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# Using a PBL Authoring Tool to Train Teachers in Designing an Online PBL Unit

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**Abstract:** Problem-based learning (PBL) is proposed as one of the most well-known alternatives to subject-based learning in educating graduates to become independent workers, critical thinkers, problem solvers, lifelong learners, and team workers. However, the PBL practice is still far from widespread. One of serious impediments to PBL's diffusion in education is that teachers have difficulties in transforming a subject-based course into a problem-driven course. In addition, teachers lack the necessary skills to make informed judgments and decisions about how to use technologies in their PBL practices. The purpose of this research is to support teachers in developing an online PBL unit. Based on schema theory we developed a PBL scripting language and an associated PBL authoring tool. The tool was developed for teachers to represent, communicate, and reuse their PBL course/lesson plans implementing in technology-enhanced learning environments. It is assumed that it can also be used as a means to educate teachers who may be not familiar with PBL to learn PBL design and to develop an online PBL unit. Through conducting an experiment we found that the PBL authoring tool can facilitate teachers to make informed decisions in their design practice through following a formal design method. Most participants of the experiment thought that the tool is useful to design an online PBL unit and easy to learn.

**Keywords:** Teacher training, Problem-based learning (PBL), Learning Design, Schema theory, PBL scripting language, online PBL unit

## 1. Introduction

A growing urgency to prepare students for 21st century challenges has many educators looking for new instructional approaches. Problem-based learning (PBL) is proposed as one of the most well-known alternatives to subject-based learning. In PBL, through learning to collect information, analyze data, develop hypotheses and apply strong deductive reasoning to the problem at hand, students acquire a deep understanding of knowledge and lifelong learning skills (Hmelo & Eberbach, 2012). However, the PBL practice is still far from widespread. One of serious impediments to PBL's diffusion in education is that teachers, with few exceptions, do not have the expertise to transform a lecture-driven course into a problem-driven course because they are well-versed in teaching and lecturing, but have a difficult time changing their role to that of a facilitator who guides students but does not give the answers (Ertmer & Simons, 2006). In addition, many information and communication technologies (ICT) tools have been used to support the implementation of PBL such as accessing learning resources and fostering collaboration (Kaldoudi, et. al. 2008). Teachers normally lack the necessary expertise to make informed judgments and decisions about how to incorporate contemporary tools and resources to maximize learning in context. They may lack experiences to design and conduct a PBL course integrating digital tools and resources to promote student learning and creativity.

The shift to PBL creates an important question for teachers: How do I design a PBL course to meet goals for both content mastery and 21st century learning? The research work described in this paper is to educate teachers in the development of technology-enhanced PBL courses through adopting the approach of learning by design (Koehler & Mishra, 2005). We adopt this approach to engage teachers in meaningful design problems in an attempt to facilitate their adoption of PBL practices and to improve their use of technology. However, learning to design an online PBL unit is a difficult and time-consuming task. To facilitate teachers in the design of an online PBL unit, we developed a PBL authoring tool. Our assumption is that teachers using the PBL authoring tool can easily acquire relevant knowledge about how to develop an online PBL unit as they are guided to make informed decisions.

## 2. Learning Design and PBL Scripting Language

Learning design has emerged as a distinct field of research, which is concerned with the development of methods, tools, and resources for helping designers in their design process (Koper, 2001; Beetham & Sharpe, 2007; Lockyer et. al., 2008). It focuses on planning, structuring and sequencing learning activities and designing learning context and environment with technical support for knowledge construction from the perspectives of learners. It also denotes the result or product of the design process, a computational description of a teaching-learning process that may happen in a lesson or a course. Learning design aims at providing a means to represent and communicate the designs of learning activities so that they can be shared among practitioners at design-time. Furthermore, the learning designs can serve as a means to orchestrate and scaffold teaching and learning practice at run-time (Koper & Tattersall, 2005; Miao et. al., 2005).

Analogous to the music notation that contains enough information to convey musical ideas from one person to another over time and space, researchers in the field of learning design tried to develop a notational system for describing and sharing learning design ideas. Many learning design languages and associated tools have been developed in the past decade such as IMS-LD (IMS-LD homepage), LAMS (Dalziel 2000), and CompendiumLD (Conole et. al. 2008). These learning design languages were developed for describing a wide range of pedagogical strategies. However, the practitioner has difficulties representing complex learning activities using languages like IMS-LD (Miao & Koper, 2007), because the vocabularies of these languages are pedagogy-irrelevant and technology-oriented terms such as “activity”, “property”, “learning object”, and “data-type”. They provide less or even no vocabularies and guidance to represent and implement specific pedagogic strategies such as problem-based learning. In order to support the design and sharing of PBL practices, we developed a PBL scripting language. The framework that we used to define the PBL scripting language is theoretically based on schema theory (Schank 1977). According to schema theory, generalized knowledge about a list of the characteristic events involved in a common routine is called a script (Schank, 1977). Scripts can be used to organize procedural knowledge, to assist recall, to guide behavior, to predict likely happenings, and to help individuals make sense of our current experiences. People know how to behave and what to expect in particular situations by using scripts. Scripts are mental structures representing the person’s knowledge about objects, people, or situations. As shown in Figure 1, the process of eating at a restaurant can be described as a script that is divided into five ‘scenes’. When a scene finishes, another scene may start. In this restaurant script, there are three roles: consumer, waiter, and chef. The script embodies knowledge about how people in a particular role (e.g. waiter, or customer) are expected to behave in each scene. For example, it is expected that a chef prepares the food that the customer ordered and a waiter passes the food to the customer in the serving scene. After being served, the customer should eat the food in the eating scene. Such expected behaviors are called behavior rules. A behavior rule combines a role, an action, an object, and others such as tool and resource. In order to represent procedural knowledge in restraint, we can define vocabularies and relevant rules that can be used to specify various restaurant scripts such as those used in McDonalds or a buffet style restaurant.


Figure 1. A typical restraint script

In the light of schema theory, we developed a PBL scripting language through analyzing and summarizing well-known PBL models. Using the language, we can represent a PBL unit as a PBL script – a computational description of a PBL process. A PBL script has properties such as *title, learning objectives, prerequisites, description, driving problem, target learners, and estimated duration*. It consists of a set of phases that can be executed in sequence (as the default structure), in parallel, in branch or in loop. When designing a phase, a teacher should choose one or more phase types from the following list: *preparation, problem engagement, problem definition, idea generation, learning issue identification, plan, information sharing, investigation, reasoning, problem resolution, evaluation, application, reflection,* and *report*. In addition, associated phase types such as *facilitation, collaboration, basic cognition,* and *assessment* will be associated with any given phase. In a given phase, only certain types of activities are suggested for completion. For example, in the phase *problem engagement* the following four types of activities are suggested: *present case/situation/scenario, observe phenomenon, introduce problem trigger,* and *clarify concept*. A type of activity may produce a certain type of artifact. The artifact types of this phase are *case, scenario, situation, phenomenon,* and *observation*. Another example is a phase with a type of *learning issue identification*. It can contain the following activity types: *identify learning issue, formulate learning issue, organize learning issue,* and *identify knowledge need*. The artifact types of this phase type are *learning issue* and *learning need*. After the teacher defines a phase through choosing one or multiple phase types, the user can further specify the activity structure within the phase in details.

Each phase consists of one or several activities that may be performed in sequence (as the default structure as well), in parallel, in branch, or in loop. Various process structures can be specified using arrows. When designing an activity, one can only choose an activity type from the types specified by the chosen phase types. One can specify an activity by assigning values to the activity properties such as *title, learning objectives, description, work mode, starting condition,* and *completion condition*. A choice of a certain property such as *time limit* as a choice of the completion condition will need further specification. In this case, one needs to specify how many hours to perform this activity. In addition, the constraints between the type of artifact and the type of activity are specified as well. For example, in the phase with a chosen type *problem engagement*, an activity *present a case* can be arranged. A learning resource with a type *case* can be used as an input of the activity. In a phase with a type of *learning issue identification*, one can arrange an activity by choosing an activity type *formulate learning issue* and define an artifact with a type of *learning issue* as an output. It also enables a detail design of an activity by defining the relations with *actors, learning resources,* and *tools*. For example, the teacher can assign the actor of activity with a type of *formulate learning issue* as a learner, a facilitator, a group of learners, all groups in a class, or all learners in a class. If the actor of an activity is assigned to multiple people, it is needed to further specify whether they should perform the activity individually, separately, or collaboratively. If choosing collaboratively, one has to further choose communicative or/and collaborative tools such as chat-room and whiteboard.

## 3. Using a PBL Authoring Tool to Design an Online PBL Unit

Planning an online PBL unit can be daunting, especially for the novice. It includes many tasks such as choosing standards and learning objectives, defining a driving problem, preparing resources, grouping students, arranging learning environments, structuring and sequencing learning activities, choosing assessment rubrics and criteria, and exploiting technologies. In order to facilitate the design of an online PBL unit, we developed a web-based graphical PBL authoring tool, called PLATE Workbench. Rather than using pedagogy-irrelevant constructs provided by IMS-LD authoring tools such as Re-Course (Griffithsa, et al. 2009) and Prolix OpenGLM (Neumann and Oberhuemer, 2009), one can use the vocabularies and rules specified by the PBL scripting language. The tool provides guidance and restrictions for the teacher to develop an online PBL unit as a PBL script. The user of the tool, for example, a teacher will be guided to make informed decisions. The user interface of the tool consists of five parts. The menu bar on the top lists basic function and the state bar on the bottom indicates the current edit state. The central area contains the file manager (on the left), the graphic edit space (in the middle), and the property edit panel (on the right). Figure 2 provides a screenshot of the tool to edit a PBL script in the activity-level. The tool enables the teacher to define activities by dragging and dropping an activity node. The type of the activity can be defined by choosing one from a list of activity types that are specified in the selected phase types. The activity can be further defined by assigning values of attributes and by connecting with actor nodes, resource nodes, tool nodes, and artifact nodes. The specified relations between concepts (e.g., which type of activity can produce which type of artifact using which type of tool) within the PBL scripting language will be used as constraints to guide and restrict the construction of the diagram. Detail description of the tool and the technical implementation of the tool can be seen in (Wang, et. al. 2014).

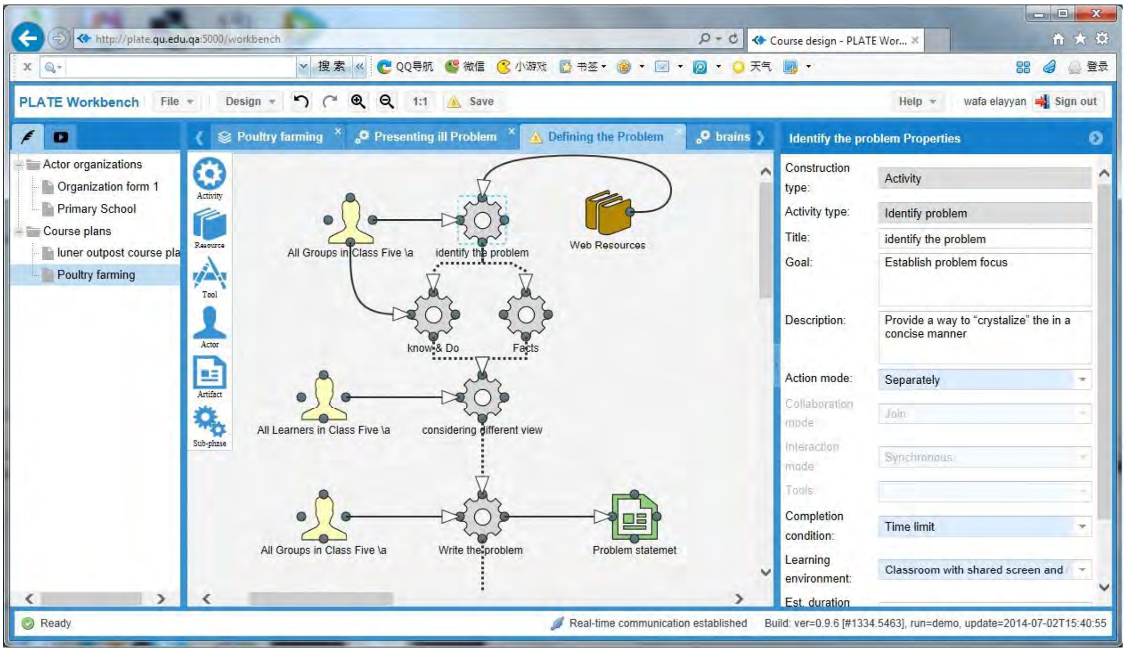

Figure 2. User Interface of the PLATE Workbench

## 4. A Pilot Study

In order to investigate whether the PBL authoring tool can be used to train teachers in designing an online PBL unit, we conducted a pilot study. We adopted an approach of learning by design to educate novice to acquire PBL knowledge and become familiar with the procedure and informed decisions. Here, we use the approach "learning by design" defined by Koehler and Mishra (2008) because their focus, like ours, is on teacher learning and professional development.

The pilot study was conducted in the College of Education at Qatar University. Participants in the pilot study were students from Masters in Education program and were enrolled in the end of the program internship having already completed an advanced curriculum development and design course. Most of the participants are still working as teachers in primary, preparatory and secondary schools or working in the education-relevant fields. This pilot study was arranged as a part of the course. In the course, two sessions were arranged and each session took three hours. In the first session, participants were introduced to PBL including basic PBL concepts, principles, and benefits. They were instructed how to design an online PBL module, in particular, to choose ill-structured problems, to design various process structures and to arrange individual and collaborative activities with various communicative and collaborative tools. At the end of the first session participants were briefly introduced PBL scripting language and the PBL authoring tool. Participants were required to create a user account in the PBL Workbench and to learn the tool by using a user manual and a tutorial video on their own. In the first half of the second session, participants were guided to represent a pre-designed PBL module with the PBL authoring tool step by step. In the second half of the session, participants applied what they learned through continually working on the representation of the pre-defined PBL module. During this time, some participants asked questions that were answered immediately in the class. Then the participants had to complete an assignment within ten days to create a PBL script with the tool. The assignment is centered on their authentic design problems. All participants (N = 17) completed their PBL scripts on time. Finally, participants were required to response to a questionnaire. Seventeen responses were collected and all were valid responses.

Two types of data were collected. The first type was collected from participants' responses to the questionnaire. The questionnaire consisted of five sections: section I asked questions about participants' background; section II addressed the computer literacy of the participants; section III contained Likert-scale questions (selecting one of five responses ranging from 1: strongly disagree to 5: strongly agree) designed for collecting participants' attitude to the PBL authoring tool; and section IV included open questions designed for collecting participants' feedback. The questions are mainly relevant to the ease to use and learn. According to participants' responses to the questions in section I, it was evident that all participants are university students and most of them are also teachers in subject areas including Arabic, math, English, health, and science. The data showed that most participants had minimal prior knowledge of PBL and that the levels of computer literacy of most participants are around an average level. The second type of data is the PBL scripts created by the participants using the PBL authoring tool and stored in the database persistently. The collected PBL scripts were assessed using three scoring rubrics: completeness, contextualization, and reasonableness. Each rubric score was ranged from 1 to 10 and the grade of a PBL script is the mean of three rubric scores. Two experts rated the students' PBL scripts and each final score is means of scores given by the two experts.

We analyzed the relations between the scores of the students and their prior PBL knowledge and their computer literacy. It seems that the influence of computer literacy on the final score is not significant. However, prior PBL knowledge has a slight positive influence on the final score. In addition, the means of the scores of all fifteen items in section III are larger than 3.0 and the total mean of the scores is 3.6. Obviously, most participants thought that it is easy to learn to make informed decisions and the tool is easy to use to design an online PBL unit. It seems that when students think the tool is easy to use, the higher score the student received.

It is obvious that participants will definitely acquire more knowledge about how to design an online PBL unit if they learn how to use the tool and it is impossible for them to represent an online PBL unit without the tool. We directly asked open-ended questions in section III to collect students' feedback. In relation to the usefulness of the tool in design of an online PBL unit, students wrote: "*I used the PBL Workbench for a science lesson. It was suitable for the topic." "When I used the PBL Workbench I did not have any difficulties performing a task. There were various possibilities to work with."* "*I liked the way. It allows connections to be made between various elements, actors, activities, etc. I also liked that it provides clarity to every phase and activity as it asks for goals and other details.*" "*This tool was amazing in helping me develop the plan of how to conduct performance management at the school especially with the complications of connections to be made.*" *"It was new and exciting experience for me"*.

In response to the question about whether it is easy to learn, students stated: *"I would not say easy. It took me time to understand the thing I needed to represent my design and not sure if it's the right thing. Yet I think with more understanding and practice it could become easy in time and the use of different design form." "First I thought it was difficult. When I started to work with it, I found it is not that difficult, yet not an easy one to use." "It will be easy if there are PBL model templates to help teacher to design one because it took me a long time to design a course plan."*

When answering the questions regarding the vocabularies and rules provided by the PBL scripting language, the participants reported that the vocabularies and rules were very helpful. They stated: "*I think that a pre-defined list of choices facilitate the design. It saves time and efforts." "Of course, it facilitates the work, especially for the teacher with little experience, while for expertise teachers it might limit the options, or ideas." "I did not understand these terms until developing the course plan." "I think they are ok and there are a lot of options to choose from which represent the basic items that are used in phase or activity. Yet I think if we could have the possibility to add our own ones …" "From my point of view it enhances and facilitates process. It gives us an option to explore and think critically. I found it appropriate, and enough to help in PBL. On the other side, yes more options will be good addition, as 'more sugar, more sweet'."*

In terms of aspects of the tool that were most valued, students wrote: "*It provides students with greater flexibility in developing solution strategies." "It is flexible as we are able to define as many phases as we wish and as many activities as we wish within each phase I used in my design three phases and more than 2 activity in each and it was easy." "PBL Workbench is very flexible and helpful, easy to use, and has many multiple options that represent various forms." "The workbench is flexible as it does not restrict us to any particular PBL model and gives room to design a PBL with as many phases we require depending upon the project."* It seems that the flexibility is an important feature of the tool.

Nevertheless, the data also revealed that students need more instruction and assistance. Some students noted that: *"Lots and lots of options and information which I need more training on." "I did develop my lesson using all of these things, it is not difficult, yet I think if there is a way to explain them more or demonstrate the different way they can be represented." "… it could be easier if there were ready-made PBL example models the teacher can choose and change what is needed for the lessons. For example, it became similar to Microsoft publisher that have ready-made template to use and change."*

## 5. Conclusions

Feedback received from the participants indicated that most agreed that the PBL authoring tool is easy to learn and use for designing an online PBL unit. The tool provides guidance to make informed decisions and provides options for choosing. Participants especially emphasized that vocabularies and rules specified in the PBL scripting language make it easy to understand and design a PBL script and that the tool provides flexibility. The responses to the questions about students' perception of the tool are basically positive and most PBL scripts created by the students were quite good.

Based on the feedback from the participants, it is important to instruct potential users on the theory of PBL and explain what are informed decisions and possible choices. Also, it is important to provide more examples and help on how to use the PBL authoring tool and to provide support to users as they develop an online PBL unit. The feedback from participants in this pilot study indicates that the PBL authoring tool will be useful for teachers to develop an online PBL unit.

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