Using Technology to Enhance Project-Based Learning in High School: A Phenomenological Study

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Educators are tasked with preparing students for college and beyond (Gómez-Pablos et al., 2017). Project-based learning can help achieve this goal (Gómez -Pablos et al., 2017). PBL engages students in real-world problem-solving activities that allow them to take ownership of their own learning and create real products (Zafirov, 2013). The problem this study aimed to solve is how technology can better support PBL so we can better prepare students for the 21st century. It has been argued that technology can directly increase the effectiveness of project-based learning in the classroom (Pitura & Monika, 2018). Effectively leveraging technology during PBL is one of the best ways to help students address real-world problems and prepare for life after college (Brown, Lawless, & Boyer, 2013; Korucu & Cakir, 2018; Pitura & Monika, 2018). The purpose of this phenomenological qualitative study is to understand how technology currently supports project-based learning for educators in secondary schools, and to determine what missing features would be beneficial. The information gained in this study has helped the researcher understand how technology enhances the project-based learning experience. The research also supports an understanding of what features and capabilities are missing in current technology from educators' perspective.

Keywords: project-based learning, technology, secondary schools, digital

Project-based learning (PBL) is a learning model that engages students in real-world problem-solving activities allowing them to take ownership of their learning to create real products (Anazifa & Djukri, 2017). This approach, in one form or another, has been around for over a century. With the increase in globalization and the rapid advancements in technology, PBL is now more relevant than ever. Project-Based Learning is one of the best ways to prepare students for the digital age because it teaches content and develops skills in communication, collaboration, critical thinking, and creativity (Gómez-Pablos, et al., 2017). Technology enhances PBL by providing opportunities for students to collaborate and communicate in ways inconceivable prior to the advent of various tools (Martinez & Schilling, 2010).

Over the past few decades, a shift has occurred from teacher-centered to student-centered pedagogy (Emaliana, 2017). Originally, PBL arose from a need to improve education in medical school by giving the students real-world experience as opposed to memorizing information from a book or lecture (Sunar & Shaari, 2017). However, since the 1960s, educators realized the benefits of PBL for students in K-12 schools (Dias & Brantley-Dias, 2017).

In a teacher-centered classroom, often called a traditional classroom, students are passive learners, and lecturing is often the mode of instruction (Emaliana, 2017). In a student-centered classroom, students are active learners and instruction can take many different forms. This increased engagement helps the student to retain information (Taheri, 2018). Additionally, students need to be prepared for both college and life beyond college. (Gómez-Pablos et al., 2017). The skills needed to succeed in both settings can be very different. In college, students need *hard skills* including how to take a test. However, for career-readiness, employers put more stock in certain "soft skills," such as creativity and collaboration (Korucu & Cakir, 2018). These soft skills are referred to as 21st century skills (Ghafar, 2020).

According to Gómez-Pablos et al. (2017), the theory behind PBL can meet the needs of preparing students for college and their future careers. In order to solve complex problems that stem from class concepts and objectives, students must collaborate in small groups and also think critically during independent work (Emaliana, 2017). Because PBL asks students to think of their audience as beyond their teacher or classmates, they must actually engage with a larger community (Aldabbus, 2018). All of this results in 21st century learning (Aldabbus, 2018).

Project-based learning activities can be very complex. For example, the students need a forum to share their project beyond the classroom. Additionally, they must practice creative and critical thinking skills and collaborate in person as well as asynchronously outside the classroom (Shin, 2018). The teacher's role is to guide and assess the process and products (Korucu & Cakir, 2018). The goal of educational technology is to offer solutions to meet the needs of educators and students in the classroom. Educational technology has already supported many components of PBL (Spector et al., 2016) and has the potential to support every phase of PBL.

However, technology in the classroom does not guarantee a teacher will make the transition from a teacher-centered classroom to a student-centered classroom (Parrish & Sadera, 2020). In many teacher-centered classrooms, technology is used by the teacher, but in a student-centered classroom, the technology is mostly used by the students (Ünal & Çakir, 2017). Due to the shift in who uses technology seen in student-centered classroom, Pitura and Monika (2018) argue that technology can directly increase the effectiveness of PBL.

Utilizing technology during PBL is one of the best ways to help students address real-world problems and prepare for life after college (Brown et al., 2013; Korucu & Cakir, 2018; Pitura &

Monika, 2018). This research seeks to understand how technology can better support PBL so students are better prepared for the 21st century.

Theoretical Framework

Constructivism as a Learning Theory has been around for a very long time and originated in philosophy but applied to other fields such as sociology, psychology and education (Handrianto & Rahman, 2019). According to constructivism, education should be student-centered because knowledge is transferred best when students are "active learners" (Qiu, 2019). Matthews (2002) calls constructivism "education's version of the 'grand unified theory,' plus a bit more" (p. 121). Constructivism as a learning theory seeks to understand how learners obtain knowledge (Qiu, 2019). Additionally, constructivists believe that a learner gives meaning to knowledge based on his/her own experiences, not the other way around (Handrianto & Rahman, 2019). This means that everyone sees information through his or her own personal filter (Feyzi Behnagh & Yasrebi, 2020). The goal of the educator then is not to allow students to receive information passively, but to find ways to achieve a connection between the learner and the information, including ways for the learner to relate to what is being taught (Qiu, 2019). Furthermore, using the constructivist learning theory is the best way to prepare students with the skills employers are looking for (Ünal & Çakir, 2017). PBL directly stems from the constructivist theory in education (Handrianto & Rahman, 2019). The goal of PBL is to create an atmosphere in which learning is meaningful because the students have a personal stake in the outcome of the project (Handrianto & Rahman, 2019).

Review of the Literature

Just because students are high achievers in high school does not guarantee their success in college and beyond (Silipo, & Caldon-Ruggles, 2021). Our world has changed significantly due to advances in technology (Kämpfen & Maurer, 2018). These rapid advances have led to globalization, in which information and resources are shared at a never-before-seen pace (Lewandowski et al., 2022). In the current century, as the world continues to rapidly change, the skills people need to be successful in life and in their careers are also changing (Korucu & Cakir, 2018). Students need to solve problems in a competitive and technology-driven world (Anagün, 2018). In order to compete in this new global marketplace, employers are looking to hire graduates who have developed called 21st century skills (Ghafar, 2020). These are skills that have been identified as essential to becoming good functioning and participating members of society (Ghafar, 2020).

The Role of Technology in Project-Based Learning

It is not so much that technology is used, but how technology is used. In a constructivist learning environment, technology is an important component because it gives students direct access to information sources and allows them to easily collaborate (Ünal & Çakir, 2017). As such, it has been argued that technology can directly increase the effectiveness of PBL in the classroom (Pitura & Monika, 2018).

Martinez and Schilling (2010) argue the best way to support students during a project-based learning activity is to leverage technology that meets their needs. A central part of the PBL framework is students' ability to discover information on their own, and utilizing technology in the classroom supports that aim (Shin, 2018). Additionally, making technology part of the learning experience allows for strong connections to the real world, another key component of PBL (Vasiliene-Vasiliauskiene, 2020). It is difficult for teachers to maintain sustained inquiry over long periods of time without the use of technology (Pitura & Monika, 2018). Pitura and Monika (2018) argue that technology tools used during PBL are "helpful in facilitating learners' knowledge construction, finding, analysis and sharing information online, collaboration, and developing multimedia products" (p. 40). Technology also allows for learning to extend beyond the four walls of the classroom (Pitura & Monika, 2018). Students are able to collaborate and communicate in ways never before imagined. Using technology, students can communicate synchronously and asynchronously (Lo, 2009). This is a tremendous help to the required groupwork aspect of PBL (Lo, 2009).

PBL and Web technology

Project-based learning itself has evolved over time, and much of this change has been driven by changes in technology (Sunar & Shaari, 2017). Significant technological advancements include the development of Web 2.0 technology and dynamic web technology (Sunar & Shaari, 2017; Ünal & Çakir, 2017). Web 2.0 tools give users the opportunity to collaborate and communicate while learning (Sahin-Topalcengiz, E., & Yildirim, B., 2020). Ünal and Çakir (2017) define dynamic technologies as "web-based applications that bring a new dimension to interaction" (p. 4). In both of these technologies, individuals are not passively consuming, they are actively sharing and creating, adding as much as they take (Ünal & Çakir, 2017).

Li (2018) points out research has shown that Web 2.0 technologies have a high capacity to facilitate collaboration. In PBL scaffolding can be very important to help students achieve the desired learning goals, and Web 2.0 technologies can also aid in enhancing other student skills such as writing and language development (Li, 2018). However, Sunar and Shaari (2017) argue that some collaborative technology has been understudied. For example, there have not been many studies on social media's effectiveness in the classroom.

In reference to dynamic Web technologies, Ünal and Çakir (2017) found that these technologies led to student success in the classroom. Additionally, in conjunction with PBL, dynamic Web technologies have the potential to help students develop the skills they need to be successful in the 21st century (Ünal & Çakir, 2017). Included in the educational benefits of dynamic Web technologies include "active learning, motivation, collaborative learning, communication and interaction, and improvement of thinking skills" (Ünal & Çakir, 2017, p. 2). Examples of dynamic Web technologies include social networking sites, podcasts, wikis, blogs, video sharing sites, virtual museums, and instant messaging programs (Korucu & Cakir, 2018).

Educational technology tools to support PBL

In the literature, many other tools that help support and enhance PBL exist. Most of the tools described are for assessment, creation or collaboration. Additionally, there are some technology

tools that help keep the students engaged in the PBL learning experience. Examples of technology tools that enhance collaboration are Google Docs and videoconferencing. Programs like Google Docs allows a group of students to simultaneously work on an assignment (Li, 2018). They can brainstorm together, make comments, and critique each other's work (Li, 2018). Video conferencing is a powerful tool that has many benefits in the classroom (Guillén et al., 2020). It allows for collaboration to extend far beyond the classroom and even include the whole world. Students are able to speak with and see people in other countries (Hopper, 2014). Hopper (2014) states that video conferencing has the ability to incorporate all of the 4Cs - critical thinking, collaboration, communication, and creativity and can achieve the goal of teaching global and cultural awareness. In addition to this kind of collaboration with other students, video conferencing can also be used to bring in experts to help mentor and guide the students through the PBL process and/or help to make the final product more authentic by having a panel of judges who would not be able to attend in person (Hopper, 2014). This type of interaction has been proven to increase student motivation and thereby help to sustain inquiry over long periods of time (Hopper, 2014).

The research has looked at many different types of tools for assessment (Brown, 2017). Most of the tools, which include blogs, websites, wikis, and ePortfolios encourage collaboration and communication between students and allow for self-reflection (Brown, 2017). Educators are then able to track students' contribution and progress (Brown, 2017). The wikis allow students to share artifacts and the threaded discussions enable students to give feedback to each other (Li, 2018). Spector et al. (2016) point out that ePortfolios support assessments in PBL because "they provide a holistic approach to recording achievements and providing formative assessments in line with professional standards" (p. 62). Despite the benefits of using ePortfolios for both formative and summative assessments, the human time investment they require make them unattractive to some (Spector et al., 2016). Self-reflection is one type of assessment, and, traditionally, students were only able to reflect via written text (Leinonen et al., 2016). However, with technology tools, students have the opportunity for video, audio, or other type of visual reflection (Leinonen et al., 2016).

A significant benefit of using technology to support PBL is the capacity for creation which allows students the opportunity to show and practice their creativity. With Apple's introduction of the iPad, they also began making their way into the education sector (Young, 2016). Young (2016) argues that since the iPad has become the dominant device in education, iPad is now synonymous with all tablets. Apple has made a point of offering applications that help students create. Keynote, iMovie, and Garageband are all examples (Levin & Schrum, 2013).

Purpose Statement and Research Questions

The purpose of this qualitative study was to understand how technology enhances project-based learning for educators in secondary schools and determine what missing features would be beneficial. The information gained in this study has helped the researcher understand how technology enhances the project-based learning experience. The research also supports an understanding of what features and capabilities are missing in current technology from educators' perspective. The use of technology to support PBL will generally be defined as a high school classroom that conducts PBL in a 1:1 student-to-device learning environment. The

research questions were:
1. How are teachers currently using technology to support project-based learning?
2. What features of current technology do teachers believe best support them in planning, implementing and conducting project-based learning?
3. What features do teachers believe are missing from the current technology?

Method

Research Design

Using a phenomenological narrative approach, this qualitative study looked at how educational technology can support project-based learning. Creswell (2013) states that this type of study is appropriate when the research aims to describe what all participants have in common. For this study, the commonality that all the participants shared was that they used educational technology to help them conduct PBLs in a high school with a 1:1 student-to-device learning environment. The researcher conducted interviews to determine the subjects' experiences.

The Participants and Setting

The Criterion method, which requires all the participants to meet the same criteria, was the sampling strategy used (Creswell, 2013). The participants of this study consisted of 10 high school teachers who had been identified by their administration as utilizing PBL in the classroom. For a phenomenological study, Creswell (2013) suggests between 5 and 25 participants. All of the teachers who participated in the study worked at the same urban private Catholic school in Miami, Florida during the 2018-2019 school year. Four of the teachers did not return to the same school the following year. One teacher left to work in a nonprofit and is no longer an educator, another left to work at a charter school, and two of the teachers left for another urban private Catholic school. The participants met the following criteria:
- Conducted true PBLs, not just long-term projects
- Conducted the PBLs in high school in the last 3 years
- Used technology to support PBL
- Were comfortable with technology
- Taught in a 1:1 student-to-device learning environment
- Were in good standing with their administration

Results

The demographic questions at the beginning of the interview addressed longevity, length of time using PBL, perceptions of classroom technology, subjects, grades and levels taught. Seven of the participants said they first started conducting PBLs because they wanted to give the students more real-world experiences. Two said they first tried PBL because they wanted the students to take more ownership of their learning. One said they were mandated by the school they taught at in the past; however, they liked it and continued even after moving on to another school. As far as experience with PBLs, three considered themselves an experienced PBL teacher, six called

themselves a developing PBL teacher and one said they were a beginning PBL teacher. Five of the participants had more than 10 years of teaching experience, four had between 5 and 10 years of teaching experience, and one had less than three years of teaching experience. When it came to the participants' views on using technology to support learning in general, six had a very favorable opinion, three had mixed feelings, and one had a negative opinion of technology in the classroom.

Current Use of Technology

The first research question addressed how teachers are currently using technology to support project-based learning. All of the participants cited multiple ways in which they use technology to support PBL. Two main themes emerged: Participants used technology to help include the 4Cs into their PBLs, and they used technology to support different phases of the PBL processes. All of the participants could point to at least two of the 4Cs and one of the phases of PBL that technology helps support.

Supporting the 4Cs

All of the participants recognized and commented on the fact that PBL is one of the best ways to instill 21st century skills, which are: communication, collaboration, creativity, and critical thinking. One participant said, "I think technology works really well with communication and allowing the students to collaborate outside of class. I mean, I would have to say that technology has helped my students so much with being creative in how they do things. So, with critical thinking, I think that goes back to some of the ways I use apps for research purposes and being able to have the kids analyze data and make connections and identify patterns."

Supporting the Phases of PBL

A PBL activity consists of many different components such as ideation, research, group collaboration, teacher mentorship, and presentation to a global audience. One participant mentioned the iPads helped them in general, explaining "whenever a kid needs to research stuff or if a kid doesn't understand something or needs a different explanation, they have the information at their fingertips." Another participant mentioned that "Just the amount of time the iPads saves is incredible. I have only ever taught with them, but as a student, I remember having to walk to the library to conduct research." Lastly, another participant said, "I just love how visual technology can make the brainstorming part of a PBL."

Features of Technology

The second research question stated, what features of current technology do educators feel best support them in planning, implementing and conducting project-based learning? All of the participants highlighted features that aide both the educator's and student's tasks during a PBL. In listening to the participants recount their experiences, two themes emerged: features of the current technology that best support educators and those that support students in PBL.

Educator Support

None of the educators mentioned technology that actually helped with the planning phase of PBLs. The PBLWorks website was mentioned twice as a place that contains documents available for download that aid in the planning process; however, none of the teachers were aware of any technology that has the goal of helping to plan a PBL. As far as managing groupwork and being able to supervise division of labor and equal effort, nine of teachers mentioned the project management application Trello. Trello was also mentioned as a means of providing students with information, collecting artifacts from students, and with being able to asynchronously communicate with students. One participant stated, "Trello has been the most effective because it is a project management app and it correlates directly with project-based learning and it makes capturing deliverables a lot easier and makes organizing classes just natural because that's what it's made for." Teachers valued and appreciated technology that made giving feedback easy and immediate, such as Showbie.

Student Support

Nine participants also mentioned Trello as the most beneficial tool for students because it helped them plan, organize, communicate, and collaborate. Trello was also described has being a great way for students to make real-world connections because it is industry level technology used by real companies. Another application that participants found useful for students was Showbie because it has a group function. Padlet was mentioned for its collaboration capacity and how it allows students to visualize the ideation phase. Padlet acts as a virtual corkboard where students can put stickies with ideas or comments and give each other feedback. One participant said, "We have our students on Trello, which worked really well, particularly for the students that aren't great at communicating their progress or who need help visualizing multistep processes. I have also used Padelt for idea exploration and sharing thoughts and you know, brainstorming things." Half of the participants pointed to native Apple apps such as GarageBand, iMovie, and Keynote as great ways for students to explore their creativity. Another participant shared, "My favorite thing that has happened in the last couple of years is Apple making the Everyone Can Create curriculum. It just gives the students so much freedom of expression and they are able to do things they never thought they could do." Other applications that allow students to create are things like Canva and Adobe Spark, which are also examples of industry level technology. Three educators pointed out that Google Suite apps like Google Docs and Google Sheets were great for students to collaborate because they could all work on the same document at the same time, seeing changes in real time.

Missing from Technology

Research question three stated, what features do educators feel are missing from the current technology? While the participants spoke during their interviews, two main themes emerged. One was how technology can evolve to better support the 4Cs. The other is how technology can evolve to better support specific phases of PBL.

How Technology Can Evolve to Better Support The 4Cs

While all of the participants reported that technology supports at least one of the 4Cs, some mentioned that they felt technology could improve in some areas. The C that participants believed was helped least by technology was critical thinking. One participant shared, "Honestly, and this is going to sound terrible, but I think the only one of the 4Cs technology doesn't support is critical thinking." Participants said it was up to the teacher to make sure that thinking was done at a higher order but that technology sometimes was counterproductive to this. Twice it was expressed that having access to technology made it too easy to find information and that students do not have to think as much anymore. One participant stated, "This day and age, kids don't have to necessarily be creative, they can just Google search everything. So, creativity is very limiting to kids." Another participant shared, "I think I had difficulty with the creativity part in terms of using technology to foster creativity and that may have been because I was hesitant regarding technology in the classroom in general." None of the participants mentioned that technology poorly supported collaboration or communication.

How Technology Can Evolve to Support the Different Phases of PBL

One very important phase of PBL is the collaboration component. Students within the classroom collaborating is definitely beneficial, however, allowing students to work with other schools in other places takes collaboration to another level. One participant said, "In the PBL process, there are some parts where I would love the students to see each other's work. And there are other parts where I would like to be able to modify that so the students are doing some individual brainstorming." Many participants said that connecting to other schools can be very difficult and that they wished there were technology tools to make it easier. One teacher shared, "I think if technology could support a vetting process that is easy to connect schools with other schools. Maybe something where you put in what you are looking for, like maybe you create a school profile and then if you match in some place, they match your school." One teacher said he/she used a tool called iEarn, which allows for collaboration on global projects, but that it was cumbersome to navigate and difficult to find the right fit. Three of the participants said they wished they had an app that helped them group the students in their classroom. While Trello helps educators manage group work, the participants were unaware of any technology that helped to group students. They mentioned wanting to be able to group students based on skills, strengths, and abilities. Another important phase of PBL is presenting to a global audience. Half of the participants said they wish there were technology tools that could help give educators a safe way to do this. One big concern in schools right now is student safety and part of that is student privacy. In addition, including members of the community as group mentors or as presentation judges is a way to provide an authentic real-world experience. Three of the participants said they wish there were technology tools that easily connected them with real-world professionals who could either visit the classroom or be available virtually.

Practical Application of Findings

The information gathered from the interviews provided a deeper understanding of how teachers perceive technology supports project-based learning and what functions and tools are missing that would aid the PBL process even more. The goal of this study was to gather information that would be beneficial in creating a technology that solves the needs of educators who practice PBL. The data gleaned from the participants describes the ways in which educators feel supported by technology and how classroom teachers realize they could be even more supported.

Instilling 21st century skills in students is vital to their success in college and beyond. Technology is changing our world so rapidly that if graduates are going to be competitive in the global marketplace, soft skills need to be taught just as overtly as the hard skills. All of the participants in the study commented on the benefit of PBL in helping to achieve 21st century learning in the classroom. Additionally, they all acknowledged that technology played a pivotal role in helping them achieve learning goals when conducting PBLs in the classroom. All felt supported in helping to impart the 4Cs, in some part of the PBL process, or both. Based on the findings, suggestions for teachers, administrators and educational technology companies:

Teachers

- Do not be afraid to experiment with technology.
- Be open to learning about new technology from students.
- Communicate the project's goals with the parents to get additional support.

Administrators

- For schools that have technology, administrators need to offer PBL training while focusing on integrating various technologies so that teachers understand the opportunities these technologies provide for the students and the difference that they will make in the design process and outcome.
- Offer professional development on technology and cognitive capacity. Target performance at levels three and four or higher on Bloom's taxonomy of cognitive development.

Educational Technology Companies

The goal of educational technology companies is to solve the problems of students and teachers in the classroom. Established by the findings of this study, educational technology companies should:

- Gather information from the people in the trenches in order to establish viable solutions to problems and issues
- Use data such as that gathered in this study to design an application that has everything needed for a project-based learning activity all in one place. The goal being everything both the teacher and the students need to do during a PBL is in one application.

Recommendations for Future Research

Many studies have looked at the benefits of using PBL is the classroom and how technology impacts learning. While technology is not a necessity for conducting PBL, it does easily enhance its effectiveness. This study looked at how technology achieves this. However, it could benefit schools and districts deciding whether or not to adopt a 1:1 student-to-device program if classrooms who do PBL with technology show greater success than ones conducting PBL without technology. Future studies should look at both teacher and student perceptions in addition to learning gains.

Implications for Practice

Based on the research from this study teachers believed that technology helps them instill at least one of 4Cs in the PBL. Communication and collaboration were cited the most and critical thinking and creativity were cited the least. Participants were also able to point to specific phases of PBL that technology aids such as project management and student research. However, participants pointed to significant areas technology is lacking. For one thing, none of the participants knew of a technology that would help them plan a PBL. They also felt that the feedback process, group creation, and progress monitoring could be improved.

Educational technology companies aim to solve problems in the classroom. Many of the applications and tools the participants mentioned were made specifically for education; however, others were not. For example, Trello is industry level technology used by real companies of various sizes. Most of the participants believed that utilizing technology in the classroom helps prepare them for the real world.

A common theme of the applications and tools participants mentioned was efficiency and ease of use. Currently, no technology exists that supports all the phases of PBL and helps incorporate all of the 4Cs. The information gathered in this study can be used to create such a resource for teachers and students who utilize PBL as a learning method.

Conclusion

In our world of rapidly changing technology, educational reform is needed for students to be competitive in a global marketplace. One way schools can help prepare them for career readiness is by being as explicit about teaching the soft skills as they are with hard skills. One particular learning model that has been proven to not only teach content but also 21st century skills is project-based learning. Since its introduction in 1918, PBL has evolved over time. Its current iteration is greatly aided by the use of technology. This study looked at how much technology enhances project-based learning and where there are still opportunities for growth.

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