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Development of a Mobile Application That Supports Less Obtrusive Peer Assessment in K-12 Engineering Education Using an Engineering Epistemic Frame (Work in Progress)

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Abstract

With social media and technology so prolifically used by kids at younger ages, and patterns of behavior where kids like to record everything or see themselves on screen and in videos with tools such as SnapChat, Instagram, Vine, and TikTok, there are untapped data sources that do not require traditional formal data collection. These interactions are less often for assessment purposes. This project describes the development of a tool that can be used in formal and informal spaces which capitalizes on behaviors students already do to capture data that might otherwise be overlooked in engineering K-12 environments. For the purposes of less obtrusive peer assessment (LOPA), students record themselves (or others) during class presentations or studio critiques and assess each other after having been trained to identify elements of a K-12 engineering epistemic frame (EEFK12).

Introduction

Engineering design is a process and interpretive practice[1], and traditional assessments often fail to assess higher order thinking skills[2]. STEM content knowledge is assessed more often, but assessment of evolution of identity, engineering values, and epistemology does occur in K-12 spaces. Various assessments attempt to capture cognitive and affective aspects of engineering thinking, but do not exist in one assessment method or tool. Teachers are often making decisions about a student's engineering knowledge or understanding often from a final group product[3].

A K-12 engineering epistemic frame (EEFK12) [4] was developed to capture and assess engineering thinking in brainstorm, prototyping, and testing interactions and dialogue between students. Inspired by epistemic frames[5-7], EEFK12 takes a broader lens that highlights skills, knowledge, identity, values, and epistemology of engineering and design synthesized with goals of local, national, and higher education stakeholders for use in K-12 formal and informal spaces.

The motivation for the research project is the development of an application that will integrate the EEFK12 into a tool that is useful in the hands of students and teachers. The mobile application has these purposes: to facilitate peer assessment after real-time interaction in studio or design critiques, to facilitate and encourage self-reflection and metacognition, to provide additional data for teachers to use in assessment, and to show students' growth and change over time (if used in long-term educational experiences). The hypothesis is that peer assessment will support reflection in the community of practice, improve metacognition because students are using a metric to identify exemplars and will approximate the exemplars themselves, improve their self-efficacy regarding specific elements of the EEFK12, and grow in

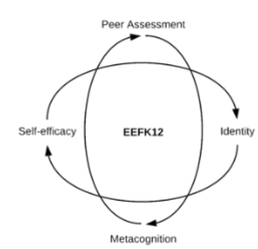

Figure 1 Interaction of outcomes of Less Obtrusive Peer Assessment using EEFK12

their epistemological identity because they can see assessment results from their peers or self-reflect. This paper describes the development of the tool, LOPA2 (Less Obtrusive Peer Assessment Application).

Engineering Epistemic Frame

The engineering epistemic frame (EEFK12) was developed as an alternatively comprehensive assessment method for K-12 students in formal or informal settings[4]. It synthesizes policy, higher education, and local standards while integrating disciplinary and industry goals for designers and engineers into a epistemic frame encompassing skills (s), knowledge (k), identity (i), values (v), and epistemology (e) [8-10] derived from policy documents and literature. The sources used in the development and relationship between sub-codes and sources can be seen in Figure 1. In the first version of the EEFK12, these five SKIVE elements had 47 sub-codes that allowed for a micro-analysis of interactions throughout the engineering design process. A pilot study was conducted with rising juniors during a college preparatory summer program to test the evidence of EEFK12 elements in the ideation, prototyping, testing, and final solution presentations of one project[4]. Video clips captured by students and counselors were coded using the EEFK12 and analyzed using epistemic network analysis. Results showed that interactions revealed evidence of skills (s), expressions of knowledge (k), projections of identity (i), display of values (v), and demonstrations of epistemologies (e) at the individual, group, and class levels. Results also showed that values and epistemologies of the profession that do not traditionally get accessed can be identified and measured.

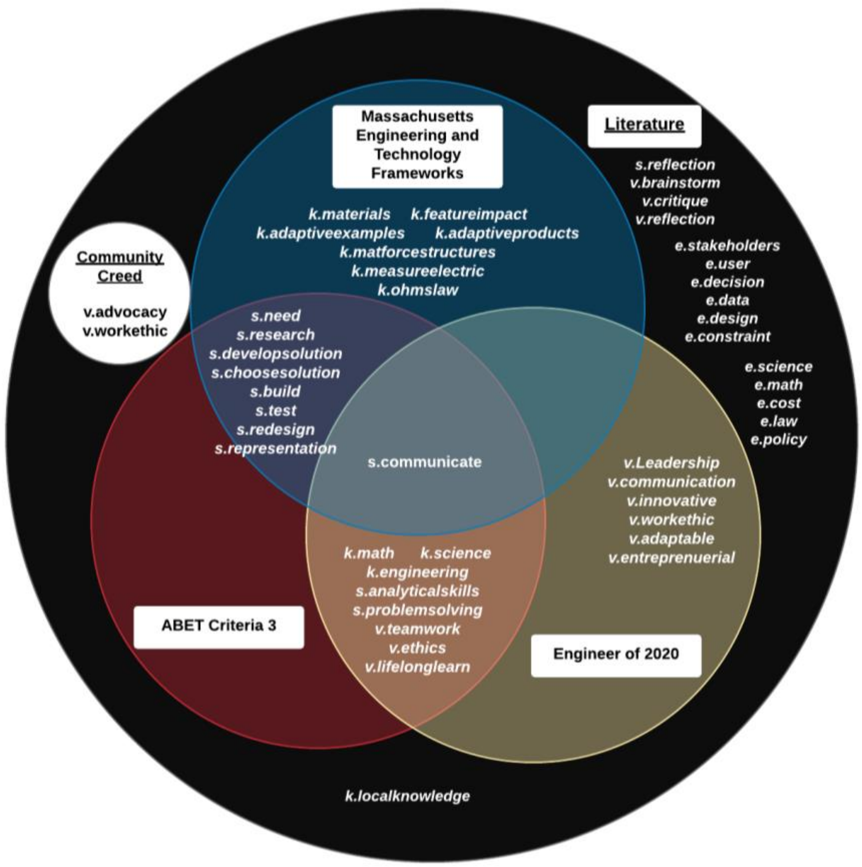

Figure 2 Engineering Epistemic Frame (EEFK12) development sources and relationship to sub-codes

Studio critique

The studio critique or design review are foundational parts of design and engineering education [11-13]. In the design review, peers, instructors, and expert judges offer feedback and design students have the opportunity to provide design rationale for their ideas and decisions. The studio critiques happen multiple times throughout the process towards an engineering or design solution. Studio critiques are often culminating events as final presentations in K-12 courses. However, summative final critiques have been noted to be least effective in facilitating learning or ideation[14]. Therefore, conducting regular design critiques throughout courses or projects creates opportunities to observe and document growth. The LOPA application was developed to accommodate this type of measurement over time.

Peer Assessment

In this context, the purpose of assessment is to identify student strengths and weaknesses, monitor progress, and assign multiple factors when assigning grades[15]. Peer assessment occurs when peers evaluate same-level peers [16, 17] based on criteria defined by both teacher and learner.

There are benefits to conducting peer assessment during design studio. These include, but are not limited to, increasing feedback opportunities and turnaround time, supporting reflection-in-action, and developing student ability to recognize and practice skills that are being highlighted for assessment. Particularly, in larger class sizes, peer assessment could be helpful since receiving teacher feedback could be scarce [18] or untimely. Peer critique occurring in design studio [19] also offers an opportunity for students to learn as they perform reflection-in-action [20, 21]. Though educators must be mindful about training students appropriately, research has shown that students' peer assessment ratings can be highly correlated to teachers' ratings [22]. If we viewed engineering and design as performance, performance ratings are highly related to student's self-efficacy in evaluating peers' work and improving work based on peers' comments [22].

Peer assessment helps students reflect on their learning through organization and engagement [23]. Research shows that peers can potentially be good at wrestling with cognitive conflict [24]. It supports scaffolding and error management via cognitive model of competent performance [25]. Learners improve their communication skills as participants explain it to each other, and affective components within a comfortable community facilitate self-disclosure of ignorance, motivation, and accountability [23].

Mobile Peer Assessment Systems

Our goal is to take advantage of student social media recording behaviors to create an assessment process "so unobtrusive to students and teachers, so seamless"[26] that it enhances disclosure, "the extent to which a task or activity produces evidence of student performance or thinking" [27]. The strategy to do that is to use a mobile peer assessment system. Mobile peer assessment systems have been used in computer science courses and science education design activities[28] [29] and have promoted self-efficacy in performing arts [22].

This mobile-enabled cloud-based web application, currently called LOPA[2] (Less Obtrusive Peer Assessment App), is designed for a wide selection of consumer devices, operating systems, and form factors. The web application was developed using the Laravel PHP application development framework and uses the MariaDB for data storage. LOPA[2] runs on a Linux server hosted and supported in a datacenter run by a local university. The implementation process is portrayed in Figure 3.

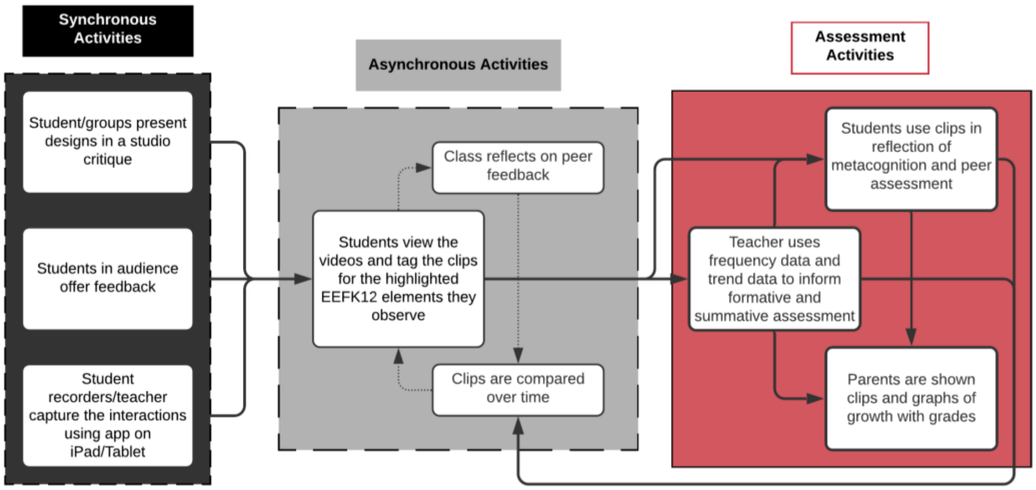

Figure 3. EEFK12 LOPAA Implementation Process

Appropriate and responsible use of LOPA2 requires teachers to do some administrative and pedagogical work before expecting students to use it properly. Teachers will have to be trained on the EEFK12. Teachers must set up classes and register students according to their roster. The teacher administration page with all of its functions is shown in Figure 4.

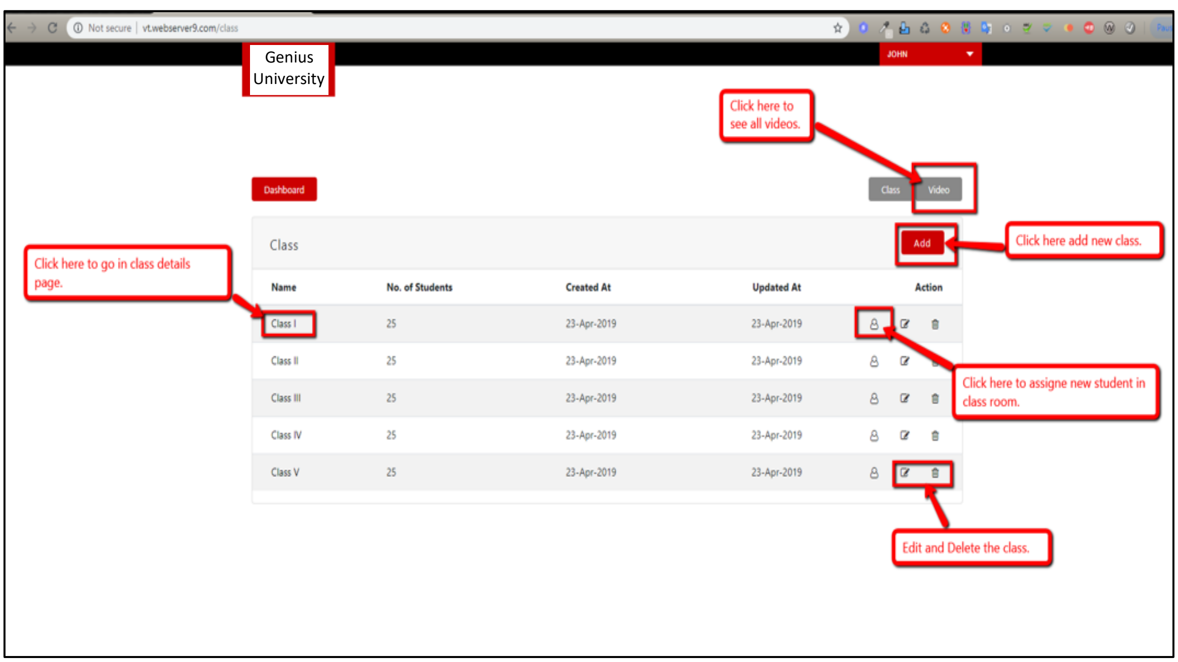

Figure 4 Teacher administration page of LOPA2

Teachers must plan the course and classroom to have appropriate time for multiple studio critiques, mobile technology for recording, and student roles for recording. Teachers must then teach learners the criteria and provide exemplars of the EEFK12 so that students recognize them prior to using the application. This should be done early in the course as norms are established and can be done using videos and materials supplied with professional development activities.

Once students are able to identify elements of EEFK12, teachers or student recorders capture design presentations of their peers using mobile devices (Figure 5) while the class is offering productive feedback. After the studio critique process is complete, students review the video clips and tag them for the elements of the EEFK12 of focus for that unit or project. Figure 6 shows a screenshot of sample tags and a filler video clip. The class can also review video clips collectively with the teacher.

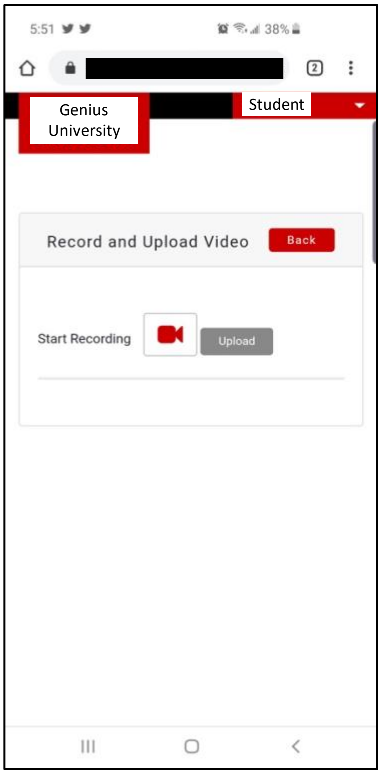

Figure 5 Mobile screenshot of LOPA2 for student recording.

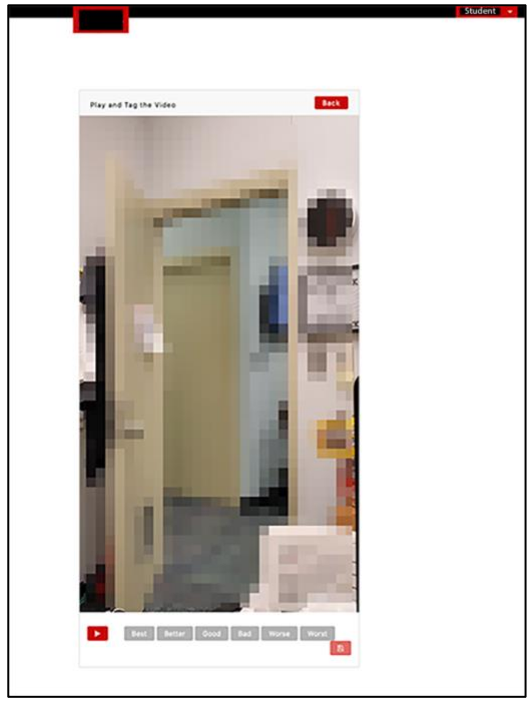

Figure 6. Screenshot of LOPA^2 student video tagging screen.

After the clips have been tagged, there are multiple assessment options. Students can use video clips as data for metacognition and evidence in reflection with parents as well as peers. Teachers can use frequency and trend data and video clips to inform formative and summative assessments, by sharing with students to support student reflection and by sharing with parents to support assessment discussions and show growth. Both students and teachers use the canon of clips over time to compare evidence to show growth and or change.

Conclusion

The next stage in the research project is to pilot LOPA$_2$ in formal and informal educational spaces and develop teacher professional development resources. The research team will conduct user studies with students to refine the applications' features and plans for pilot studies in small community schools, outreach programs, and engineering summer programs.

Long-range goals are to develop ways to quantify such data into metrics that complement the metrics used in traditional schools, and further develop the application so that teachers will find it a useful tool for assessment by engaging in user studies with teachers.

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