

LARGE SCALE PBL ACTIVITY DEVELOPS
CORE COMPETENCIES IN STUDENTS
- PILOT STUDY -

By
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Large Scale PBL Activity Develops Core Competencies in Students

- Pilot Study -

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Abstract

This research specifically aims to see whether a large scale PBL activity naturally develops the core competencies of the new B.C. curriculum in secondary students. An online survey was created to gather the responses of students' own identification of their core competency levels before and after a large scale PBL task. The project, a school wide Rube Goldberg machine, took an entire year for completion and comprised of all staff and students in a B.C. middle/secondary school. Through the creation of the Rube Goldberg machine, students' core competency development of creativity, critical thinking, communication, social responsibility and personal responsibility were tested among participants.

The set profiles of the aforementioned core competencies were derived straight from the B.C. Ministry of Education documents and participants were given multiple choice options on where they believed their developmental levels were in each core competency before and after the project was completed. The Cronbach's Alpha formula was used to test the reliability of the data.

Results suggest that a large scale PBL activity does support the development of core competencies in students as described in the new B.C. curriculum. 83.3% of student participants had a positive change, or strong positive change, in all of the following core competencies: communication, creative thinking, critical thinking and personal responsibility. 75% of participants also noted a positive change to their social responsibility competency. The data further reveals that all competencies of all participants either remained constant or improved in profile competency levels. The results of this study support that PBL enhances the core competencies in students, including large-scale school wide projects.

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Chapter One: Introduction

The Organisation for Economic Co-operation and Development (2016) recognizes the education system in Canada and B.C. as one of the best around the globe. In 2011, the province of British Columbia was documented as scoring significantly higher than the international and national averages of the Progress in International Reading Literacy Study (PIRLS, 2011).

However, this study also revealed that there was not a significant change since the 2006 PIRLS assessment. The ministry has also distinguished the need to revisit the B.C. Education Plan to meet the needs of the 21st century learner (BC Ministry of Education, 2015). The new curriculum that is being brought forth by the B.C. Ministry of Education has a focus that will provide the 21st century learner with skills to succeed in a rapidly changing world that is more connected than ever before.

There is much discussion in the education realm describing how graduates should be problem solvers, critical thinkers, effective and confident workers, time managers, and responsible citizens that work well independently and with others, (Boyer and Crippen, 2014; Dweck, 2009; Larmer, Megendoller and Boss, 2015; Lemley, Schumacher, and Vesey, 2014; W Preus, 2012). As stated in the 2015 B.C. Education Ministry document titled, “Introduction to British Columbia’s Redesigned Curriculum”, the education system must “be one that engages students in their own learning...that enables and supports personalized learning through quality teaching and learning, flexibility and choice, and high standards” (p. 1).

Based on National and International trends in education, this new shift to B.C.’s Education Plan has come at a time to prepare students to enter the flexible yet demanding world around them after graduation (BC Ministry of Education, 2015). The B.C. Ministry of Education

identifies a few key features of the new curriculum which include literacy and numeracy foundations, essential learning targets, and core competencies. These all relate to the Sullivan Commission, or the Royal Commission on Education that was developed and put into policy in 1988. The policy states that “a quality education system assists in the development of human potential and improves the well being of each individual person in British Columbia society” (BC Ministry of Education, 2015, para. 7). In the first of the key features, the Ministry of Education recognizes that literacy and numeracy are more than related to language learning and mathematics, but are critical in all areas of learning and apply to many aspects of life. The second key feature focuses on the essential learning targets for each subject which represent society’s objectives for B.C.’s educated citizen; which are to become a citizen that can think critically and creatively, to be one that communicates information clearly and contributes to society, and to become a global citizen that respects themselves and members of the community. The new curriculum has been developed around essential content, concepts, skills, and big ideas that the educated citizen of today needs to adopt in society (BC Ministry of Education, 2015). The final key feature of the core competencies has been developed in direct correlation to the educated citizen as these are the characteristics that the ministry values in all of their citizens and students.

After reading the new curriculum documents, educators might begin to feel overwhelmed with how to implement the new core and curricular competencies as well as the learning standards of the new education plan. With a variety of pedagogical practices being pushed in education such as integration, differentiated instruction, response to intervention, assessment of, for, and as learning, how do educators and administrators adopt this new curriculum change? Quality feedback and assessments take time to do well, prepping for tomorrow’s class is no

quick task, especially when truly meeting every student's individual needs, and collaborating with other staff members to create integrated and engaging lesson plans may also seem daunting when considering all that teachers are required to do.

The Western and Northern Canadian Protocol for Collaboration in Education (2006) realizes that 20th century approaches to assessment are outdated as there are new contexts to what education in the 21st century should look like. The old mechanism of teaching a unit to students, testing students' knowledge of that content, making judgements about that demonstration of learning and assigning a grade, and finally starting the process over again is all in need of a change. It was well understood that this method of teaching and learning does not work for everyone and that deeper levels of understanding that used to work in the past are no longer effective using this approach (Larmer et al., 2015). Today, high school graduation seems to be necessary for most career options and the proficiencies of problem solving, critical thinking and strong communication have been emphasized for life outside of school. Additionally, learning is now viewed as a differentiated progression of creating an understanding of content and connecting new information to previous ideas and skills (Larmer et al., 2015). These new realizations of 21st education have created more expectations from teachers. Aside from being an expert in their field, teachers are encouraged to be risk takers, more collaborative, and to integrate more technology into the classroom (Educational Origami, 2010). Because of these demands, new teaching practices are being implemented to try and meet those difficulties while also promoting a rich learning experience for students.

There are several research based teaching methods that can help foster the application of the new curriculum while still ensuring quality assessments are completed and teacher time constraints are manageable; for example: as inquiry based learning, or IBL, problem based

learning and project based learning (BC Ministry of Education, 2015, Patchen and Smithenry, 2013). Halbert and Kaser discuss (2015) how foundational learning targets and essential skills can still be taught effectively using these methods. They continue to add that “inquiry involves design, discipline and a critical focus on evidence that matters” (p.9). Inquiry based learning involves assessment of and as learning, in which Halbert and Kaser describe how these assessment strategies provide learners with clear learning intentions, put learners at work as learning resources for each other, and make the learners as owners of their own learning. Furthermore, inquiry based learning and project based learning, or PBL, methods highly encourages the use of feedback. They also acknowledge the result of John Hattie’s work and how quality professional feedback has an effect size of over 0.7 which highly influences learning among students. Effective feedback causes learners to think while relating to learning targets, and the strong use of feedback draws attention to what is next in the learning process.

Oxford Learning (2015) recognizes that most educators have had challenges of keeping students engaged and motivated while also ensuring students are retaining the content being brought forward. They suggest that an inquiry approach to teaching helps overcome these difficulties. As a method in which both teachers and students share the responsibility of learning, inquiry based approaches to learning help address the constraints of teacher prep time, quality assessment practices, and teaching curriculum content. It is not easy but inquiry and project based learning methods have been demonstrated to develop the foundational skills of the curriculum, while maintaining learning targets and proficiencies of 21st education plans. (Boss 2013; Halbert and Kaser, 2015; Oxford Learning, 2015). As a middle school teacher, Wolpert-Gawron (2016) recognizes that although IBL and PBL may be complex, it can mysteriously be

easier on teachers as the responsibilities transfer from teacher to student and this release of authority truly engages students in their learning.

Coffey (2013) states that because of the developments in intellectual research and the changes in modern education of the latter part of the 20th Century, project-based learning has gained popularity among education. Learning has been described as a social activity, therefore teaching methods that can build on students' prior knowledge and involve the community and culture will be ones that will be implemented more in the 21st century. IBL and PBL are such types of teaching strategies, and with a world that is increasingly more technological and connected, teachers are using these methods more and more. To conclude this introduction, educators are encouraged to use inquiry approaches to teaching such as PBL because they apply to the learning standards and content of the past and present B.C. Education Plans, while also meeting the quality assessment practices of the ministry and sound pedagogy that teachers of British Columbia have long demonstrated (BC Ministry of Education, 2015).

Purpose of Research

Larmer, Megendoller, and Boss, 2015 describe that in the best PBL activities, or “Gold Standard PBL” (p.37), there are seven ideal elements to incorporate which include a challenging problem or question, sustained inquiry, authenticity, student voice and choice, reflection, critique and revision, and a public product. Combined, the elements of Gold Standard PBL tasks will help foster the key knowledge, understanding, and success skills that students of this century will need to succeed in life outside of secondary school. While there is much research about what an engaging PBL task should include, little research has been completed around large-scale PBL activities in a high school setting. Furthermore, the new B.C. core competencies are just

beginning to be implemented around schools across the province of B.C. and there is little research on how PBL tasks relate directly to the development of the core competencies specific to the new B.C. curriculum. This paper will specifically focus on these two areas and attempt to answer the following question: do large scale project based learning activities contribute toward developing the core competencies of the new B.C. curriculum?

Outline of the Paper

This paper proceeds as follows. In chapter two, there are four sections of the literature review. The new B.C. Education Plan will be discussed, followed by the core competencies, project-based learning, and then Rube Goldberg machines. The reason for these subtopics is to provide the necessary background of this paper which included the creation of a school-wide Rube Goldberg machine. Chapter three will outline the research methodology followed by the results in chapter four. Chapter five includes the analysis, implications and conclusions of the research followed by the references and other important documentation in the appendices.

Chapter Two: Literature Review

New B.C. Education Plan

BC's education system has been modelled by practices from earlier centuries, much different from today (BC Ministry of Education, 2015). Although traditional methods have served education well in the past, those developing educational programs worldwide feel traditional approaches to teaching require restructuring to meet the 21st century learner and digital citizens of today (International Education Advisory Board, 2016; Wismath, 2013). OECD Education Directorate, Andreas Schleicher (2017), points out that the world today is changing faster than ever in history and simply reproducing knowledge and skills of the past will not help students of today succeed when meeting the challenges of tomorrow. He further maintains that students need to be taught skills and competencies that will help prepare them for jobs that have not yet been created. He and other educational leaders around the world are identifying the need for educational paradigm shifts (Larmer, Mergendoller, & Boss, 2015).

A major study in 2005 asked professors in various American colleges about what is needed to succeed in entry level courses, and these were the responses: critical-thinking, analytical and problem solving skills, being open to and utilizing critical feedback, open to possible failures at times, clear written and oral expression, having time management skills, and the ability to reach conclusions independently (Larmer et al., 2015). In 2013, an online survey was conducted using 318 employers across the U.S. in which the findings gave some insight into what college students needed to succeed in the workforce (Hart Research Associates, 2013). The final responses were that innovation and core capacities were more important than the choice of undergrad program their employees completed. Furthermore, the survey revealed that 93% of

the surveyed employers valued communication, critical thinking and problem solving skills as more important than their employee's undergraduate major. Summarizing all these results, it appears as though traditional knowledge of specific subject matter is insufficient for the 21st century. Technology and business futurist Joel Barker (2015) illustrates that paradigm shifts are needed for a successful future. Islam, Islam, Zatzman, and Ali Hassan Mughal (2013) have also identified the need of an education paradigm shift. They acknowledge that the new curriculum has advantages in acquiring knowledge, preventing current economic problems involving global injustice and environmental concerns, as well as preventing some of the current curriculum problems surrounding plagiarism, engagement, non-representative grading and motivation (Islam, et al., 2013).

A recent Canadian survey of 32 000 students titled, "What Did You Do in School Today?" revealed that academic engagement lowered from 60% in grade 6 to 30% in grade 10; furthermore, attendance dropped from 90% in grade 6 to 50% in graduation year (Drake, Reid, and Kolohon, 2014). Due to low scores in literacy, mathematics and science, even Australia has begun implementing a new National curriculum change (Lowe and Appleton, 2015). The International Education Advisory Board (2016) realizes that 8 out of 10 high school students play networked online video games and are soaked in media entertainment. They further suggest that teachers willing to design their classroom teaching environment that simulates video-game like environments may help provide the analytical, problem solving, and team building skills that our students will need in their future jobs (2016). As a response to educational statements like these around the globe, the Province of B.C. has started a paradigm shift in education while addressing these concerns.

As previously stated above, there is a focus for students to develop better problem-solving skills and self-regulation with the new B.C. curriculum and these are the primary goals behind inquiry based learning (Drake, et al., 2014). All of these attributes are closely related with the goal of developing the educated citizen of B.C., which is to become one who can think critically and creatively, one who communicates information clearly and contributes to society, and to become a global citizen who respects themselves and members of the community (BC Ministry of Education, 2015). Boyer and Crippen (2014) state that the sole purpose of the new B.C. Education Plan is to promote the concept that “every learner will realize their full potential and contribute to society” (p. 345). Additionally, there are five aspects that support this idea which include: personalized learning, quality teaching and learning, flexibility and choice, high standards, and learning using technology (Boyer and Crippen, 2014).

The International Education Advisory Board (2016) further agrees that 21st century students are ones who like to be in control, are social and group-orientated, are inclusive, enjoy choice, are familiar with digital technology, think differently, are more willing to take risk, and value their own time. On the other side of that, the 21st century teacher needs to respond to these student needs and should be ones who do not overwork students while also making learning relevant to students’ interests and ensuring that the use of technology is not a distraction either (International Education Advisory Board, 2016). “The twenty-first century will belong to the passionate and resilient learners” (Dweck, 2009, p. 9). Educators across the globe need to create learning atmospheres that will help encourage our students to be the dedicated students that today’s economy and world demands.

The B.C. redesigned curriculum is there to prepare students for the 21st century through personalized environments based on a Know-Do-Understand model that supports both a concept

and competency approach to learning (B.C. Ministry of Education, 2015). The B.C. Ministry documents point out that students should be communicative, thoughtful, creative, flexible, self-motivated, cooperative, respectful, able to think critically and able to contribute to society as they prepare for life outside of school. The purpose of the core competencies that have been developed in the redesigned curriculum is to facilitate this growth in students. I now turn to an examination of these core competencies.

Core Competencies

For quite some time already, educational leaders have begun to identify key areas, or core competencies, that are needed for the 21st century learner. In his book, *The Art and Science of Teaching*, Marzano (2007) argues that students should be engaged in inquiry and investigation tasks, as well as problem-solving and decision-making tasks that require them to generate and test hypotheses. He continues that students should design their own tasks and be involved in setting up cooperative learning environments which will encourage self-examination of their thinking and knowledge. Howard Gardner (1993) writes about the multiple intelligences of the human brain and through his model of learning, creativity and arts integration has been more widely accepted as a useful way of teaching and learning. Project Zero (2016), created by Harvard School of Education, acknowledges that art and design are all around us and have supported the exploration, skills and capacities of the arts for nearly five decades. They further state that collaboration and group learning are essential to the learning process. Renown arts educator Elliot Eisner (2008) further supports these claims while suggesting that artistic processes foster cognitive development and imagination. Art advocate Sir Kenneth Robinson (2011) also describes that creative thinkers and innovative problem solvers are established through creative approaches to learning through the integration of the arts.

In his TED talk (2007), Robinson describes how many education systems are being renewed around the world; however, he worries that they are being driven by political and commercial interests that misunderstand how diverse we all are as learners. He continues to suggest that many education systems are not reaching the diversity of all children and the creative talents we are all born with. Furthermore, he describes that most student creativity is being lost through the standards approach to assessment in most schools. He argues that many skills and attributes of students are often ignored, under appreciated, or stigmatized in a standards based education program, which may deter highly valuable and brilliant individuals. He strongly promotes the need for creativity in schools and is at the forefront of promoting this agenda in education today. Project-based learning activities, like the one described in this paper, demand creativity (Larmer et al., 2015). Although concerned about the future of education systems, Robinson does agree that there are great schools and school districts that are promoting more of a holistic view of education (TED, 2007). B.C.'s new education plan is promoting creativity among students which may help encourage all students in all their strengths and qualities (B.C. Ministry of Education, 2015).

Creativity and five other proficiencies have been identified as the six core competencies that are being implemented by the new B.C. Education Plan; these include communication, creative and critical thinking, personal and social responsibility, and finally personal and cultural identify (B.C. Ministry of Education, 2015). Marope (2014) similarly identifies some of the fundamental competencies as creativity, critical thinking, mindfulness and service learning. Banks (1997) likewise discusses how “students must develop multicultural literacy and cross-cultural competency if they are to become knowledgeable, reflective, and caring citizens in the twenty-first century” (p.13). Peter Block (2008) has realized that “the small group is the unit of

transformation and the container for the experience of belonging” (p. 95). To bring forth positive classroom learning environments and a strong cohesive school community, it must begin with the educators and the relationships with their colleagues and students. Robinson (2011) adds that the role of a teacher is to create a culture where students can share ideas and feel that they are valued.

In 2010, nearly 300 000 students were surveyed in the United States from 2006 to 2009 and the research identified that 49% of the secondary students were bored in at least one class each day and 17% of students were bored in every class (Larmer et al., 2015). Furthermore, the students gave reason for their boredom, such as the material being boring or irrelevant and having little interaction with the teacher (Larmer et al., 2015).

In response to issues of both new curricular needs and the reality of disengaged students, the Educational Origami article “21st Century Teacher” (2010) lists the characteristics of a millennial teacher as being collaborative, adaptive, a good communicator, a visionary, a risk taker, a learner, a model, a leader, and knowledgeable in both information media and technology. In a 2014 study, it was noted that the presence of a positive 21st-century learning environment is related to student satisfaction and student-teacher relationships (Lemley, Schumacher, and Vesey, 2014). Boyer and Crippen (2014) identify that in the new millennium students, parents, educators, schools, the local and even global community must respectfully work together to bring new positive opportunities for learning and teaching. The 21st-century teachers need to be ones that embrace positive change. Fullan (2013) states that “new pedagogy involves helping students find purpose, passion, and experimental doing in a domain that stokes their desire to learn and keep on learning” (p. 24).

For these reasons and ones already mentioned in the above section on the New B.C. Education Plan, inquiry based teaching approaches to learning have been widely promoted in today's public education system as they help promote core competency development. The B.C. Ministry document on the redesigned curriculum further states that in order to foster inquiry based learning, questions that inspire a sense of wonder and curiosity are needed at its very core (BC Ministry of Education, 2015). Inquiry approaches to learning are designed to engage students in genuine, real life problems that are of interest to them or that may apply to their life or future goals (The Galileo Educational Network, 2014).

Traditional approaches of learning do have their places in the classroom. Drake et al. (2014) illustrate that the stand up and deliver approach in traditional methods can be efficient for large groups and a portion of the population that are bound for post-secondary academics, but for the majority of 21st century learners, inquiry approaches to learning, such as PBL are cultivating students' own learning experiences that will help prepare them for adult life. I will now describe and discuss the features and merits of project-based learning.

Project-Based Learning

Project-based learning can be traced all the way back to John Dewey in 1938 with his work on experiential education followed around the same time by the constructivist and social interaction theories of Piaget and Vygotsky in the first half of the 20th century (Martelli and Watson, 2016; Drake, Reid, and Kolohon, 2014). However, during the early parts of the 19th century, traditional teaching methods were justly practiced by the influence of mechanical engineer Frederick Taylor whose sole purpose was to make work factories more efficient (Drake, Reid, and Kolohon, 2014). However, it has long been understood that constructivist or

traditional teaching methods have been on an implementation pendulum from the 1840s to the early 2000s for various reasons (Drake, Reid, and Kolohon, 2014). Today, inquiry based teaching, a constructivist approach to teaching, is becoming quite popular among educational leaders.

Drake et al. (2014) describes how constructivist theorists, such as John Dewey, Jean Piaget, and Lev Vygostky helped shape the theory of constructivism and how we make learning by interacting with others and connect our learning to past experiences. Moreover, constructivist theories acknowledge the stages of moral and personal development and constructivist theorists encourage teachers to act more like facilitators and address topics such as differentiation, collaboration, equity, and provide ongoing feedback to students. These characteristics closely relate to those of inquiry based teaching methods.

Inquiry brings a personal experience into a learning environment where the learner must gather more information to solve a problem (The Galileo Educational Network, 2014). Furthermore, knowledge is created through this experience instead of being taught which then provides a deeper level of understanding (The Galileo Educational Network, 2014). With inquiry based learning, students are the designers, teachers are the facilitators. Drake, Reid and Kolohon (2014) discuss two of the more common models of the inquiry approach. These two models are the discipline-based inquiry approach and the student-centered method.

In the discipline-based inquiry approach, learning is authentic, academically rigorous, and goes beyond the school walls; in addition, this model involves an active exploration of content that connects with experts in the field and thus contains rich communication with those experts (Drake, et al., 2014). This approach involves a lot of planning and an encouraged use of

technology, which may dampen some educators from heading in this direction as a teaching strategy.

The student-centered inquiry approach to learning truly lies in its own terminology where students are at the center of their own learning through asking and pursuing their own questions (Drake, et al., 2014). Reflection is also a big part of this method which can occur throughout the whole learning process, which is highly valued for in-depth learning opportunities (Drake, et al., 2014; Marzano, 2007). With either discipline-based or student-centered, learners tie in the big ideas and enduring understandings of the curriculum when discussing and evaluating their own work (Drake, et al., 2014). However, motivating students in today's classroom seems to be a challenge when students seem to be bombarded with distractions all around them.

Rennie, Venville and Wallace (2012) state that integrated approaches to learning where students work on more elaborate problems is more motivating for them. The student-centered inquiry project developed in this paper ties directly to this statement. More than simply engaging students through motivation, education should also prepare students to make logical decisions about complex problems and teachers should provide a context to integrate these problems into the curriculum (Wraga, 2009). Drake et al. (2014) discuss a few different types of integration in which the project at hand will be a combination of the interdisciplinary and transdisciplinary approaches. Interdisciplinary integration is where a concept is learned through different curricular competencies and content, while transdisciplinary integration involves students coming up with questions or concerns and the curriculum revolves around those questions (Drake, et al., 2014). Project-based learning relates nicely to either of these integrated approaches to learning

PBL is defined as a method of teaching and learning that is intended to engage students in their own investigations of authentic scenarios and realistic problems (Blumenfeld, Soloway, Mark, Krajcik, Guzdial, and Palincsar, 1991). PBL was invented to try and promote problem solving skills, as the research revealed that students were retaining little information from traditional methods (Samford Problem Based Learning Initiative, 1992). Furthermore, project based learning activates the prior knowledge of students, helps students apply and recall information to related situations in the future, and provides students with the opportunity to dig deeper into problem solving (Samford Problem Based Learning Initiative, 1992). Brundiers and Wiek (2010) discuss how PBL has its uses in university coursework and conclude that there are three key features that need to occur to ensure that students experience core competency development; these include collaborative design, coordination, and integration. Kovalyova, Soboleva, and Kerimkulov (2016) also suggest that PBL has effective uses when working with English Language Learner undergraduate students. Additionally, Durkin (2016) suggests that PBL has a positive influence on undergraduate students' problem solving skills. Even elementary educators have acknowledged that PBL approaches to teaching improves motivation, problem solving and learning achievements (Hung, Hwang, and Huang, 2012).

In either a secondary, middle or elementary setting, PBL is a fantastic teaching tool that motivates students, prepares them for post secondary education, develops their thinking skills and meets the learning standards in depth while allowing more communication between parents, schools, communities, and the world (Larmer, et al., 2015). In response to the demand of new inquiry teaching based practices, this study created a school wide Rube Goldberg machine through a PBL lens.

Rube Goldberg Machine

Reuben Lucius “Rube” Goldberg was an American cartoonist and designer born in 1883 (Wonderopolis, 2017). His most renowned works were drawings of complex gadgets that completed simple tasks in intricate and elaborate ways, known as Rube Goldberg machines, and by 1931, the term “Rube Goldberg” was added to Merriam-Webster’s dictionary (Wonderopolis, 2017). Today, the idea of creating complex Rube Goldberg machines has taken hold in homes and schools across the globe and has even inspired national and global competitions. Below are three examples. They illustrate a variety of Rube Goldberg machines, notably Rube Goldberg’s “Self-Operating Napkin” which was created in 1931 (Wikimedia Commons, 2016).

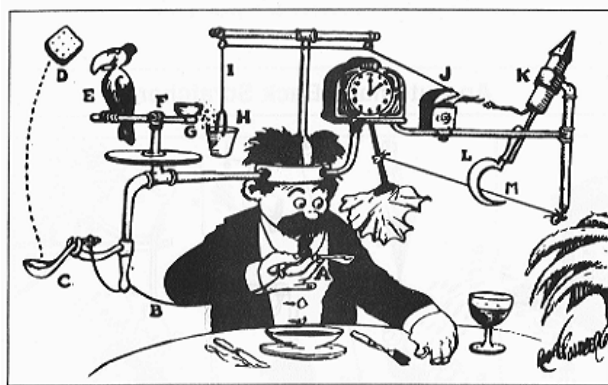


Figure 1 - Self-Operating Napkin, Wikimedia Commons, 2016



Figure 2 - The Lifesize Mousetrap, Kobetime, 2008

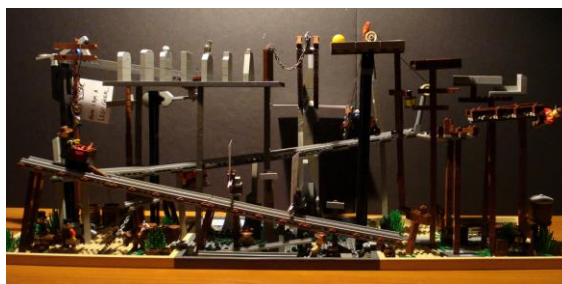


Figure 3 - The Intro Machine, Eylar, 2010

This Research Project

The school wide Rube Goldberg project described in this paper incorporated authentic learning experiences with academic rigor while letting students actively explore the design and

creation of their own machines in rich communication with their peers. The research project was designed as an inquiry into how well a large-scale PBL activity incorporates features of the new curriculum plan, specifically the development of the core competencies. According to my understanding of the Galileo Education Network (2014) principles and guidelines, the project incorporated many, if not all, of the dimensions needed for an inquiry-based learning opportunity including authenticity, active exploration, elaborate communication, academic rigour, ongoing assessment, student engagement, learning with technology, connecting with experts and adding value beyond the school walls. The project at hand involved all students of all grades of a Canadian Middle/Secondary School in British Columbia. After watching a video titled, “This Too Shall Pass” (OK Go, 2010), staff members of the school were intrigued with the level of dedication, involvement, and integration of both the arts and subject matter involved in this specific Rube Goldberg machine. The school was inspired to apply for a grant to create their own machine of similar magnitude and excited about the incredible learning opportunity for their students. The grant was accepted and over the entire school year, “Get the Ball Rolling” Rube Goldberg machine was created on all floors of the school and then professionally recorded and uploaded to online media (Abbotsford School of Integrated Arts Sumas Mountain, 2016). In the following chapter, I outline the methodology of this research project and the survey that was conducted to gain insight into how well the students developed the core competencies of the new B.C. curriculum through their involvement of this large-scale, school-wide, PBL task.

Chapter Three: Methodology

The purpose of this study was to investigate how a large-scale, school-wide PBL task naturally teaches core competencies of the new B.C. curriculum. The study was a non-experimental, quantitative pilot study. Participants were given an online survey after the completion of the Rube Goldberg project in order to assess their core competency development as a result of participating in the project. As a pilot study, the goals and design were tested for realistic results and the study assessed whether the research questions are suitable for further research in this area (Crossman, 2017).

Non-Experimental Research Designs

This was a non-experimental design as there was no control over what may have influenced the responses of participants and there was an interest in studying what occurs naturally with a PBL task (McMillan and Wergin, 2010). Also, this type of research was conducted because there was an interest in discovering if there was relationship between core competency development through the involvement of a large-scale PBL task.

Quantitative Research and Surveys

As a quantitative research design, numerical calculations were completed to summarize and explore the relationships between the Rube Golberg PBL task and the core competencies of the new B.C. Education Plan (McMillan and Wergin, 2010). Through a quantitative approach, prescribed procedures were used to ensure reliability and validity (Learn Higher, 2009). Additionally, the research questions could be replicated for further research in similar areas. An

online survey was used to collect the data for a variety of reasons. Cohen, L., Morrison, K., Manion, L. (2007) state that surveys are useful because they are efficient at gathering information quickly in numerical form, which was true for this research. Furthermore, the survey gathered multiple choice information that was standard for each participant, which was then used to support the hypothesis in question. Finally, the online survey was used in statistical analysis to make generalizations about core competencies and PBL.

Ethical Principles and Procedures

With human subject research, participant informed consent, confidentiality and privacy were of the utmost importance. Smith (2003) outlines how ethical principles in research should clearly notify the participants about the intended purpose of the research, the expected duration and procedures, including their rights to decline participation at any time with no penalties. Along with those characteristics, efforts were made in this study to further outline the potential risks for participants and who they could contact if they had any questions or concerns about the research. To ensure these principles were followed in this research, potential participants were read a script about the intentions of the research and their confidentiality. Interested students were then given information sheets for themselves and their parents further explaining the intended purpose of the study, the Rube Goldberg project, as well as an informed consent sheet for parents/guardians to sign and return. Once participants submitted the completed consent forms, they were then read the script one last time before completing the survey during their lunch period. For more information about the ethical principles and procedures in this study, all scripts, information sheets, consent forms and survey questions can be accessed in the Appendices.

Participants

Participants in this research comprised of grade eleven and twelve students, ages sixteen to eighteen, with a wide range of socio-economic backgrounds from a middle/high school in the Fraser Valley. Students who were involved in the production of “Get the Ball Rolling” Rube Goldberg machine were voluntarily asked to participate in the online questionnaire during lunchtime hours. The online survey was password encrypted and only the researcher had access to the survey and data. Students who were involved in the project the year before were only available to participate as the new grade 6 class was not part of the project the year previous and the grade 12s of the earlier year had graduated, thus leaving only grade 7 to 11 students to participate in the survey. The school is a B.C. Integrated Arts school comprising of roughly 300 students ranging from grades 6 to 12. Of the available students that participated in producing “Get the Ball Rolling”, 12 individuals volunteered to complete the survey. The participants were both male and female grade 11 and 12 students. The sections of the Rube Goldberg machine they were involved with included principles and topics that varied from physics, dance, drama, mathematics, social studies, visual-arts, photography, and digital media arts portions. Participants were first informed about the project and asked if they would be willing to voluntarily participate in the survey. If they agreed to participate, they were given an informed consent form to sign. On this informed consent form, it was clearly stated that individual responses would be completely anonymous and confidential. It was also stated that their consent could be withdrawn at any time for any reason, without penalty. Students were additionally informed they could ask questions about the research project at any time. Once permission forms were collected, participants were given a password to access the online survey and given time to complete the survey during their lunch period. Most participants finished the survey within ten minutes, so the time allotted to complete the survey was deemed sufficient. Once the

survey was completed, students were still given the opportunity to withdraw from the study without any penalty.

Procedures and Instruments

Research questions for the study included participants first self identifying their core competency set profile level—of each of the core competencies mentioned in the new B.C. curriculum plan—before and after the completion of the project. Additionally, participants were asked to identify if the Rube Goldberg project had an influence on their core competency development as a Likert-type scale. The multiple-choice responses were generated directly from the set profiles described in B.C. Ministry of Education website (BC’s New Curriculum, 2017). Participants answered five sets of three questions for each of the five core competencies tested. The following is an example of the first set of three questions and response selections for the communication core competency (BC Ministry of Education, 2017):

RQ1. Identify where your Communication Skills were AT THE BEGINNING of the Rube Goldberg Project.

- Beginning - Level 1: Ex: I respond meaningfully to communication from peers and adults. With support, I can be part of a group.
- Developing - Level 2: Ex: In familiar situations, with some support or guidance, I communicate with peers and adults.
- Moderate - Level 3: Ex: I communicate with peers and adults with growing confidence, using forms and strategies I have practiced.
- Competent - Level 4: Ex: I communicate clearly, in an organized way, using a variety of forms appropriately.
- Extended - Level 5: Ex: I am intentional and strategic; I am able to engage and accomplish my purpose with an increasing range of audiences, including those I do not know.
- No Response

RQ2. Identify where your Communication Skills were AT THE BEGINNING of the Rube Goldberg Project.

- Beginning - Level 1: Ex: I respond meaningfully to communication from peers and adults. With support, I can be part of a group.
- Developing - Level 2: Ex: In familiar situations, with some support or guidance, I communicate with peers and adults.
- Moderate - Level 3: Ex: I communicate with peers and adults with growing confidence, using forms and strategies I have practiced.
- Competent - Level 4: Ex: I communicate clearly, in an organized way, using a variety of forms appropriately.
- Extended - Level 5: Ex: I am intentional and strategic; I am able to engage and accomplish my purpose with an increasing range of audiences, including those I do not know.
- No Response

RQ3. If there was a change in your response from question #1 and #2, please identify how much you think being involved in the Rube Goldberg Project has influenced this change.

A positive change indicates that you feel your communication skills have improved or enhanced. A negative change means you feel your communications skills were reduced or changed for the worse.

- Strong Negative Change
- Negative Change
- No Change
- Positive Change
- Strong Positive Change
- No Response

Participants were given questions and responses for the following core competencies: communication, critical thinking, creative thinking, personal responsibility, and social responsibility. The responses that were provided were similar to the example above, and again, were derived from the Ministry's set profiles list for each perspective core competency (BC's New Curriculum, 2017). A complete list of the questions can be seen in Appendix 4.

Statistical Analysis

In order to test the reliability of the internal consistency of the data, the Cronbach's Alpha formula was calculated using Excel software and the results from the survey. Deviant (2017)

describes the term reliability as the degree of how consistent a test instrument measures what it is supposed to measure. Furthermore, Cronbach's Alpha is most commonly used in Likert-scale type questionnaires and its purpose is to identify if the test used is designed to accurately measure the latent variable of the study or not. Cronbach's Alpha was used due to the continuous scored variables in the Likert-scale that was used in the questionnaire and because the test assumes unidimensionality (Deviant, 2017; Ziontz, 2017). As this study is simply comparing the results to a PBL task, this reliability test was deemed sufficient. The formula and calculations can be seen in the results section below. Using resources from Deviant (2017), Ziontz (2017) and Grande (2016), the Cronbach's Alpha formula was calculated to be 72% which signifies that 72% of the variance in the composite scores is reliable variance. Lance, Butts, and Michels (2006) state that 70% is commonly cited as acceptable for exploratory research, however, for this applied scenario, a 90% reliability score is preferred. Ziontz (2017) suggests that more participants increases this percentage so that would be an area of future growth to support the reliability of the data. However, qualitative social research Dr. David L. Morgan (2015) from Portland State University recognizes that in a pretest or pilot study, the Cronbach Alpha coefficient is sufficient to measure the reliability of data even if the sample size is low. As this is a pilot study, the 72% is acceptable among research.

Research Limitations

Although the findings of this study are reliable, there are a couple limitations to consider. First, the response rate was low for the sample size and was limited to a specific geographic region. Secondly, it is not clear if all participants fully understood the language of the set profiles used in the questionnaire, which may have affected their multiple-choice responses. Additionally, the researcher oversaw collection and distribution of the survey which may have

affected the responses of the participants. It is unclear if their responses were based on their individual experiences of the project or on their wish to align with the set profiles described in the questionnaire. For these reasons, and the fact that this was a pilot study, the results should be used with caution when discussing whether the results can be generalized.

Chapter Four: Research Results

The results of the online survey from participant responses are summarized in four titled tables to highlight any changes that may have occurred from being involved in a large-scale PBL task. Table 1 summarizes the changes in core competency development that participants felt were associated with being involved in creating the school-wide Rube Goldberg project.

Table 1 Changes in Core Competency Development from Participants Involved in Rube Goldberg Project.

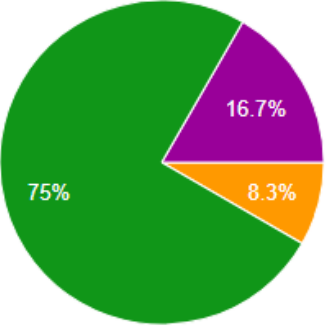
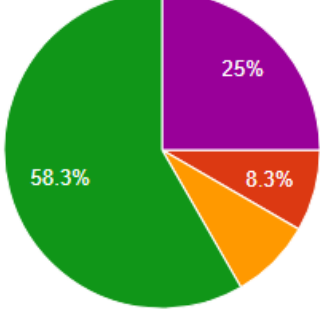
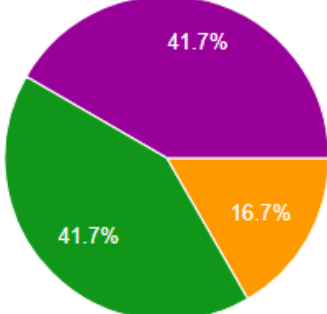
Core Competency	Pie Chart and associated percentages
Communication	 <ul style="list-style-type: none"> ● Strong Negative Change ● Negative Change ● No Change ● Postive Change ● Strong Postive Change ● No Response
Creative Thinking	 <ul style="list-style-type: none"> ● Strong Negative Change ● Negative Change ● No Change ● Postive Change ● Strong Postive Change ● No Response
Critical Thinking	 <ul style="list-style-type: none"> ● Strong Negative Change ● Negative Change ● No Change ● Postive Change ● Strong Postive Change ● No Response

Table 1 Changes in Core Competency Development from Participants Involved in Rube Goldberg Project.

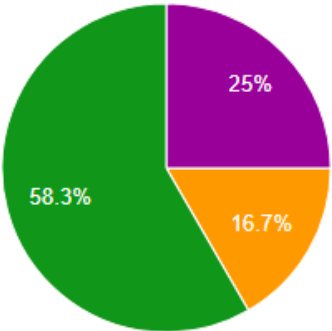
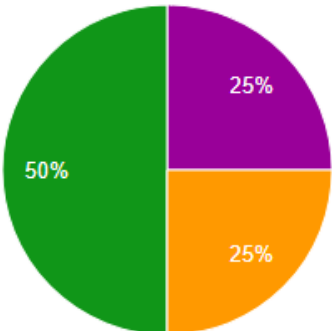
Core Competency	Pie Chart and associated percentages
<p align="center">Personal Responsibility</p>	 <ul style="list-style-type: none"> ● Strong Negative Change ● Negative Change ● No Change ● Postive Change ● Strong Postive Change ● No Response
<p align="center">Social Responsibility</p>	 <ul style="list-style-type: none"> ● Strong Negative Change ● Negative Change ● No Change ● Postive Change ● Strong Postive Change ● No Response

Table 2 displays the before and after self identification of each core competency tested. The first row identifies the core competency level before the Rube Goldberg project began and the single asterisks signifies where the same participant’s level was after the project was completed. Both in table 2 and 3, one participant chose the no response option for unknown reasons. Table 3 summarizes all the participant’s level of each core competency before and after the completion of the project.

Table 2 Before and After Self Identification Levels of Core Competencies

Participant	Communication	Creative Thinking	Critical Thinking	Personal Responsibility	Social Responsibility
P1	Developing	Moderate	Moderate	Moderate	Developing
P1*	Competent	Competent	Competent	Extended	Moderate
P2	Competent	Competent	Moderate	Extended	Developing
P2*	Competent	Extended	Competent	Extended	Developing
P3	Moderate	Competent	Moderate	Competent	Extended
P3*	Competent	Moderate	Moderate	Competent	Extended
P4	Moderate	Competent	Competent	Extended	Competent
P4*	Extended	Extended	Extended	Extended	Competent
P5	Moderate	Extended	Moderate	Competent	Extended
P5*	Competent	Extended	Competent	Competent	Competent
P6	Moderate	Competent	Moderate	Competent	Moderate
P6*	Competent	Extended	Competent	Extended	Competent
P7	Competent	Competent	Competent	Moderate	Competent
P7*	Extended	Extended	Extended	Competent	Extended
P8	Moderate	Developing	Beginning	Beginning	Beginning
P8*	Competent	Competent	^b Extended	Moderate	Moderate
P9	Competent	Moderate	Competent	Extended	Competent
P9*	Extended	Extended	Extended	Extended	Extended
P10	Moderate	Competent	Competent	Beginning	Moderate
P10*	Extended	^a no response	Extended	Competent	Competent
P11	Developing	Extended	Competent	Moderate	Moderate
P11*	Competent	Extended	Competent	Competent	Moderate
P12	Moderate	Competent	Competent	Moderate	Moderate
P12*	Competent	Extended	Competent	Competent	Competent

Notes: * Participant’s core competency profile level after the completion of the Rube Goldberg project.

^a Participant chose the no response category for unknown reasons

^b Note the large improvement in core competency set profile

Table 3 Summary of All Participants’ Core Competency Level Before and After PBL Task.

Core Competency	Before Rube Goldberg	After Rube Goldberg
Communication	0% Beginning 16.7% Developing 58.3% Moderate 25% Competent 0% Extended	0% Beginning 0% Developing 0% Moderate 66.7% Competent 33.3% Extended
Creative Thinking	0% Beginning 8.3% Developing 16.7% Moderate 58.3% Competent 16.7% Extended	0% Beginning 0% Developing 8.3% Moderate 16.7% Competent 66.7% Extended *8.3 % No response
Critical Thinking	8.3% Beginning 8.3% Developing 41.7% Moderate 41.7% Competent 0% Extended	0% Beginning 0% Developing 8.3% Moderate 50% Competent 41.7% Extended
Personal Responsibility	8.3% Beginning 8.3% Developing 33.4% Moderate 25% Competent 25% Extended	0% Beginning 0% Developing 8.3% Moderate 41.7% Competent 50% Extended
Social Responsibility	8.3% Beginning 16.7% Developing 33.3% Moderate 25% Competent 16.7% Extended	0% Beginning 8.3% Developing 25% Moderate 41.7% Competent 25% Extended

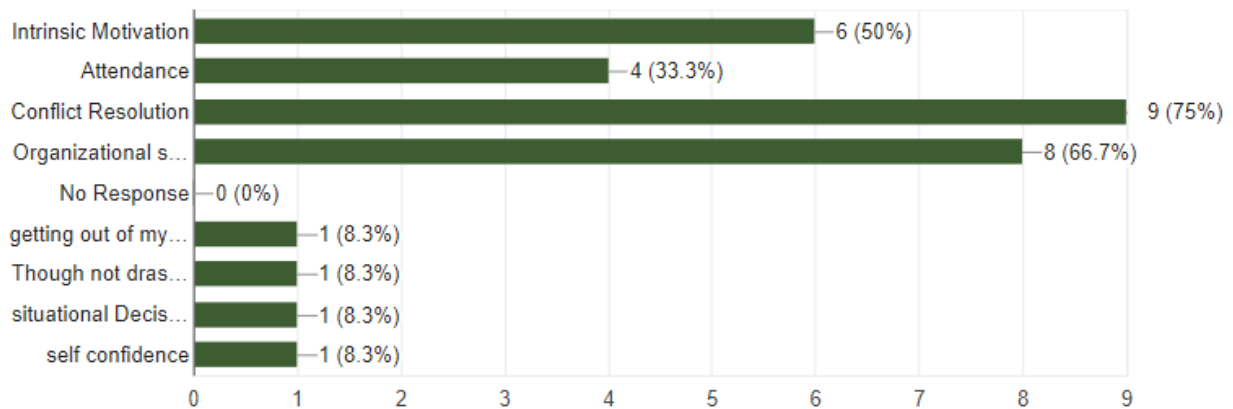
Note: * Participant chose the no response category for unknown reasons

A further diagnostic was completed in the survey asking participants to identify which of the core competencies, if any, was more developed than any other competency due to their participation of the Rube Goldberg project (data not displayed in the paper). Of all 12 responses,

8 students identified that their communication skills were developed most throughout the PBL task. Furthermore, participants were given the opportunity to identify any other areas that were improved individually through their involvement in the school-wide Rube Goldberg project.

Table 4 is a summary of that data.

Table 4 Number of Individual Improvements in Other Areas Through Participation of PBL Task



The following data shows the formulas, calculations, and spreadsheets pertaining to the Crochbach’s Alpha formula. Responses from each participant were assigned a score of 1 to 5 in the Excel spreadsheet depending on their set profile development identified through the survey. If a level 1 was given as a response, then a score of 1 was entered into the spreadsheet; if a level 5 set profile was identified as a response, then a score of 5 was given on the spreadsheet, and so on. This was needed to calculate the Cronbach’s Alpha reliability score.

The formula for Cronbach’s alpha is:

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N - 1) \cdot \bar{c}}$$

Where:

N = the number of items,

\bar{c} = average covariance between item-pairs, and

\bar{v} = average variance.

	Comm.	Creative T	Critical T	Personal R	Social R	TOTAL
P1	2	2	2	1	1	8
P2	3	3	1	3	3	13
P3	2	2	3	2	1	10
P4	2	1	2	3	3	11
P5	2	2	2	2	2	10
P6	2	2	2	2	2	10
P7	2	2	2	2	2	10
P8	2	2	1	2	2	9
P9	2	1	1	2	2	8
P10	1	1	1	1	1	5
P11	2	3	3	2	3	13
P12	1	2	1	1	2	7
TOTAL	23	23	21	23	24	114
<i>Variance</i>	0.243056	0.409722	0.520833	0.40972222	0.5	2.083333

k 5
 \sum var 2.083333
 var 4.916667
a 0.720339 CRONBACKALPHA B2:F13 = **0.720339**

To confirm the Cronbach Alpha calculations, an ANOVA Two-Factor without Replication test was completed with Excel software and can be seen below. Calculating the Cronbach’s Alpha score through the ANOVA test gave the same percentage thus confirming the internal reliability of the survey data.

Anova: Two-Factor Without Replication

SUMMARY	Count	Sum	Average	Variance
Row 1	5	8	1.6	0.3
Row 2	5	13	2.6	0.8
Row 3	5	10	2	0.5
Row 4	5	11	2.2	0.7
Row 5	5	10	2	0
Row 6	5	10	2	0
Row 7	5	10	2	0
Row 8	5	9	1.8	0.2
Row 9	5	8	1.6	0.3
Row 10	5	5	1	0
Row 11	5	13	2.6	0.3
Row 12	5	7	1.4	0.3
Column 1	12	23	1.91666667	0.265152
Column 2	12	23	1.91666667	0.44697
Column 3	12	21	1.75	0.568182

Column 4	12	23	1.91666667	0.44697
Column 5	12	24	2	0.545455

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Rows	11.8	11	1.07272727	3.575758	0.001203	2.014046
Columns	0.4	4	0.1	0.333333	0.854043	2.583667
Error	13.2	44	0.3			
Total	25.4	59				

Cronbach alpha
= **0.720339**

Chapter Five: Discussion and Analysis, Implications, Conclusion, and Future Research

Discussion and Analysis

There are a few important pieces of information to note from table 1. Based on the student responses, 83.3% of students had a positive change, or strong positive change, in all of the following core competencies: communication, creative thinking, critical thinking and personal responsibility. 75% of participants also noted a positive change to their social responsibility competency. In all core competencies tested, there was at least one student in each core competency surveyed who did not experience any change in core competency development, and two individuals further experienced no change with the critical thinking and personal responsibility competencies, and 25% of participants experienced no change in regards to their social responsibility competency. Although in these few instances participants did not experience a positive change in the core competencies, the majority of participants did. This result agrees with similar research in how a PBL task increases competency development (Durkin, 2016; Hung, et al., 2012; Kovalyova et al., 2016; Larmer, et al., 2015).

Another very important realization in table 1 is that a single student felt that there was a negative change in their creative thinking competency. This response is most likely in correlation to the no response submitted in participant #10 in table 2. There could be several possible reasons for a response like this. Perhaps, the group came into conflict with each other around what they collectively wanted to create and were not able to resolve their troubles. Maybe one of the group members exhibited more of dictator style of leadership and left little choice for other group members to offer suggestions, such as participant #10. There could have

even been a lack of guidance from the teacher in which to help promote and foster the creativity with this participant. The most important aspect to realize here agrees with what Brundiers and Wiek (2010) suggest: that in order for students to fully experience PBL core competency growth, then there are three key factors that need to occur which include collaborative design, coordination, and integration. They continue to state that real-world learning opportunities can align well with key competencies; however, students do not automatically build competencies when engaging in such tasks (Brundiers and Wiek, 2010). It would be interesting to follow up with participant #10 and discover if the design creative process was a collaborative effort or not, because research has identified that PBL supports collaboration and the social skills among students (Lee, Huh, Reigeluth, 2015). In relation to this statement, this area is an important area for future research to not only ensure that PBL approaches to learning follow these three characteristics, but it would allow the researcher the opportunity to understand why some students may not be developing strong core competencies through a PBL task.

While focussing on the summary of table 3, it appears that all core competencies in participants improved through their involvement of the Rube Goldberg project. Overall, the percentages within each core competency set profile improved, or the profile level improved by one or more categories. With an additional look at table 2, the data further reveals that all competencies and all participants either remained constant or improved in profile competency levels. This is an important realization. Even though some participants experienced no change, the majority of circumstances demonstrated an improved development of the core competencies. In table 2, participant #8 identified themselves as a beginning profile for critical thinking and then self identified themselves as extended by the end of the project. Perhaps the student did not have a strong understanding of the exact definition of the set profiles and due to the nature of the

online survey, the student could not ask questions about any of the definitions. Without knowing whether the participant had a strong understanding of the set profile descriptions listed or not, this noticeable growth cannot be overstated.

Table 4 illustrates whether there were any improvements in other categories that were not identified as a core competency from the B.C. Ministry of Education. Looking at the responses from table 4, 75% of students identified an improvement in conflict resolution followed by a 67% improvement in organizational skills. 50% of participants also saw their intrinsic motivation grow and 33% recognized an improvement in attendance. Students also were given a free response opportunity to identify further categories of development. Participants individually stated that there was growth in self confidence, problem solving, situational decision making, and working outside their comfort zone. Part of these responses agrees with a study in Hong Kong where a PBL task helped promote intrinsic motivation (Lam, Cheng, Ma, 2009). These other areas of improved attendance, conflict resolution skills, and improved organizational skills would be an interesting area for future research. Although the findings do support the findings of similar research, there may be some other factors that may have accounted for the differences in the results.

As previously stated in the limitations section, it is not clear if all participants fully understood the language of the set profiles used in the questionnaire, which may have affected their multiple-choice responses in possibly choosing the most positive response. The core competency set profiles could have been taught to the students before the project began to ensure that students were familiar with the language and competency levels, thus improving student response reliability and consistency. Furthermore, the majority of questions were given in a Likert-type scale where the layout was consistently structured from a positive to negative format,

which may have affected how the participants responded; however, this arrangement was used to prevent confusion among participants. An additional factor may have been due to the researcher overseeing the collection and distribution of the survey which may have affected the responses of the participants in a biased way. It is unclear if their responses were based on their individual experiences of the project or on their desire to align with the natural objectives of the project or with the set profiles described in the questionnaire. To improve the generalization of these results in a similar study in the future, ensuring that the researcher is not distributing the scripts and questionnaire will help eliminate any other causal factors. Moreover, more survey testing could have been conducted throughout the project to improve the reliability of the results (Trochim, 2006). Having the participants complete the survey at three separate occasions, before, during and after the project, would also help eliminate other factors affecting the results.

Implications

The primary goal of B.C.'s education system is to develop each students' potential to gain the knowledge and develop their skills and abilities needed to contribute to a healthy, growing and sustainable economy (BC Ministry of Education, 2016). The research findings here support the claim of the new curriculum plan and how pedagogical approaches such as PBL contribute to developing the core competencies. The implications of this research apply to students, educators, administration, school districts, community members and even national education programs.

Students

The experimental results and feedback from students in this study conform to what has already been indicated by researches, specifically, that project-based learning develops core competencies among students (Brundiers and Wiek, 2010; Durkin, 2016; Hart Research

Associates, 2013; Hung, et al., 2012; Kovalyova et al., 2016; Lam, et al., 2009; Larmer, et al., 2015). In a 2013 study, researchers identified that students who participated in a STEM PBL school atmosphere were active learners working alongside community partners learning the oral and written communication skills needed to work in teams (Cha and Brown, 2013).

Furthermore, the researchers learned that students were quicker to mature in this type of learning environment and the students were more articulate, confident, and willing to share their knowledge (Cho and Brown, 2013). These results are quite similar to the results pertained to this paper. Boss (2013) identifies eight essential characteristics of high-quality PBL tasks which contain a driving question, significant content, in-depth inquiry, voice and choice, revision and reflection, a public audience, and 21st century competencies including communication, critical thinking, problem solving, collaboration, creativity and innovation. He continues to add that teachers should follow these features when creating strong PBL activities.

Educators

Caring out PBL in a school setting is challenging, exhaustive, and time consuming for both teachers and students. However, Cho and Brown (2013) discuss that effective use of PBL requires extensive planning and professional development, a supportive environment, and effective tools and strategies for instruction. Halbert and Kaser (2015) recognize that teachers are interested in research-based evidence that work in the classroom. This study and other research have identified that the implication of PBL activities are important in teaching our students 21st century skills that are needed for a successful future. If teachers are to rise to the challenges of PBL, then these aforementioned teaching skills will be essential to follow and they will need the support of senior management when adopting this kind of practice.

Administrators and School Districts

John Sole (2015), founder and CEO of Guerrilla Educators, has identified 10 experienced based Hallmarks of 21st century teaching and learning, which include: project based learning, student ownership and engagement, collaborative teaching and learning, mastery of curriculum and development of higher order thinking skills, reporting out and celebration, 21st century skills, technology, as well as community partnerships. Noting that PBL is at the top of this list, it will be up to school districts and their administrators to support this model of education and inspire their teachers to engage in IBL and PBL activities in the classroom. If resources and professional development are readily available, then educators will be more likely to try these methods of teaching. Connecting with the community will be challenging for teachers involved with PBL activities, so administrators can further help their staff members connect with community needs. If educators care about their students' learning environments, then how much more should administrators and school districts. Perhaps programs that tie in community needs and PBL tasks within schools could be an area for future development.

Community and Ministry

Larmer et al. (2015) suggest making these community partnerships through contacting local businesses to get ideas for projects, or using their resources, or even asking community members to help facilitate projects as mentors, audience members or clients. As community members, we should care about the education of our youth. Being involved in their education and providing resources in whatever way possible should be important in any municipality. Perhaps the Ministry of Education could start related programs and initiatives that will support this view. However, that would most likely require new policies and laws to be set into motion. Considering the implications of all the shareholders involved in PBL activities, then a respectful collaborative approach of all parties will be needed as we continue to improve our learning

environments for students and provide engaging learning opportunities for them (Boyer and Crippen, 2014). A daunting task, but imagine the possibilities!

Conclusions

Many PBL leaders are swayed that PBL teaches more than just content but develops a deeper understanding of content as well as the necessary skills for students to flourish in today's everchanging world (International Education Advisory Board, 2016; Larmer et al., 2015). This paper has identified how useful PBL is at teaching the new core competencies of B.C.'s curriculum.. Educators around the world should be encouraged to take the leap into more of an inquiry approach to teaching no matter the size and scope of the project. Davis and Sumara (2007) suggest that educators should embrace complexity and chaos theories of academic courses and apply them to education because the world is increasingly unpredictable, complex and chaotic. They propose that students should learn in similar environments that the world itself operates. Munakata and Vaidya (2015) discuss how the teacher role changes into more of a facilitating coaching role rather than a lecturer in this type of scenario. Educator Kelly Remijan (2016) outlines a 12-step program to support teachers in developing any PBL assignment and is worth a look for anyone interested in trying a PBL task.

The strongest schools make a lifelong impression on student learning especially when their school plans contain specific targets and policies that are in place to produce positive changes (Education Improvement Commission, 2000). School plans need to address many areas of education including administrative directives, district plans, and a focus on the educational plans of the ministry, especially if there are new ones! There has been much research that suggests better administrative leadership in schools plays a significant role in improving student achievement (BCPVPA Standards Committee, 2015). So in order to develop higher levels of

education in all areas of the school, administration, staff and students should be reflecting on the following questions: “Where are you going with your learning? How are you doing with your learning? Where are you going next with your learning?” (Halbert and Kaser, 2015). Do the learning opportunities provide students with a chance to reflect on a world that is increasingly complex, connected, unpredictable and rapidly changing? Halbert and Kaser (2015) further describe that innovative learning environments are promoted through encouraging engagement, motivation, integration and the development of self-regulation. With an inquiry approach to learning, meaningful supervision of instruction, a strong understanding of current assessment practices, sound pedagogy, and embracing 21st century teaching and learning, schools are going to improve and flourish with any new curriculum changes. The students of today deserve the best and we as educators, administrators, and community stakeholders need to meet those needs.

Future Research and Direction

Although the present pilot study seems to be effective, there are some limitations in generalizing the findings. Firstly, the results of this study were from senior secondary students; therefore, the findings may not apply as well to middle school students and even elementary students. The results were from a school in the Fraser Valley of B.C. and the socio-economic status of the participants are varied, as such, the results may not apply to other geographic and demographic areas. Moreover, this study examined the responses of 12 individuals from the entire school population, so to improve the reliability of the results, more responses should have been included. This study has suggested that PBL naturally develops the core competencies of the new B.C. curriculum, therefore the results of an entire school response to a school wide project is worth examining in the future. Additionally, this study included a single variable

measure. It has been stated that in a one variable statistical analysis, more than one testing should be done throughout the project to further improve the reliability of the results (Trochim, 2006). Perhaps a multivariate analysis with a number of independent variables would be better suited in future research. Another limitation is the lack of a control group. Including a control group would allow for more of a comparison between those that did participate in the PBL task and those that did not. Finally, Halbert and Kaser (2015) have observed that it takes roughly 40 hours of intense professional development to shift assessment practices, so if educators are to implement this shift from traditional to inquiry based teaching, or a synthesis of the two methods, then there must be the professional development resources and time to support them. Before this school wide Rube Goldberg project began, all staff members did not receive 40 hours of professional development in project based learning. In order to ensure that students are given the best learning environments for a PBL task such as this, then teachers in the future should be given a respectful amount of time for professional development.

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Appendices

Appendix 1: Information Package for Students and Guardians

RE: A letter of information to the parents of students involved in ASIA's Rube Goldberg Project:

Dear Parents/Guardians and Students:

Two years ago, I was introduced to a video from a band called OK GO. The title of the video was called "This too shall pass". In the video, the band created a song to complement their complex Rube Goldberg machine. The video is simply amazing and definitely worth a quick YouTube search. It really inspired me! It contains the elements of mathematics, physics, chemistry, music and visual art. I have seen Rube Goldberg machines in the past, but none that have integrated the arts like this one had. After watching the video, a colleague and I started discussions about attempting something similar at our school, Abbotsford School of Integrated Arts – Sumas Mountain Campus. We dreamed of an integrated Rube Goldberg machine that contained even more of the elements of art and other subjects such as: Dance, Drama, Digital Media, Photography, PE, and more. We dreamed of a machine that would involve the entire school, every student grades 6 to 12, and one that would be filmed throughout the entire school on all floors and finally uploaded to YouTube. For those of you wondering at this point, a Rube Goldberg machine is simply an invented machine that performs a simple task, often including a chain reaction of events.

The purpose of the project is to develop the students' core competencies, including problem solving, creative thinking, critical thinking, communication, social and personal responsibility, overall teamwork skills, and to instill a passion for learning and the arts. Students will also integrate the learning standards within their individual classes as they pertain to the machine. This will vary from grade to grade. We look forward to including you and your child in this year's Rube Goldberg Project.

If you have any concerns or questions regarding the process of the project, please do not hesitate to email the administration or myself.

Sincerely,

Andrew Matty

ASIA – Sumas Mtn. Campus
Senior Math, Photography, Film Studies
andrew_matty@sd34.bc.ca

Appendix 2: Informed Consent Form for Students

Dear Parents,

I am currently completing my thesis for my Master of Education program at City University which is focused on whether student participation in the school wide project influences the development of the core competencies in individual students. During your child's/children's lunch block, I will be conducting a 21 question survey in relation to the core competencies of the new curriculum and the Rube Goldberg project that was completed last year at the school; I am including information about the project in this letter. The questions will be directed to what your child/children learned or prohibited their learning in relation to the core competencies outlined in the new BC Education Plan via their participation in the Rube Goldberg project.

I am wondering if your child/children might be interested in participating in this research study. The School District has given approval for this research project. The questionnaire should not take longer than 10 minutes and will be completed using an iPad given to each participant to complete the online questionnaire; this will be done outside of regular instructional time. The online questionnaire will be completed in Google Forms and will not contain your child's name and personal information. Your child's/children's involvement is completely voluntary, even if you give consent, there are no penalties for anyone who does not participate, and your child/children may withdraw from the study at any time, even when they are completing the questionnaire or any time afterward. All responses will be anonymous and all information from participants will be kept confidential; maintaining confidentiality of those who participate is of highest importance for me as a researcher.

There is minimal risk that involvement in this research study would cause any distress for your child/children. But I will notify the school counsellors of the study, its goals and methodology. They will be available for any counselling should your child/children need to talk with a counsellor.

Please sign the consent document below to ensure your child's participation in the proposed research survey. If you have any questions, you can contact me via email or by phoning the school during school hours. Thank you for your time.

Mr. Andrew Matty

Name of Student(s):

_____ Grade(s): _____

Parent/Guardian Name: _____

Parent/Guardian Signature: _____ Date: _____

Appendix 3: Script for potential student participants

"Mr. Matty is doing a research project. He is hoping to conduct a questionnaire in relation to the core competencies of the new curriculum and the Rube Goldberg project we completed last year. You (students) are being asked if you would be willing to participate in his research study.

The questionnaire should not take longer than 15 minutes and will be completed online using a school laptop. Your involvement is completely voluntary, there are no penalties for anyone who does not participate, and you may withdraw from the study at any time, even when you are completing the questionnaire or any time afterward. All responses will be anonymous and all information from participants will be kept confidential; maintaining confidentiality of those who participate is of the highest importance for Mr. Matty as a researcher. All interested participants will be given a letter to show your parents that provides further details of the research, as well as, parental consent. The letter also explains the Rube Goldberg project; in case they have any questions about it or its learning goals. If you wish to participate, you can bring your signed parental consent form back to Mr. Matty all week long. Mr. Matty will then conduct the survey the following week and you can drop by his classroom during the lunch period to complete the online questionnaire. Does anyone have any questions? Then please take the permission form and information letter and talk to your parents tonight about it.

If you have any friends in gr 11 or 12 in other blocks that might be interested, please pass on the information.

Appendix 4: Research Instrument—List of main set of questions for participants

1. What grade are you in?

Identify and check off the correct box.

- Grade 10
- Grade 11
- Grade 12
- No response

2. Do you identify yourself as male or female?

- Male
- Female

- No response

3. Briefly describe the section of the machine were you a part of (example: dancing section, or physics room). 75 characters or less please.

Please describe, in one or two sentences, which section you and your group built or performed during the Rube Goldberg Machine.

4. Identify where your Communication Skills were AT THE BEGINNING of the Rube Goldberg Project.

Using the options below to describe your communication skills before the project was introduced.

- Beginning - Level 1: Ex: I respond meaningfully to communication from peers and adults. With support, I can be part of a group.
- Developing - Level 2: Ex: In familiar situations, with some support or guidance, I communicate with peers and adults.
- Moderate - Level 3: Ex: I communicate with peers and adults with growing confidence, using forms and strategies I have practiced.
- Competent - Level 4: Ex: I communicate clearly, in an organized way, using a variety of forms appropriately.
- Extended - Level 5: Ex: I am intentional and strategic; I am able to engage and accomplish my purpose with an increasing range of audiences, including those I do not know.
- No Response

5. Identify where your Communication Skills were AT THE COMPLETION of the Rube Goldberg Project.

Using the options below to describe your communication skills at the end of the year when the project was finished.

- Beginning - Level 1: Ex: I respond meaningfully to communication from peers and adults. With support, I can be part of a group.
- Developing - Level 2: Ex: In familiar situations, with some support or guidance, I communicate with peers and adults.
- Moderate - Level 3: Ex: I communicate with peers and adults with growing confidence, using forms and strategies I have practiced.
- Competent - Level 4: Ex: I communicate clearly, in an organized way, using a variety of forms appropriately.

- Extended - Level 5: Ex: I am intentional and strategic; I am able to engage and accomplish my purpose with an increasing range of audiences, including those I do not know.
- No Response

6. If there was a change in your response from question #4 and #5, please identify how much you think being involved in the Rube Goldberg Project has influenced this change.

A positive change indicates that you feel your communication skills have improved or enhanced. A negative change means you feel your communications skills were reduced or changed for the worse.

- Strong Negative Change
- Negative Change
- No Change
- Positive Change
- Strong Positive Change
- No Response

7. Identify where your Creative Thinking Skills were AT THE BEGINNING of the Rube Goldberg Project.

Using the options below to describe your creative thinking skills before the project was introduced.

- Beginning - Level 1: Ex: I get ideas when I play.
- Developing - Level 2: Ex: I can get new ideas or build on or combine other people's ideas to create new things within the constraints of a form, a problem, or materials.
- Moderate - Level 3: Ex: I can get new ideas in areas in which I have an interest and build my skills to make them work.
- Competent - Level 4: Ex: I can get new ideas or reinterpret others' ideas in ways that have an impact on my peers.
- Extended - Level 5: Ex: I can develop a body of creative work over time in an area of interest or passion.
- No Response

8. Identify where your Creative Thinking Skills were AT THE COMPLETION of the Rube Goldberg Project.

Using the options below to describe your creative thinking skills at the end of the year when the project was finished.

- Beginning - Level 1: Ex: I get ideas when I play.
- Developing - Level 2: Ex: I can get new ideas or build on or combine other people's ideas to create new things within the constraints of a form, a problem, or materials.
- Moderate - Level 3: Ex: I can get new ideas in areas in which I have an interest and build my skills to make them work.

- Competent - Level 4: Ex: I can get new ideas or reinterpret others' ideas in ways that have an impact on my peers.
- Extended - Level 5: Ex: I can develop a body of creative work over time in an area of interest or passion.
- No Response

9. If there was a change in your response from question #7 and #8, please identify how much you think being involved in the Rube Goldberg Project has influenced this change.

A positive change indicates that you feel your creative thinking skills have improved or enhanced. A negative change means you feel your creative thinking skills were reduced or changed for the worse.

- Strong Negative Change
- Negative Change
- No Change
- Positive Change
- Strong Positive Change
- No Response

10. Identify where your Critical Thinking Skills were AT THE BEGINNING of the Rube Goldberg Project.

Using the options below to describe your critical thinking skills before the project was introduced.

- Beginning - Level 1: Ex: I can use evidence to make simple judgments.
- Developing - Level 2: Ex: I can ask questions and consider options. I can use my observations, experience, and imagination to draw conclusions and make judgments.
- Moderate - Level 3: Ex: I can gather and combine new evidence with what I already know to develop reasoned conclusions, judgments, or plans
- Competent - Level 4: Ex: I can evaluate and use well-chosen evidence to develop interpretations; identify alternatives, perspectives, and implications; and make judgments. I can examine and adjust my thinking.
- Extended - Level 5: Ex: I can examine evidence from various perspectives to analyze and make well-supported judgments and interpretations about complex issues.
- No Response

11. Identify where your Critical Thinking Skills were AT THE COMPLETION of the Rube Goldberg Project.

Using the options below to describe your critical thinking skills at the end of the year when the project was finished.

- Beginning - Level 1: Ex: I can use evidence to make simple judgments.
- Developing - Level 2: Ex: I can ask questions and consider options. I can use my observations, experience, and imagination to draw conclusions and make judgments.

- Moderate - Level 3: Ex: I can gather and combine new evidence with what I already know to develop reasoned conclusions, judgments, or plans
- Competent - Level 4: Ex: I can evaluate and use well-chosen evidence to develop interpretations; identify alternatives, perspectives, and implications; and make judgments. I can examine and adjust my thinking.
- Extended - Level 5: Ex: I can examine evidence from various perspectives to analyze and make well-supported judgments and interpretations about complex issues.
- No Response

12. If there was a change in your response from question #10 and #11, please identify how much you think being involved in the Rube Goldberg Project has influenced this change.

A positive change indicates that you feel your critical thinking skills have improved or enhanced. A negative change means you feel your critical thinking skills were reduced or changed for the worse.

- Strong Negative Change
- Negative Change
- No Change
- Positive Change
- Strong Positive Change
- No Response

13. Identify your Personal Responsibility competency AT THE BEGINNING of the Rube Goldberg Project.

Using the options below to describe your level of personal responsibility before the project was introduced.

- Beginning - Level 1: Ex: With support, I can show a sense of accomplishment and joy, and express some wants, needs, and preferences.
- Developing - Level 2: Ex: In a safe, supportive environment, I can share my ideas and accomplishments, and accept responsibility for my actions.
- Moderate - Level 3: Ex: I can recognize my strengths and use strategies to focus, manage stress, and accomplish my goals.
- Competent - Level 4: Ex: I can recognize my value and advocate for my rights. I take responsibility for my choices, my actions, and my achievements.
- Extended - Level 5: Ex: I can identify my strengths and limits, find internal motivation, and act on opportunities for self-growth. I take responsibility for making ethical decisions.
- No Response

14. Identify your Personal Responsibility competency AT THE COMPLETION of the Rube Goldberg Project.

Using the options below to describe your level of personal responsibility at the end of the year when the project was finished.

- Beginning - Level 1: Ex: With support, I can show a sense of accomplishment and joy, and express some wants, needs, and preferences.
- Developing - Level 2: Ex: In a safe, supportive environment, I can share my ideas and accomplishments, and accept responsibility for my actions.
- Moderate - Level 3: Ex: I can recognize my strengths and use strategies to focus, manage stress, and accomplish my goals.
- Competent - Level 4: Ex: I can recognize my value and advocate for my rights. I take responsibility for my choices, my actions, and my achievements.
- Extended - Level 5: Ex: I can identify my strengths and limits, find internal motivation, and act on opportunities for self-growth. I take responsibility for making ethical decisions.
- No Response

15. If there was a change in your response from question #13 and #14, please identify how much you think being involved in the Rube Goldberg Project has influenced this change.

A positive change indicates that you feel your personal responsibility has improved or enhanced. A negative change means you feel your personal responsibility has reduced or changed for the worse.

- Strong Negative Change
- Negative Change
- No Change
- Positive Change
- Strong Positive Change
- No Response

16. Identify your Social Responsibility competency AT THE BEGINNING of the Rube Goldberg Project.

Using the options below to describe your level of social responsibility before the project was introduced.

- Beginning - Level 1: Ex: I am aware that other people can be different than I am.
- Developing - Level 2: Ex: In familiar and structured settings, I can interact with others and the environment respectfully.
- Moderate - Level 3: Ex: I can interact with others and the environment respectfully and thoughtfully.
- Competent - Level 4: Ex: I can take purposeful action to support others and the environment.
- Extended - Level 5: Ex: I can initiate positive, sustainable change for others and the environment.
- No Response

17. Identify your Social Responsibility competency AT THE COMPLETION of the Rube Goldberg Project.

Using the options below to describe your level of social responsibility at the end of the year when the project was finished.

- Beginning - Level 1: Ex: I am aware that other people can be different than I am.
- Developing - Level 2: Ex: In familiar and structured settings, I can interact with others and the environment respectfully.
- Moderate - Level 3: Ex: I can interact with others and the environment respectfully and thoughtfully.
- Competent - Level 4: Ex: I can take purposeful action to support others and the environment.
- Extended - Level 5: Ex: I can initiate positive, sustainable change for others and the environment.
- No Response

18. If there was a change in your response from question #16 and #17, please identify how much you think being involved in the Rube Goldberg Project has influenced this change.

A positive change indicates that you feel your social responsibility has improved or enhanced. A negative change means you feel your social responsibility has reduced or changed for the worse.

- Strong Negative Change
- Negative Change
- No Change
- Positive Change
- Strong Positive Change
- No Response

20. Of all of the core competencies listed, identify which, if any, of the competencies you HAVE developed MORE through the involvement of the Rube Goldberg project.

Check off the boxes to identify which competencies that you feel have improved due to you being involved in the Rube Goldberg Project.

- Critical Thinking
- Communication
- Personal Responsibility
- Creative Thinking
- Social Responsibility

21. Aside from the core competencies above, check off any other areas in which you have improved individually.

- Intrinsic Motivation
- Attendance
- Conflict Resolution
- Organizational strategies
- No Response

- Other: _____