Using Mobile Technology for Fostering Intellectual Engagement

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Using Mobile Technology for Fostering Intellectual Engagement

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Abstract—**Student engagement, and in particular intellectual engagement, has been identified as a key factor in learning at the high school level. While this type of engagement has an impact on student learning in fields related to science, technology, engineering and mathematics (STEM), it also has a positive impact on the learning of other disciplines such as English, Fine Arts, and Social Sciences. This report describes a set of projects co-designed by teachers and education specialists aimed at engaging students intellectually in each major high school subject area. Student use of mobile technologies, in this case the iPad2, features prominently in each of these projects. Interviews with teachers and students were conducted in order to identify evidence of intellectual engagement, as well as students' interactions with the mobile device. Data from a survey was also used to identify the level of engagement of students involved in these projects.**

Index Terms—**Intellectual engagement, mobile technology, high school, curricular design.**

I. INTRODUCTION

In recent years student engagement has acquired increasing attention from researchers and policy makers. Focused originally on high school completion [1], student engagement has been associated with student achievement, positive classroom and school climate, and effective instructional practices [2]. In contrast, disengagement has been identified as a cause of withdrawal from school, and seems to be more prevalent in student populations from low socio-economic areas or where great cultural and linguistic diversity exists [1,3]. The social effects of students disengagement has been researched in several countries, including Canada: "disengagement in and from school is linked to school violence, social exclusion, and a polarization severe enough to pose a threat to social cohesion in Canada" [4]. Student engagement has been considered not only as a strategic process for learning, but also as an accountability outcome unto itself [1]. As we share this perspective, we believe that engagement should be considered beyond final grades or school completion.

Student engagement has been defined generally as "a disposition towards learning, working with others, and functioning in a social institution" [5]. In this paper we focus on three dimensions of engagement: social, institutional, and intellectual [4,5]. *Social engagement* refers to the sense of belonging to school, including the participation in school activities such as sports, arts and community involvement. *Institutional engagement* corresponds to the fulfillment of school requirements. *Intellectual engagement* is described as a serious emotional and cognitive investment in learning characterized by intrinsic motivation and higher order thinking skills—associated with the state of flow [6].

Our focus on engagement entails a shift of educational paradigm. Current conceptions of education have evolved from schools organized to meet the needs of the industrial age [7]. Such conceptions are based on a traditional notion of knowledge being static and the need for schools to sort people into categories based on their final employment destination. Instead of considering knowledge as static content and standard procedures that can be broken down and transmitted to students, new conceptions of knowing and learning place importance on: collaborative knowledge building, scaffolding learning, through ongoing formative assessment, understanding the connections and interactions among different knowledge systems and modes of representation; emphasis on diversity; and foreground process, rather than products [7]. In order to shift the focus from educational paradigms from the industrial age to these new conceptions, educational reforms need to focus on creating the conditions needed to engage all students intellectually [8]. Such reforms also require supporting teachers in the design of learning environments in accordance to these new perspectives.

The Galileo Educational Network Association (GENA) provides professional learning support for teachers to enable them to design tasks and assessment practices that foster student intellectual engagement. For the past two years GENA has worked closely with teachers from a high school in a low-income, culturally diverse district located in a Western Canadian city, to design and enact a variety of discipline-based studies aimed at increasing students' intellectual engagement. This report describes the studies these students and teachers were engaged in, as well as their perceptions of the work and the role of mobile technology in this context. A preliminary version of this research report was presented at the IEEE Global Engineering Education Conference, Berlin, 2013. This refined and extended paper elaborates further on both the methodology and the implications of the research.

II. STUDENT ENGAGEMENT

Student engagement has been studied internationally for more than 25 years, mostly from the psychological and the social perspectives with a strong focus on measurement using self-reported surveys [9]. Research has consistently shown strong correlations between student engagement and completion of high school as well as improvement of grades. In [2], Yazzie-Mintz and McCormick argued for taking into account students' perceptions of the learning environments and conducted a survey with multiple options and open questions. They concluded that the quantitative data commonly used for measuring student en-

gagement do not provide information on the kind of learning that students have experienced, the depth with which students have engaged in their learning, or what adults might do to help students experience school in a more engaged way: There is a need for qualitative research on student engagement [2].

In the Canadian context, in 2007, an initiative aimed to capture, assess and inspire new ideas for enhancing students' learning experiences was launched: the Tell Them From Me survey (TTFM), designed by Dr. J. Douglas Willms, [4]. In 2008, Penny Milton, Chief Executive Officer of the Canadian Education Association brought two other research and development organizations, GENA and The Learning Bar Inc., to engage in a 3-year research and development project to study, assess and enhance the learning experiences of adolescents in classrooms across Canada. Intellectual engagement was a construct added to The Learning Bar's TTFM student engagement survey instrument. In the province of Alberta, in Western Canada, provincial, district and school leaders have been tracking student engagement using the TTFM survey instrument. Three aspects of student engagement are assessed in the TTFM survey: sense of belonging at school, including participation in school life (social engagement); the extent to which students value schooling outcomes, (institutional engagement); and the extent of their serious emotional and cognitive investment in learning (intellectual engagement). The results of this survey have consistently shown that students: (a) prefer strong relationships with the teachers and their communities; (b) want to explore real problems, issues, questions or ideas that are of real concern to individuals and their communities; and (c) seek learning environments that build interdependent relationships—these results are consistent with [2]. However, a more detailed description of how students experience intellectual engagement is barely reported in the literature. As far as we know, the only two studies that have analyzed qualitative data used open question in surveys ([2] and [4]). The need for more studies that include voices of teachers and students has been a current concern among researchers—e.g. [4].

Focused on the experiences of adolescents in classrooms and schools from across Canada, the TTFM initiative expanded into a framework which put forward a set of teaching principles and strategies shown to improve levels of student engagement: the Teaching Effectiveness Framework (TEF) [10]. This framework is based not only on psychological and social features of engagement, but also on neurological research in education. The most effective learning takes place when learners have reached what Csikszentmihalyi calls a state of 'flow' or intense cognitive and emotional engagement [6]. At this point, the brain begins to make connections and patterns emerge in the information, resulting in powerful illuminations and understanding [10]. This approach contrasts to the mainly psychological and social approaches to student engagement commonly held by other researchers—e.g. [9].

The TEF framework served as a guide for the development and research initiative outlined in this paper. At the risk of an oversimplification, we summarize the core principles that underpin the TEF as they framed our analysis and data presentation. First, *teachers are designers of learning environments that engage students intellectually and academically*: In addition to having disciplinary, curricular, and pedagogical knowledge, teachers thoughtfully

and intentionally design learning environments to engage their students. Intellectually engaging environments sponsor curiosity and awaken the desire to know and understand within learners. The result is a deep, personal commitment on the part of students to explore and investigate ideas, issues, problems or questions that have personal relevance, that matter to the discipline being studied or the world beyond the classroom. Second, *work students are asked to undertake is worthy of their time and attention, personally relevant, and deeply connected to their world*. This work engages students in the broader community where they explore real problems and concerns not only relevant to the discipline, but also connected to students' lives inside and outside school. Such explorations foster strong habits of mind where students are invited to formulate plausible theories and defend them through reasoned discourse based on evidence and in light of different viewpoints. The work that students undertake is authentic in that it mirrors the ways of thinking and acting reflective of practitioners in the field—e.g. historians, biologists, journalists, photographers, and architects. Third, *assessment practices improve student learning and guide teaching*. Assessment is a seamless part of the learning process that involves students in examining their work in progress, checking to decide what has been learned and what needs to be learned next. It includes setting and using criteria, having students self-assess, being engaged in peer coaching, receiving feedback about their work, collecting and organizing evidence, and presenting evidence of learning to others. It identifies what has been accomplished, what needs to be done, and informs the next steps for both teacher and students. Four, *teachers foster a variety of interdependent relationships*. Effective learning environments are characterized by a series of interdependent relationships that promote and create a strong culture of learning. The teacher engages students in dialogue by: stimulating discussion, posing questions, provoking thinking, suggesting resources, and helping students determine their next learning steps. Students collaborate with each other as well as with discipline experts both inside and outside of the classroom in order to build their collective understanding about the topic under study. And five, *teachers improve their practice in the company of peers and others*. Teachers improve their practice, and hence their effectiveness, when they have opportunities to learn in the company of their peers. A scholarship of teaching begins to emerge where a regular part of the school discourse centers on the learning of students, and where teachers have access to each other's classrooms, and time to plan collaboratively. Teachers become reflective practitioners who seek out the constructive feedback from peers, mentors and experts in an effort to constantly improve their practice.

An additional aspect of student engagement is the relationship of new generations with technology. The infusion of digital technologies is an essential part in the programs of study, in most Canadian provinces [11]. However, in order to take advantage of this technology in education, roles of, and interactions among, students, teachers, academic subjects, and the technological devices must be reconceptualized [12]. New forms of learning are associated with the daily use of technology. New generations born into high-technologized societies, known as "millennium learners," have different ways of learning and socializing [1,13]. Mobile devices have played an important role in

the emergence of these new cultures and now the role of teachers, students and technology at school are shifting in such a fashion that the teacher is no longer the expert, at least not in the use of the mobile technology [12].

III. RESEARCH DESIGN

The study presented in this report was based on a three-year participatory design-based research ([14]) in which researchers were actively involved in working with teachers and students. The purpose of this study was to better understand how student learning and engagement are impacted when teachers are provided with intensive professional learning informed by the principles outlined in the TEF.

Design-based research in education is situated in real educational contexts and studies innovations, as they are implemented, involving multiple iterations of design and testing of significant interventions in collaboration with researchers and practitioners. In the last ten years, the adoption of this methodological approach has been increased prominently in educational research ([14]). Due to its focus on the complex phenomena of education, design-based research employs both qualitative and quantitative methods. The term 'participatory' refers to the role of practitioner—e.g. teachers—and researchers in the study. In contrast to other forms of research in which students, and teachers, are studied by researchers, in participatory design-based research both researchers and practitioners play an important role in the design of the innovations. Researchers are co-designer, and teachers are often co-researchers, as they engage also in the development of new insights and knowledge derived from the collaboration.

The first year of this participatory design-based research was mainly devoted to: building trust between teachers and GENA's staff, assessing teaching practices, evaluating levels of student engagement, and developing a strategy for teacher professional development. The preliminary findings reported in this paper correspond to the perceptions of students and teachers of two Grade Ten groups, called the pod, during year two of this research and development initiative[1]. We particularly addressed the following research questions: How did students experience intellectual engagement when involved in the learning environments co-designed with GENA? What were the teachers' experiences, in terms of the TEF, when participating in the second year of this project?

In order to capture the experience of students and teachers in this project, we considered a mainly qualitative approach for this part of the research. We incorporated varied sources of data as a means to better understand the complexities of the school setting: field notes; task designs and unit plans; class observations; semi-open interviews conducted at the end of the year with six students, the teachers involved, and administrators; artifacts of students' work; and the Tell Them From Me (TTFM) survey [4,15]. While the survey and the class observations provided quantitative data regarding the level of engagement, the interviews provided details of students and teachers' perceptions of their engagement in the studies co-developed and enacted with GENA. The TTFM survey

served as an external measure of student engagement as a dependent variable. However, the survey accounts for the whole experience at school, not only for those projects co-designed with GENA. In this sense, the results of the survey are considered only as an indirect measure of the results of GENA's initiative. Class observation was adapted from the Class Observation Protocol designed by State Educational Technology Directors Association. Class observation was conducted as a means to identify instructional practices and levels of engagement. Each observation was conducted by at least two researchers, who compared their results thereafter, discussing and negotiating discrepancies. Class observation took place during the first year of the intervention, evidencing a prominent teacher-centered approach to instruction, with a strong emphasis on procedural knowledge and memorization. This observation informed the design of the intervention for the second year.

The TTFM survey was usually administrated twice a year. However, during the academic period 2011 and 2012 it was only administered in November, which was a limitation for this study. During the first part of this academic year, GENA worked intensively only with the Mathematics and Science teachers of the pods.

Students and teachers were interviewed in pairs by the end of the school year. One pair of interviewed teachers were the English Language and Arts and Social Sciences, the other pair consisted of the Mathematics and the Science teachers. Only six students agreed to participate in the interviews and were sorted in three pairs. The Interviews were transcribed and coded in terms of the five core principles of the TEF by at least two researchers. The Nvivo software for qualitative research was used to compare and select excerpts based on both the students' descriptions of their intellectual engagement and the teachers' activities reflecting the TEF core principles. Following the principles of quality for qualitative design, we present excerpts of these interviews as a means of giving participants a voice, to represent multiple perspectives, and to allow the reader to judge the merits of our conclusions ([16,17]). Descriptions of the Projects Designed for Stdents

The teachers involved in this research had expertise in one of the four subjects students are required to study at high school in Alberta, Canada: English Language Arts, Mathematics, Science, and Social Studies. During the second year of this initiative, teachers worked in pairs: Mathematics with Science; and Social Studies with English Language Arts. The later pair merged their two courses into a single-year course: Humanities.

The following projects for students were selected due to their deliberate focus on intellectual engagement. It must also be noted that the appropriate use of digital technologies is infused into each of the five principles outlined in TEF. In this case, the iPad 2 was the mobile technology that featured prominently in the teaching and learning of students involved in this stage of the initiative.

A. Humanities - Mash-ups

As part of a novel study in their Humanities class, students were invited to choose one of the key ideas from the novel *To Kill a Mockingbird*, by Harper Lee, and develop it into a digital collage, or mash-up. They were encouraged to use any combination of media from a variety of sources, including movie trailers, news clips (audio and

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[1] Although this initiative was extended to other teachers at this school, we had the opportunity to work with all the teachers in the four main subjects who taught these two groups

video), still images, music, poetry, sound effects, pop-culture representations from television, and radio to represent their interpretation of a key theme or message from the novel. The multimedia features of the iPad played a central role for this project.

The mash-ups were aired for an authentic audience during a public screening when prospective new students and their parents, were visiting the school.

B. Humanities - Romeo and Juliet

Students worked with professional actors to interpret and re-enact scenes from Shakespeare's Romeo and Juliet. Many of the scenes were placed in different contexts and represented fresh and original interpretations, re-created in contemporary contexts proposed by the same students.

The portability and versatility of the iPad tablets enabled students to take on and easily switch between diverse production roles: from scriptwriter, to director, actor, photographer and film editor. It also meant that student production teams could set the stage in almost any setting where today's teens might actually congregate including coffee shops, shopping centers and movie theatres. This approach inspired students to both study the play and also work through their own original interpretations in ways that closely mirrored those employed by contemporary actors and film production companies.

C. Science/Math - Field Study

The mathematics and science teachers collaboratively designed a unit with experts from a biogeoscience station located in a nearby provincial park. Teachers used the Galileo Discipline–Based Inquiry Task Rubric, described in [18], to guide their design of an engaging study. Working in teams, students used the same tools and methods of gathering data that scientists at this field station would use to explore how the environment changes as you move up a slope or in a northerly direction. Once students had collected their data, they were asked to synthesize their findings, compare their results to other studies conducted by scientists in that area, and identify questions for further study. Students presented their findings during a poster session using the same format that scientist from the field station used in presenting their results. The connection with scientists at the field station was essential for the design of the task and to enable students to obtain meaningful feedback about their work as they tested the validity of their findings.

The iPad allowed students to gather, record and analyze data they collected during their visit to the station.

D. Science/Math - Public Service Announcement

After visiting an energy efficient house, students were asked to identify energy issues in the school building and develop a proposal for improving energy efficiency. This project demanded students to provide a sound scientific rationale for the basis of their conclusions relative to the amount of energy saved, as well as determine the real cost of implementing their proposals. Students used the iPad to develop and present their proposal in the form of a short, but compelling, video Public Service Announcement (PSA). Proposals that students presented to the School Board facilities and maintenance directors were both defensible and feasible. As a result a monetary sum was awarded to the school to enable a number of the proposals to be implemented.
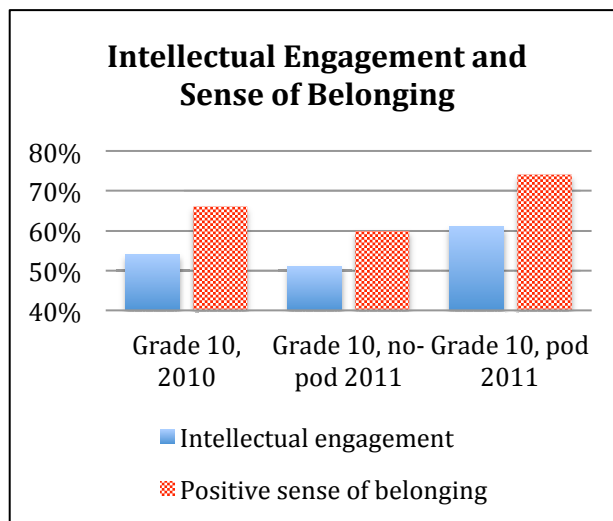

Figure 1. Results from the TTFM survey

E. Mathematics - Expanding Cube

Students used the multimedia capacities of the mobile technology to solve a mathematical problem during several sessions—see [5] for more details on this task. The technology enabled students to conjecture and verify results, and to communicate both their process and final solution in the form of electronic documents that included photographs, tables and both written and oral descriptions of their findings. At the end of the unit students wrote a test on manipulation of polynomials based on the formulae developed through the project.

IV. RESULTS

The TTFM survey indicated an increased level of engagement when compared with other Grade Tens during both the same and the previous year (Figure 1). In particular, the level of intellectual engagement was 11% higher when compared with non-pod students in the same year, which suggests that the intervention impacted positively on student intellectual engagement.

Although it was not a main focus of this research, it is worth noting that social engagement improved as well: The category *Sense of Belonging* was 14% higher in the pod group compared with the other non-pod Grade Ten students in the school, as illustrated in Table 1. The data from student and teacher's interviews provides additional details of how engagement was embodied in the studies students undertook as part of the initiative.

During the interviews conducted at the end of the year, students were asked to identify work they had completed that they were most proud of. The examples cited most frequently were those projects co-designed with GENA: particularly, the Romeo and Juliet, Mash-ups, the Biology field study and PSA projects.

A. Students' perceptions

The following excerpt from a student reflection journal in science and mathematics represents an instance of intellectual engagement: the student was intrinsically motivated and self-directed during the study.

I now understand that an ecological field biologist is a very interesting profession. It's like solving a mystery. You have questions, a purpose, and you try to figure out the

answer to the questions. What is causing it? It's all about questioning something and then getting out there and trying to figure it out. It's a hands-on experience. You pick your own tools and YOU decide how you will solve your mystery. It takes patience and constant monitoring, and lots and lots of observations. You also need to be able to interpret information and make connections.

Students were also asked to describe the difference between their courses with their experiences of those same courses in previous years. The following comment contrasts a superficial experience of language arts with a more challenging program that demanded more of students.

We would usually do whole bunch of grammar things and just general learning how to use the language. This year, there was a lot of reading comprehension, like we had to do with To Kill a Mockingbird. We had Romeo and Juliet. We had all of these essentially bits of reading or we would read through the passages of anything that [teachers] gave us and we'd have to comprehend what we read, like what did this character do at this time and how did that affect the story? So, it was a lot less learning how to use the language and more learning to kind of think with it, really, because we know how to use it now, so you get to think.

Students were asked to identify something they did in high school that had meaning and relevance for them. The following two excerpts show how work students undertook was relevant to their personal life in terms of effort invested in the project, personal relevance, authenticity regarding arts, and being proud of their work.

I was sort of thinking of the Mash-up that we did. We spent so much time on it, it's like it was so important it was just...I don't know, it was just all the experience built into it and what we got to do and how it like, related to us. To me, it felt like it was really important

I like the Romeo and Juliet project, that was really fun filming. We just did like a little thing and we have like, we did–I think it was Act 3, Scene 1, the fight scene. We just did like this cat fight it was really fun. It was like a film.

I still like the To Kill a Mocking Bird project. We got– I'm pretty sure I had a fairly good mark on that because we showed (our teacher) that one and he was speechless. Ours was just like, it was completely done when we showed it so it was like, "Oh Yes, let's show it." When he watched it he was like, "Wow, I don't know what to say, it was really good." I was really happy with that one, it took a lot of effort, so much work.

The relevance of the mash-up study went beyond a good mark: it was rewarding, as suggested in the student comments from the previous excerpt. Another aspect of relevance mentioned by students was the involvement of a broader audience, as we can read in the following:

The challenging part is to make my Mash-up appeal to— you want to make it appeal to all age groups, from old to young— explaining how the young shouldn't try to grow up too fast. And reminding the adults that it's OK to have fun, and not be yourself and just be a kid. ... [And we] try to make it seem sentimental and trying to incorporate the "To Kill a Mockingbird" [ideas] into the mash-up. It took my group a while but you notice how Scout, the girl in the movie, she isn't afraid to be a tomboy and just play around and not try to grow up too fast, since she doesn't want to grow up to be a lady. She just wants to be herself. So we tried to incorporate it.

Students were asked also about how assessment was conducted in their courses. In this case, the interviewed student explains how the expectations for the assignments were made explicit.

On the first day [teachers] gave us like an idea and then the next day we would talk it over and then they'd give us more of like what they expected and stuff. They wanted it to be like a lot of details and like appealing and good pictures and stuff.

Moreover, most interviewed students described their preference for performance-based assessments over quizzes and tests. In the following transcripts students explain their preference based on how these studies were more interesting and allowed creativity.

I like the Mash-up better. I do not like tests. It's more interesting and really got me involved and I learned a lot more than on a test.

Same with her, like I prefer the Mash-up because I guess to show my creativity and if I'm having fun I put more effort into the work I've done. So on tests and quizzes, even though I study hard on it, once the test comes there are terms that I couldn't get or I just get lazy and I just guess or I second guess myself.

Only one of the interviewed students preferred assessment in the form of tests and quizzes. However, this student acknowledged that the studies and projects supported a deeper understanding of the course content, as we can read in the following comment:

I think tests and quizzes I do best on, and I think it's just easier for me to express when it's taught that way, rather than say writing your answers for an assignment. ... The assignments and seminars and things helped me with my understanding of the content of the course. But I think tests and quizzes are really, they're the best way for me to determine how much I actually know on the subject.

The previous excerpt can be analyzed in terms of two different types of assessment: summative and formative. The student seems to focus exclusively on summative assessment—to evaluate the state of knowing at the end of a unit or semester regarding content matter. However, an important component of the studies and projects codesigned with GENA was formative, ongoing assessment—to improve student's learning. The student's comment in the excerpt places a value on the assignments in terms of the learning of course content, which is the purpose of formative assessment.

B. Teachers' perception

Teachers' perceptions are presented in relation to each of the five core principles of the TEF. These core principles are interwoven and the excerpts therefore reflect more than one principle. However, one example illustrative of each of the five principles is included in this paper. The interviews were conducted in the corresponding pairs Mathematics-Science, and Humanities.

1) Teachers are designers of learning

Prior to the work conducted in this second year of the intervention, the mathematics teacher used a workbook for the course. In every single class, mathematics teachers had to cover designated pages of the book. However, after the second year of the intervention the teaching practices of the mathematics teacher were more in alignment with those outlined in the TEF as evidenced below:

We don't start at the textbook and work towards the curriculum anymore. We start with the curriculum, start with a big project, and work in the details. It's no longer about starting with the details and getting to the big picture. It starts with the big picture and then filling in the details–and I find that it's actually a much better way to do it because then the students really understand the concept. It's not just the details and they get lost in the concept. It's the other way where they get the concept and then the right details.

One of the Humanities teachers reflected on how the mash-up study provoked greater reflection about the quality of the tasks students were being assigned.

I think the one thing it did make me more conscious of though was thinking deeply about why are we giving students this task? What do we hope for them to accomplish? How does it cover those competencies? Especially in a Humanities class, where English and Social Studies are so closely linked, thinking about can we kill two birds with one stone? If we give them this piece of literature to read and it links to historical globalization but it also requires them to analyze a piece of literature then we've really hit on the competencies for both subject areas.

2) Students engage in worthwhile work

The PSA project engaged students in a real problem that was directly related to their school: energy consumption. The Science teacher explained that students went deeper in their studies by examining the environmental impact of the material of one alternative put forward by students.

I think they certainly went much, much deeper than we expected them to go because they were into it and they want to do it. They were so interested in it that one group started looking at insulation materials and then started looking at, well, what kind of environmental impact it is going to make. So they found this awesome material but it's really expensive and it's not very good for the environment to make. So then they decided, well, they're going to switch to a local company

3) Assessment practices

Assessment for learning was a key feature of each of the projects co-designed during this part of the initiative. In the following script from a Humanities teacher a connection between strong feedback and the personal relevance for students is explained.

When you are constantly giving them that feedback it enables them to feel as though their final product would be something that's worthy of all of their efforts and has made use of that feedback that they had been given. I know for the Mash-up project, a number of the kids, when we saw their first sort of go-around, we were able to say to them, you know you might want to rethink the sound track, or you might want to rethink some of those images, are they really conveying your theme? They were able to take that feedback and then go back and make some changes. That I think resulted in a more meaningful final product.

In the following excerpt a Humanities teacher explains the relevance of peer assessment in the Mash-up project. The script also reflects the expertise in the use of technology of some students in the classroom. The teacher is no longer the expert in the classroom; some students are actually the experts and provide feedback to classmates.

I think that in particular the peer assessment is quite powerful. ... In the case of the Mash-up, I think I said earlier, they are all pretty savvy consumers of technology. ... I think for a lot of them that was probably more meaningful than having their 40-year old teacher say, "I don't really understand what you've tried to accomplish with this set of images."

I think it was scary frankly to do a project where you are asking kids to use technology but you yourself don't really understand how the technology works.

Another component of assessment is the student engagement in the design of the assessment tools, such as performance-based rubrics. In the following excerpt the Mathematics and Science teachers explain the process of developing the assessment rubric for the PSA project.

Then [the project] was marked on every rubric we had but it's the same rubric that the kids have been working with for all the feedback loops. There must have been at least four or five loops. ... Specifically when it came to PSA's. We looked at exemplary examples and poor examples and really came up with what makes a good PSA, what makes a poor PSA.

So when we have a project such as PSA we would give them an opportunity to kind of start working [through it and] assess themselves, and then we'll give them some more chances to improve on the scale, I guess. Then one of us would sit down with them and go through it again. Then they would try to improve a bit and then they might sit down with their friends and try and improve again until they know exactly what they're getting assessed on. They know exactly what our expectations are.

4) Interdependent relationships

One of the educators from GENA arranged for professional actors to work with the students on their Romeo and Juliet projects. A teacher commented in an interview about the significance of having an expert in the group.

The actors helped the kids write their scene and gave them some notes about how to do their performance. We had time to kind of walk around and give suggestions but again we weren't necessarily saying you have to have this, this and this in your scene. It was very much up to them. They blew us away with their creativity and humor. They were really well-done at the end and they were really proud of them [Romeo and Juliet projects].

The English teacher reported students who were so involved in the creation of poems during a field trip, that they kept doing poetry afterward.

So, having the chance to do outside trips to see what they're learning in the real world. We went to a Spoken Word Festival for English. They were really into that. They were doing slam poetry on the train home.

Both social engagement and institutional engagement seemed to be outcomes of this initiative, as we can read in the following excerpt from the Science teacher.

Another thing that I'll add to that too is our students are much more involved in our school, that there's been multiple times where we would just ask "Do we have any volunteers?" and 20 hands would go up when we only needed five but that's okay. Our students love volunteering. They are always the first ones to step up to the plate and it's part of the relationship that we've built. They know that we need them and we'll give back to them.

5)   Teachers practice in the company of their peers

Humanities teachers explained how the process of co-teaching was a process of mutual teaching and learning.

In terms of my development, I think it's really a new teacher's dream to be with an experienced teacher first thing. I went from being absolutely terrified walking in to having someone I trusted and was able and willing to help me. I feel that I learned a ton from [my teaching partner]. *I don't know how she would feel.* [Laughter]

I think it's reciprocal. ... Day one, [Partner teacher] *was getting to know the kids, talking to them, engaging with them, getting to know them as learners and as individuals and bringing creative ideas that I haven't thought of or haven't ever considered. I think it worked out well for both of us. She got to be with somebody a little more experienced. I get to be rejuvenated with her new ideas.*

The Mathematics and Science teachers also commented on their learning when planning as a whole group of teachers from the four major disciplines.

We have common prep times ourselves, the four of us, and we meet at the minimum once a week.

We meet with all four teachers involved with this initiative. It's not that Math and Science are separate from the Humanities; we all get together and talk.

The teachers' excerpts presented in this section demonstrate how the major studies and projects co-designed with GENA were related to the TEF. These excerpts describe ways in which students became intellectually engaged when involved in the projects. Additionally, this evidence suggests that social engagement and institutional engagement could be other outcomes of the initiative.

V. CONCLUSIONS

It is very challenging to disrupt conventional teaching approaches. The projects and learning environments described in this report not only served to engage students in authentic tasks related to the major subject areas at high school, but also engaged teachers in designing rich learning tasks and in strengthening their practices.

The preliminary findings reported in this paper offer accounts of intellectual engagement from the perspective of teachers and six interviewed students: representing a contribution to the research on student engagement—as suggested in [4]. The results of the TTFM survey evidence an increase in the levels of both intellectual and social engagement in those students involved in the studies co-enacted with teachers and GENA. The excerpts provided in this paper represent the voices of students and teachers involved in this development and research initiative.

Teachers participating in this professional learning opportunity came to understand the importance of thoughtfully and intentionally designing learning opportunities to intellectually engage students. The mobile technology played a significant role in enabling students to think differently, use digital technology to solve problems, and express their understanding in more richly textured ways than paper and pen may have afforded. Also, the technology in this case required teachers to assume a new role in which they came to realize that they do not hold all the knowledge and expertise. Students, with their expertise and capability using multi-media and iPad Apps, assumed leading roles as experts who supported both peers and their teachers in using these technologies.

The mathematics study, the Expanding Cube, was not mentioned as a memorable project in the interviews. We observed students being engaged during this project and initially expected comments about it in the interviews. Notice that the results of the survey could only be impacted by the work with the Science and Mathematics teachers: no major projects, other than the Expanding Cube, took place before the survey was conducted. A reason for this may be the fact that this math study happened early in the school term and lasted for only one week, while the other studies were conducted more recently and required longer periods of time, sometimes exceeding a month. Another reason might be that students were asked to cite the most memorable and relevant projects. However, there may be an additional explanation. This mathematical task did not involve a broader community, and did not entail connections outside of the classroom: two features described in the TEF. These two factors may be important features of the design of memorable learning experiences.

Although social engagement was not a focus for this study, the evidence suggests that the studies collaboratively designed and enacted in this intervention had a positive impact on this type of engagement as a side effect. This finding is important in that social engagement has been identified as a factor for both student retention at high school and a pre-cursor to the cultivation of socially engaged citizens.

The role of the mobile technology was not limited to facilitate the project co-designed with teachers and GENA specialists. While the use iPads helped students to collect, organize and analyze information, as well as communicate their thinking, a students were able to participate in the classroom as expert, savvy users of mobile technology. Both teachers and students acknowledged the lack, in some cases, of teacher's skills in the use of particular technologies. The increased rate of change in day-to-day technology makes it very difficult, or even impossible, for the teacher to be up to date with the most recent apps and software available, and adaptable, for educational purposes. The teacher is no longer the expert in the classroom in tis regards, which opens the possibility for students to contribute with their knowledge and skills in mobile technology. As argued in [12], the roles of the students and the teacher change allowing a more participatory contribution of students to the class.

Finally, we claim that the work students undertake needs to be relevant, meaningful and authentic–in other words, it needs to be worthy of their time and attention. Too frequently, the work students are asked to do at school does not engage them in personally relevant experiences, nor allow them to experience the life and vitality of rigorous exploration. Both the research field [6,19] and the students themselves [2,5], are clear: The work adolescents want and need to be able to do must be worthy of their time and attention and therefore must be intellectually engaging.

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