Analysing Project Based Learning Scenarios to inform the design of Learning Analytics: Learning from related concepts

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Abstract. Project Based Learning is a complex concept that is related to Problem Based Learning and Collaborative Problem Solving. These latter concepts are well represented in the literature by models and frameworks that can usefully be adapted to develop a framework for the analysis of Project Based Learning. We present such a framework that has been designed for learning situations that involve the use of technology. This technology can be used to capture data about learners' interactions as well as to support their learning. We suggest that this data can be combined with data collated by human observers and analysed using the framework.

Introduction

The literature on Project Based Learning is complex with many related concepts, for example: Practice Based Learning, Problem Based Learning, Collaborative Problem Solving and Inquiry Learning. In this paper we explore the frameworks for two of these concepts: Problem Based Learning (PBL) and Collaborative Problem Solving (CPS) in an attempt to identify a framework for the analysis of Project Based Learning activities to inform the design of Learning Analytics. We have selected these two concepts, because they are well supported by existing models and frameworks.

1.1 Problem Based Learning

Problem based approaches encourage learners to become actively engaged in meaningful real-world problems that often require practical as well as intellectual activity. The premise is that the students who participate in a PBL approach will learn through solving problems together and then reflecting upon their experience (Barrows and Tamblyn, 1980). Problem-based approaches to learning (PBL) are not new, they date back to the early 20th century in the work of Dewey (1938) for example (Hmelo-Silver, 2004). Whilst they were initially part of medical education and law schools; they have recently gained more popularity with educators in schools and universities for teaching STEM subjects. A key element of PBL is that the students work collaboratively, learning from each other and solving the problem together. The teacher's role is that of facilitator, but the students are very much self-directed. The PBL approach therefore requires that participating students have good collaborative skills and sufficient metacognitive awareness to steer them through the problem space in a manner that enables their learning. As a result the potential outcomes for the students are not merely cognitive in terms of their increased understanding of the subject matter of the problem, but also there are advances in the transferable twenty first century skills of communication, collaboration and critical thinking.

Hmelo-Silver (2004) uses a stepwise model to describe the PBL process from the teacher's perspective (see Figure 1). Students start by identifying relevant facts about the problem, which increases their understanding and enables them to generate their hypotheses about potential solutions. The teacher or potentially a more able peer helps the student to recognize what are referred to as knowledge deficiencies that will become the goals of their self-directed study. Once these knowledge deficiencies have been addressed the student can re-evaluate their hypotheses and learn through a process of reflection and application.

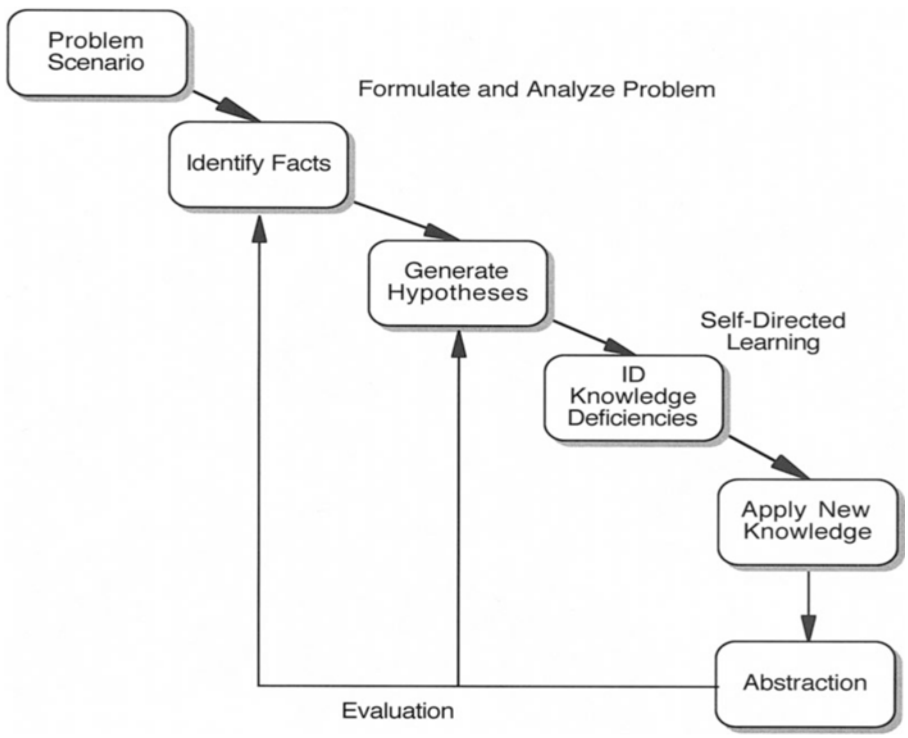

Fig. 1. PBL Tutorial Model (Hmelo-Silver, 2004)

1.2 Collaborative Problem Solving

More recently, and in preparation for the 2015 PISA assessments, the OECD has developed a framework for the assessment of collaborative problem solving (CPS) that is complementary to the traditional PBL approach outlined above (OECD, 2013). The OECD defines CPS as:

> Collaborative problem solving competency is the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills and efforts to reach that solution.
>
> (OECD, 2013, p.6)

There are three core competencies that are fundamental to this definition of CPS:

1. Establishing and maintaining shared understanding;
2. Taking appropriate action to solve the problem;
3. Establishing and maintaining team organisation.

These are combined with a set of problem solving competencies that are similar to those outlined by Hmelo-Silver (2004), although there is no explicit reference to knowledge deficiencies. This is not surprising because the PBL model is one of tuition, whereas the OECD CPS model is one of assessment:

1. Exploring and Understanding
2. Representing and Formulating
3. Planning and Executing
4. Monitoring and Reflecting

The OECD framework for CPS also includes three further elements:

1. Three conceptual dimensions for the assessment of problem solving. These are the problem context, the nature of the problem situation, and the problem solving process;
2. Two aspects of the problem solving context: the setting (whether or not it is based on technology) and the focus (whether it is personal or social);
3. Two problem presentation types: static problem situations in which the information about the problem situation is complete, and interactive problem situations, where it is necessary for the problem solver to explore the problem situation in order to obtain additional information.

These additional elements highlight the complexity of CPS activities and are pulled together in Figure 2 below.

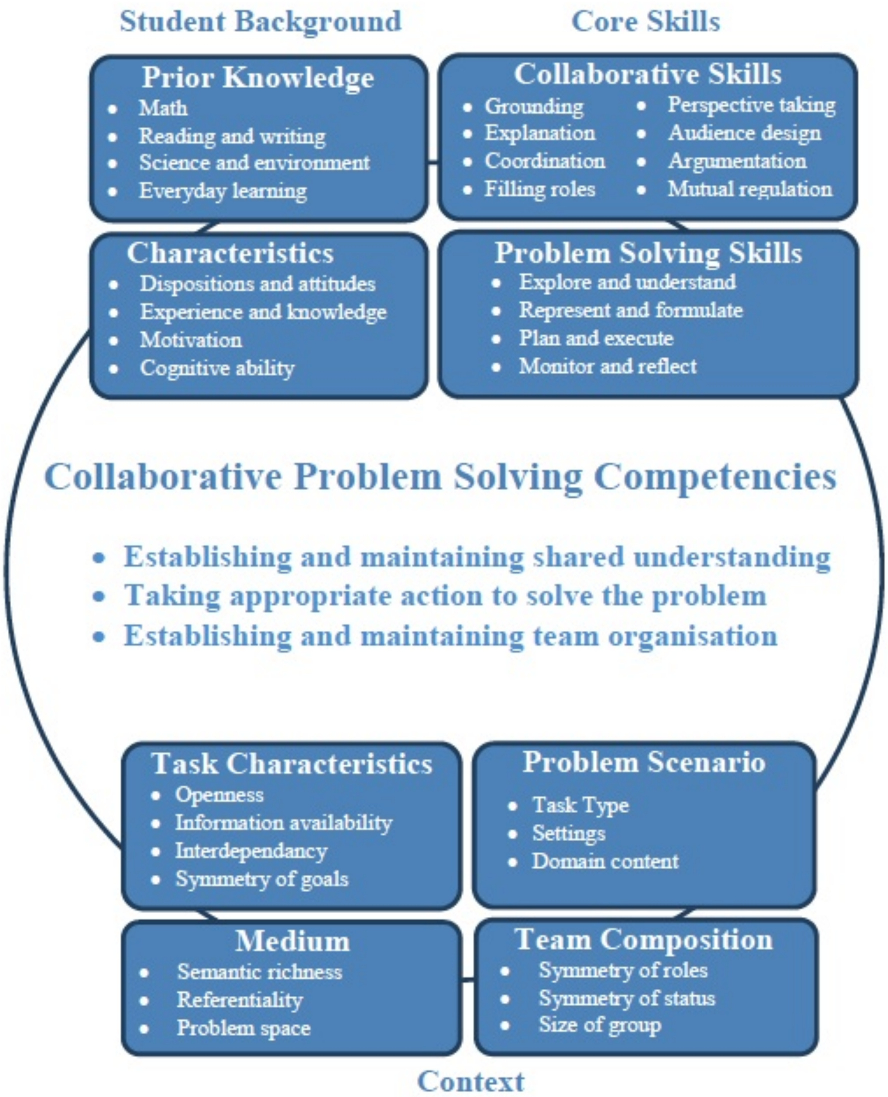

Fig. 2. Overview of factors and processes for Collaborative Problem Solving in PISA 2015

In addition to this overview the four problem solving processes and the three major collaborative problem solving competencies are merged to form a matrix of specific skills, see Table 1. In the resulting matrix, the skills have associated actions, processes, and strategies. These specify what it means for the student to be competent.

	(1) Establishing and maintaining shared understanding	(2) Taking appropriate action to solve the problem	(3) Establishing and maintaining team organisation
(A) Exploring and Understanding	(A1) Discovering perspectives and abilities of team members	(A2) Discovering the type of collaborative interaction to solve the problem, along with goals	(A3) Understanding roles to solve problem
(B) Representing and Formulating	(B1) Building a shared representation and negotiating the meaning of the problem (common ground)	(B2) Identifying and describing tasks to be completed	(B3) Describe roles and team organisation (communication protocol/rules of engagement)
(C) Planning and Executing	(C1) Communicating with team members about the actions to be/ being performed	(C2) Enacting plans	(C3) Following rules of engagement, (e.g., prompting other team members to perform their tasks.)
(D) Monitoring and Reflecting	(D1) Monitoring and repairing the shared understanding	(D2) Monitoring results of actions and evaluating success in solving the problem	D3) Monitoring, providing feedback and adapting the team organisation and roles

Table 1. Matrix of Collaborative Problem Solving skills for PISA 2015

Learning from Problem Based and Collaborative Problem Solving

The type of matrix in Fig. 1 has the potential for use when analyzing data of collaborative activity, but for a PBL approach, the missing component of knowledge deficiency requires attention. In Table 2, we add the PBL tutorial stages to the matrix to address this limitation. In this way we combine a tuition model with an evaluation model and in so doing address both aspects of the teaching learning process.

	(1) Establishing and maintaining shared understanding	**(2) Taking appropriate action to solve the problem**	**(3) Establishing and maintaining team organisation**
(A) Identifying facts	(A1) Discovering perspectives and abilities of team members, making knowledge explicit	(A2) Discovering the type of collaborative interaction to solve the problem, along with goals	(A3) Understanding roles to solve problem
(B) Representing and Formulating	(B1) Building a shared representation and negotiating the meaning of the problem (common ground)	(B2) Identifying and describing tasks to be completed	(B3) Describe roles and team organisation (communication protocol/rules of engagement)
(C) Generating Hypotheses	(C1) Critically analysing the problem representation	(C2) Generating and Communicating potential solution paths	(C3) Present Hypothesis, encourage feedback from others and offer feedback on others' hypotheses
(D) Planning and Executing	(D1) Communicating with team members about the actions to be/ being performed	(D2) Enacting plans	(D3) Following rules of engagement, (e.g., prompting other team members to perform their tasks.)
(E) Identifying Knowledge and Skill Deficiencies	(E1) Comparing the team's knowledge and skills with the proposed actions	(E2) Identifying and specifying individual deficiencies	(E3) Identifying and specifying team deficiencies
(F) Monitoring, Reflecting and Applying	(F1) Monitoring and repairing the shared understanding	(F2) Monitoring results of actions and evaluating success in solving the problem	(F3) Monitoring, providing feedback and adapting the team organisation and roles

Table 2. Combined Matrix that merges PBL and CPS concepts adapted from PISA 2015

Each of the 18 cells can be associated with different levels of learner proficiency. For example;

Low — the student responds to or generates information that has little relevance to the task.

Medium — the student responds to most requests for information and prompts for action, and generally selects actions that contribute to achieving group goals.

High — the student responds to requests for information and prompts for action, and selects actions that contribute to achieving group goals (OECD, 2013).

The contents of the cells C1 to C3 and E1 to E3 have been generated by the authors informed by Hmelo-Silver (2004).

Final Remarks and Further Research

Frameworks such as this offer a flexible approach to the analysis of data collected from project based learning scenarios. This analysis may be that completed by humans as we strive to understand whether and how learning happens, but could it also be useful for data collected and analysed by machine? It needs to be acknowledged that PBL activity may not be captured completely through technology and that there will be aspects of the activity that take place away from any current technology. It may therefore be necessary for any analytics to use a combination of human and machine generated data. Our next steps are to test the framework empirically with a project based data set and to consider what appropriate learning analytic requirements might be extracted. At the workshop we will bring some examples of data and associated analysis to support further discussion of the framework.

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