Learning trajectories in Open Source Software: Implications for designing problem-based learning experiences in support of higher order thinking

Contents

Problem Statement

A general problem in CE is that it still focuses mainly on knowledge acquisition, while effective practice relies on effective problem solving. (O'Grady). As well, CE has seen a decline in enrollment of students (stats here) as well as issues with retention and a lack of women and minority participation. Problem-based learning has been touted as a learning experience that helps with development of higher-order thinking skills and has been proposed by many as approach that should be taken for computing education. (refs) Besides cognitive skill development, proposed affective learning aspects of PBL include increased motivation generated by the problem challenge and satisfaction from participation in an authentic, applied learning exercise. Wider spread adoption of PBL may help not only development of the cognitive higher-order skills that may affect retention in the major, but also with the affective aspects such as motivation and interest that may impact attraction to the field. (refs)

However, despite these claims little adoption of PBL in CE has occurred because institutional and pedagogical reasons; this research proposal focuses on addressing pedagogy and learning outcomes. Regarding instruction there's the difficulty of developing adequate problems and the lack of instructional design prescriptions to support structuring the PBL process. What if there existed a ready-made learning environment that provided authentic problems for students to learn from that may also provide some of the support structure needed for PBL? Open source software systems, as informal learning environments, have the potential to do so.

Paragraph on OSS and how can support PBL..

However, while there has been some involvement of participation in OSS for CE there is a lack of instructional design support, lack of rigorous measure of skills exercised and learning outcomes. This research proposes to study OSS communities to identify the resources provided that support PBL activities and their relationship to higher-order skill learning practice. This research will be used to influence the instructional design of PBL-based learning activities in support of higher-order thinking skill development. Success in achieving learning objectives will be determined through testing of activities with undergraduate computing students.

Vision statement (wrap it up)

RQs

1. What opportunities does OSS community participation provide to exercise higher-level thinking skills? What is relationship to resources provided by the community (e.g., tasks, technology, community)?
2. Can PBL- tailored student involvement in OSS communities assist with the development of higher-order thinking skills while satisfying CE learning goals?

Lit review

RQ 1- What opportunities does OSS community participation provide to exercise higher-level thinking skills? What is relationship to resources provided by the community (e.g., tasks, technology, community)?

State of PBL in CE (adoption, empirical study in relation to HOT skill development)

What is PBL, why PBL?

Problem-based learning (PBL) is a method of constructivism, a philosophy of how people learn.

Constructivism has three central tenets: 1) Understanding comes from interacting with the

environment, 2) the stimulus for learning comes from problems which in turn direct the learning process; and 3) knowledge is derived through social interactions. Savery 01 lists instructional principles following from this philosophy, noting that among the many learning environments, PBL addresses these most closely:

1. **Anchor all learning to a larger task or problem**- learning must have a purpose for the learner.
2. **Support the learner in developing ownership for the overall problem or task** –align learner goals with instructional goals
3. **Design an authentic task**-the cognitive demands should align with the cognitive demands where the learner will perform ultimately.
4. **Design the task and the learning environment to reflect the complexity of the environment they will function in at the end of learning**
5. **Give the learner ownership of the process used to develop a solution**-don't simplify the environment, but support the student within the complex environment
6. **Design the learning environment to support and challenge the learner's thinking**-don't "proceduralize" how the student approaches solving the problem.
7. **Encourage testing ideas against alternative views and alternative contexts**-Because knowledge is socially constructed, interactions in collaborative group can be used to test individual understanding.
8. **Provide opportunity for and support reflection on both the content learned and the learning process**

Comment [MP1]: Hamalainen also lists steps.

Comment [MP2]: I think material from constructivism _practical_historical_context can be added in here. Look in learning sciences PBL folder.

Problem-based learning is conducted in small collaborative groups working on realistic ill-structured problems (non-deterministic). The teacher acts as a facilitator guiding the learning process helping them learn the cognitive skills involved in problem solving and collaboration. Student groups analyze and define the problem by identifying the important components of the problem scenario. From there, they generate hypotheses of how to solve the problem. During this process self-directed learning is employed as students encounter gaps in knowledge. From there they apply their new knowledge and evaluate their hypotheses and reflect on what they've learned. For students to be successful they must learn how to be self-directed learners which

requires they be reflective and apply critical thinking about what they are learning. (04 Hmelo-Silver)

In general, it has been proposed that PBL helps students: 1)develop an extensive, flexible knowledge base; 2) develop problem-solving skills; 3)become self-directed learners; 4)become effective collaborators and 5)become intrinsically motivated learners. With regard to knowledge this also means students learn to connect information across multiple domains. Effective problem solving requires developing metacognitive and reasoning strategies. Metacognition development is important to both evaluating problem solving progress and learning progress for self-directed learning. Developing collaboration skills involves working with others to identify actions needed, come to agreements over issues and effective communication within the group and also aids in the facilitating the social aspect of learning. PBL can aid in intrinsically motivating students that through involvement in problems that are proximal and relate closely to their own learning goals. (04 Hmelo-Silver)

Research studying learning effectiveness of PBL

Evidence suggests … Caveat, most research has been in medical and ? domains. Evidence is still needed for collaboration and motivation (04 Hmelo Silver) (need to fill in this, but first need to finish reading Hmelo-Silver)

Why PBL in CE?

Problem-based learning lends itself well to computing education because computing is driven by problems; requires life-long learning to stay current with emerging technology; work is mainly done in project teams and it generally crosses multiple disciplines. (98 Ellis, 02 Aramego) In addition, while not the focus of this proposal, studies have shown also that when used in CE it may help attract more female students (04 Hamainen, 98 Barrows (need to read), improve

retention (04 Hamainen), motivation (04 Hamainen, 10 Wang), and passing rates (04 Hamainen, 03 Parham).

However, CE is still mainly via knowledge transmission (12 OGrady), not focusing on the development of higher-order thinking or advanced reasoning skills, which are critical for a career in the computing industry (12 OGrady, 12 Exter). Effective instructional design in support of this skill development is still an open question. (12 OGrady) Furthermore, given the potential for PBL in CE to increase female enrollment (why?) and improve retention (sources) there is further reason learn how to use effectively. (need to tie PBL to females and application and retention from literature)

PBL in CE, measurement of skill development

Most literature has focused on the affective part of not cognitive

Even when attempting to measure cognitive:

Used student perceptions of what was learned

Got closer perhaps to study of cognitive with examining learning diaries and grades

But very few specifically attempted to measure HOT skills

Limitations in empirical study of PBL in CE/(limited HOT)

These studies attempt to here are the limitations.

What other methods have been used to help generate HOT that aren't PBL?

Have they worked?

Why OSS?

Not only does a successful PBL-approach require authentic problems, but industry practitioners have also called for student exposure to authentic problems indicating that such an approach during formal education would be the best method to prepare students for work in computing. It was noted that real-world types of large projects that involve technical writing, testing, version control, and exposure to design concepts and problem solving were needed. (12 Exter)

However, a common problem expressed through literature on PBL in CE has been the difficulty in developing problems. (05 Clark, 06 OKelly) But, problems alone are not the only resources used in PBL. PBL requires many other resources to be successful: 1) facilitation, 2) subject guidance, 3) scaffolding, 4) production, 5) assessment. (98 Ellis) Open source software communities provide a ready-made pool of authentic problems that can be leveraged, and other technological and social elements that can aid in providing resources in support of PBL.

What is OSS? What has been studied?

There are many success stories in OSS from Apache and Firefox to lesser known but not less important projects such as those in humanitarian free and open source software. Sizes of projects in terms of contributors range from tens to thousands. As of 2008, a conservative estimate of the number of active OSS projects was 18,000 and that it was growing at an exponential rate. (08 Deshpande – The Total Growth of Open Source)

To understand the extent of OSS use, the internet infrastructure mostly runs on open source products. For instance, Apache Tomcat is used on over 60 percent of websites. (ref) In addition, OSS is generally free of direct cost and traditionally better than proprietary systems in terms of portability. Given the openness of code it also generally more reliable and secure; A

famous saying related to open source, “Given enough eyeballs, all bugs are shallow,” attests to that. (Deek says Raymond, 1998, however check source) There is some evidence to refute these claims. For instance, an empirical study of MySQL showed six times less defects than similar commercial databases (Tong, T. (2004). Free/Open Source Software in Education. United Nations Development Programme’s Asia-Pacific Information Programme, Malaysia).

The open source software movement grew out of a desire to keep software innovation open, by making source code generally available, much like the intellectual style of science. (Deek 08) These projects consist of self-organizing groups of distributed contributors. Generally artifacts and process are transparent and most contribution is voluntary. However, some companies pay their workers to contribute. (Mockus 02 Deek 08) These communities often use lean media to coordinate activities and share knowledge, tools such as CVS and Git for version control of code, web sites and online tutorials for instructional content, and Internet Relay Chat (IRC) and mailing lists for communication. (08 Weller)

How is it a form of PBL? (tie back to how OSS provides not only problems but other resources that support PBL)

What are the benefits of OSS? (describe some of the general learning in OSS papers here and how map to PBL and constructivist learning)

Readymade authentic problems

Technology to support

Social structure may also support some of the PBL functions

What is the extent of OSS participation for learning?

What skills are developed? Discuss methodological concerns and lack of study of HO skills?

RQ 2 –

Can PBL- tailored student involvement in OSS communities assist with the development of higher-order thinking skills while satisfying CE learning goals?

State of Instructional Design of PBL in CE

State of Instructional Design for OSS participation in support of CE

While there has been student participation in OSS for learning there is a lack of instructional design for using. Discuss lack of formalism from literature and many problems in applying.

Research gaps/methodological limitations

Here making a case to set up a case study of students participating in OSS that follows an ID incorporating the PBL process to measure HO and other skill development.

Methodology

RQ1 - study of artifacts (mailing lists, IRC, etc.) related to participants' progression in OSS to identify skills exercised, in particular HO. This will be used to tie OSS activities to learning goals and to understand how to leverage the community and technology as part of PBL instructional design that will be tested to answer RQ2.

RQ2 - Case study of PBL instructional design of student participation in OSS. As part of an independent study students will participate in an OSS community. Instructor will follow PBL instructional designs developed from output of study for RQ1. Assessment will include pre and post testing of higher-order thinking skills, and evaluation of activity in the community, and student learning diaries.