggest some directions for our future PBLMS.

The learning environment will supply many management tools to lead learners to use this space to achieve their project. This platform will be dedicated to project management education, but also could be used to support different types of PBL activities. We will analyze the utility of various tools, for example:

- Blogs (individual and group) can supply spaces for learners to describe the process of their actions and their states of mind. It can help the learners to well understand the project context, to explain the reasons of some indicators’ value (as delays or the group’s state of mind). This information will be useful for teachers to be able to intervene at the right time. Two discussion tools will be offered to learners and teachers, which can help learners to communicate about the projects in the group and help teachers to share their expertise (e.g. process of every group, learning projects designing).
- A scheduling tool can helps learners and teachers to plan and coordinate their activities.
- A learning contract with simple questions that learners answer at the beginning of the activity can regulate their behavior during the learning and help them to acquire metacognitive skills.
- A documents sharing tool can help to share knowledge and to centralize the documents needed for the projects.

The system will include four types of indicators, (reporting, monitoring, guiding, and supervision) from two dimensions (individual and group). Grouped into a dashboard, theses indicators will display comprehensive information about the collaboration. Based on the content expressed in the groups’ vs. individuals’ blogs or in the documents produced during the activity, we can analyze what the learners are thinking and the quality of the learning. We have to analyze the possibility and limit of the different method of text analysis in order to choose the right approach. For example, text mining provides thin analyzes but requires complex natural language treatments, whereas semi-structured method should be sufficient in our case.

We want to create an appropriate learning environment for learners in which they can feel like in face-to-face with the others. It will enhance their motivations and their participations. The customized interface will be used to refine the quality of human-computer interaction and to improve the participants’ satisfactions. Because of the different abilities of learners and teachers to interpret indicators, it is necessary to used different visualization mode (even for the same information). Maybe the use of textual interpretations and metaphors will help learners to well understand the information displayed by the indicators.

But the use of dashboards and indicators is not easy. That’s why we choose to work, in the context of our PhD, on a participatory design approach. The prototype will be used in a real learning process in the future in order to understand its utility, usability and acceptability.

Conclusion

This paper presents an ergonomic study in PBL context by analyzing the utility, usability and acceptability of existing PBLMSs’ features, as well as the indicators used. To better understand the situation of PBLMSs, we have analyzed four different PBLMSs from three points: aim, functionalities and indicators. For the indicators, we have analyzed four attributes: purpose of indicator, concept of indicator, data construction and visualization. Through this analysis, we have discussed the advantages and disadvantages of the PBLMSs and their indicators in three dimensions (functionality, visualization and object users) that we can sum up as follows:

- Most systems support collaboration only by offering communication tools.
- Most indicators just supply some simple reporting analyzes of the learning process and some monitoring information about the learning environment, while guiding indicators and supervision indicators are not paid much attention.
- Most of indicators are about the activities process, while only few indicators supply information about the content of the products of the activities or about the thoughts recorded by learners during activities.
- Most of these indicators have no textual interpretation or metaphors associated.
The feature of customization hasn’t been considered in some UI design of PBLMSs. PBLMSs should recognize object user profiles and supply them with suitable information according to their profile. It is good to give the evaluation about the group as a whole instead of only centralize all information from individuals’ indicators.

Our aim is to design a PBLMS with metacognitive and monitoring tools, which can help the actors to have a global view of their activity. Information sharing tools can also help them to share their experience. We suggest other directions for our future work:

- We will offer several management tools for collaboration.
- The system will include four types of indicators: reporting, monitoring, guiding, and supervision, from two dimensions (individual and group).
- We will create an appropriate learning environment for learners in which they can get high satisfaction.

This study can lay the foundation for our future works. In our future research, we will model the process of PBL and define the activities carried out in our system. At the same time, we will study further the research areas of data mining, data structure, model structuring of indicators and other important fields of PBLMS.

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References


