Design Strategies for developing a Visual Platform for Physical Computing with Mobile Tools for Project Documentation and Reflection

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Abstract. This poster discusses work on the design of a visual-based programming language for physical computing and mobile tools for the learners to actively document and reflect on their projects. These are parts of a European project that is investigating how to generate, analyze, use and provide feedback from analytics derived from hands-on learning activities. Our aim is to raise a discussion about how learning analytics, intelligence, and the role of learners' documenting their work can provide richer opportunities for supporting learning and teaching.

Keywords: learning analytics, human factors and interface design, prototyping

1 Introduction

Educators, researchers, business leaders, and politicians are working to initiate new modes of education to provide 21st Century skills that focus on the following: creativity, innovation, critical thinking, problem solving, communication, and collaboration [4]. Recently, researchers and practitioners have provided strong cases for the value of hands-on activities like digital fabrication than could be part of the toolbox to bring powerful ideas, literacies, and expressive tools to learners [1]. This poster presents on-going work in the Practice-based Experiential Learning Analytics Research And Support project (PELARS) that aims to generate, analyze, use and provide feedback for analytics derived from hands-on these project-based learning activities. The focus of the PELARS project activities is on learning and making things with physical computing that provide learners with opportunities to build and experiment with tangible technologies and digital fabrication. One of the key research aims of the PELARS project can be summarised as: *How can physical learning environments that use hands-on digital fabrication technologies be better designed for ambient and active data collection for learning analytics?* The project addresses three different learning contexts (university interaction design, engineering courses, and high school science) across multiple settings in Europe. The goals of the project are first to define learning (skills, knowledge, competencies) that is developing, and how we can assess it in the frame of learning analytics. Then to determine what elements of this learning we can capture by designing the physical environment and activities around digital fabrication technologies. Then to identify what patterns of data we collect can tell us about learning, collaboration and how the system can help support the learning activities.

The PELARS project approach has been to develop an intelligent system for collecting activity data (moving image-based and embedded sensing) for diverse learning analytics (data-mining, reasoning, visualisation) with active user-generated material from practice-based and experiential activities. This rich range of data is used to create learning analytics tools for learners and teachers that range from assessment to exploring intelligent tutoring. The PELARS system carries forwards the ideas of knowledge communities and inquiry [7] and provide conceptualising, representing, and analysing distributed interaction [8]. However, there are multiple challenges for designing learning analytics and intelligent support for these types of tangible activities. Learning situations in these contexts include open-ended projects, small group work, and the use of physical computing components that require construction and programming. Therefore, these types of activities present difficulties for collecting meaningful data for learning analytics.

This poster specifically discusses our work on the development of a visually based programming platform for the physical computing hardware and the mobile tools for the learners to actively document and reflect on their projects. These two parts of the PELARS project provide opportunities for discussion on the relationships between intelligent support, active learner engagement, and analytics. Our aim for the workshop is to raise a discussion about how learning analytics, intelligence, and the role of learner documenting their work can provide richer opportunities for supporting learning.

2 Methodological Approach

The PELARS project has a design-centric approach that includes the use of low-fidelity prototyping and "wizard of oz" scenarios [5]. These methods that include paper prototypes and technology sketches to investigate how to find the best way to get the design right [2]. The goal of the two cases below is to investigate how we can better understand the needs of the users. The need to develop a visually based programming experience to support students and supply data for analysis and lack of student documentation were identified as challenges through literature and own contextual user research in the project.

For the visual programming platform, a kit was created that contained foam core versions of hardware blocks with strings and pins to act as the cables to connect them. A small magnetic board with paper-based magnets acted as the computer screen that represented what blocks were connected. A set of simple tasks were provided to pairs of testers (recruited students from Interaction Design and Computer Science) while one of the researchers acted as the computer in a “wizard of oz” scenario. Figure 1 illustrates how the students connected the hardware blocks of sensors and actuators (the paper blocks and strings) on the table and then the researcher put on a magnetic board (computer screen) the associated blocks (printed magnets). The researcher acted as the wizard representing the smart system that recognised which blocks the students had connected and represented the computer screen showing the visual programming interface. This prototyping system allowed the teams to discuss and adjust the inputs to generate the hypothetical outcome for the different tasks.

Fig. 1. Visual programming platform prototyping

For the mobile reporting part of the PELARS system we adopted a web-based system developed by colleagues [9] that allowed us to create a series of forms that could be accessed by students in an Interaction Design course where they have a 4 week block in physical computing. The students needed to fill in three forms, the first form asks them to briefly describe their plan for solving the task, the second form allows them to document their progress with text and photos, and the final form asks them to reflect on the outcome, did the project succeed as planned. Figure 2 shows the different screens of the mobile system. The intention of our prototyping effort has been to explore the similarities between practice-, problem-, and inquiry-based learning [3] and the challenges in student self-documentation practices in physical computing.

In addition to the forms, the students were also asked to complete a lightweight pre-survey and post-survey to evaluate the usability of the mobile documentation tool. The surveys were inspired by Read and MacFarlane’s [6] work on surveys for children in computer interaction and designed to take a few minutes to fill out. The survey results were intended to supplement the submissions received through the mobile system. The pre-survey intended to cover their general experience with documenting their work and the post-survey their views on the usefulness of the tool. Additionally, the pairs of students were interviewed in a semi-structured after the prototyping session.

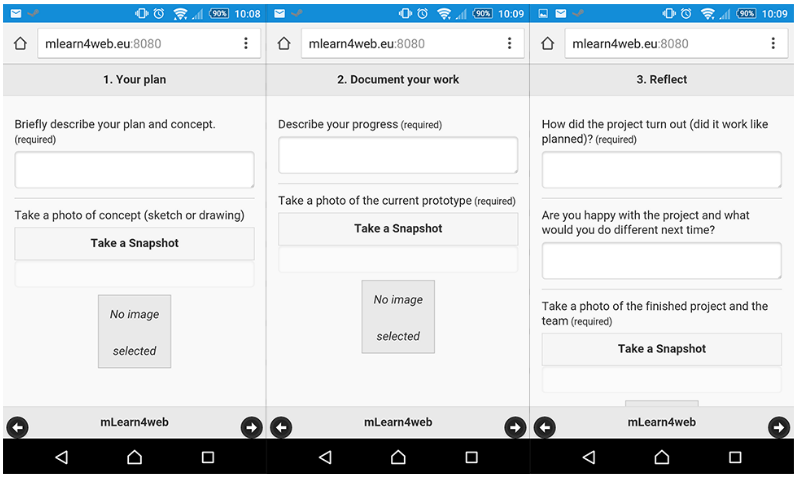

Fig. 2. Mobile system screen captures

3 Initial Results

3.1 Visual Programming

The initial results for the visual programming platform points towards the less experienced programmers finding the visual programming system easier for solving the different tasks. The less experienced students were more open to exploring how to solve the open-ended tasks. While the experienced programmers were frustrated by their perceived limitations of the system, for example not being able to code a loop statement to blink an LED. During the post activity interview, the experienced programmers did however see the system as useful both for learning programming but also for communicating ideas in a prototype stage. Importantly to note, that these perceptions may reflect that design students are more used to open-ended tasks and familiar with throw-away prototyping.

In some cases, the designers worked with more experienced programmers and in these cases communication between the team members helped the programmer shift metaphors to a more visual style of programming. After the initial tasks the more experienced programmers felt they had a better understanding of the concept. Additionally, in the follow-up interviews, they expressed that they liked the idea of visual coding, but primarily saw it as a teaching tool or a communication tool rather than something that they would use to build their projects.

3.2 Documentation Tools

The mobile tools initially seemed to have the right balance of short text entries and the uploading of rich media. The aim was to allow the students to plan easily, document and reflect via smartphones or laptops. Our initial findings suggest that the structure of planning, documenting the process and then reflecting on the project was utilised by the students. The students reported in the post-survey that it is easy to forget to document, to ignore it, or do it later. While the submitted documentation captured the students progress, it was also often submitted the day after or when they were finishing their work, rather than at the end of each session. Our thoughts for these results are that students faced the combination of not seeing the relevance of documenting the projects was important and not having practiced documenting their work.

Students reported in the post survey that the usability of the system needs to be improved. For example, they pointed out that the system did not let them go back to add, or amend their documentation. The need for better clarity what happens with the data after they submit it could help with the students. Connecting the documenting tools to their normal work practices and digital tools, like blogs or online portfolios need to be explored. Additionally while documenting some students appeared were frustrated when submitting as a group. The data shows that when students used a personal device they choose to submit individually. This suggests that the group submissions are useful, the students desire to submit individual reports as well.

4 Discussion

We feel that that the low-fidelity and sketching the technology for the PELARS project are important means to design better intelligent support while engaging with the needs of the different users. The PELARS project has been influenced by inquiry-science learning. However, the nature of making and solving problems with physical computing in interaction design courses can be more dynamic and open-ended than more traditional classwork. Prototyping both the programming interface and the documentation tool as parts of the same project, rather than as separate entities gives a broader design approach. This allows us to explore different aspects of the learning environment and test out ideas in pseudo-real world situations. One of the design goals is to support the visual programming activities with intelligent tutoring and means for teachers and students to analyse of time how they programmed and built the different projects. Additionally, the documentation tool provides a different perspective to the ambient data collection and a process framework for the learning activity. We feel that using these different design approaches provides us with a means to explore the complexity of project-based experiential learning scenarios.

Acknowledgments. The Project is a European Union Research Project for Small or Medium-scale Focused Research Project (STREP) part of the FP7-

ICT-2013-11 Objective ICT-2013.8.2 Technology-enhanced Learning. The Grant Agreement number is 619738. http://www.pelars-project.eu/.

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