

CREATING A SCIENCE BOARD GAME: INCREASING STUDENT MOTIVATION
AND ACHIEVEMENT IN LEARNING

by

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ABSTRACT

In this investigation, the teacher had students create board games to increase student motivation and achievement to learn about electric circuits. The goal of the study was to determine if applying knowledge about circuits to a familiar format of a board game would encourage students to learn the content to a greater depth than other types of projects they have done to demonstrate knowledge. Data showed the creative aspect of a board game was a motivating factor for students and gameplay had a positive affect on both motivation and achievement over and above other ways of presenting information.

INTRODUCTION & BACKGROUND

School Background

Pascack Valley High School is a public high school in Hillsdale, NJ. It is part of the Pascack Valley Regional High School District which includes two high schools, Pascack Valley High School and Pascack Hills High School. Pascack Valley High School serves the towns of Hillsdale and Rivervale, while Pascack Hills High School serves the towns of Woodcliff Lake and Montvale. The district is situated in Bergen County, NJ and borders New York State. The school enrolled 1,185 students in 2017 (US News). Pascack Valley High School is an 85% white district while minority populations include 7% Asian and 6% Hispanic (US News, 2015-16). The district has a low level of economic disadvantage (US News). For example, only 2% of the student receive free lunch (US News). I am one of four teachers in the physics department. All students at Pascack Valley High School are required to pass physics to graduate. Pascack Valley High School offers students three levels of physics. The three levels offered are AP Physics, College Prep Physics, and Conceptual Physics. I taught four Conceptual Physics classes in which 50% of the students have IEPs. Conceptual Physics is offered to students who may generally struggle with physics. All four Conceptual Physics classes I taught were co-taught with a special education teacher. Some students who do not have IEPs were in Conceptual Physics because of a lack of motivation and achievement in school or due to a difficulty with math. Conceptual Physics focuses more on the concepts of physics rather than the mathematical rigor.

Project Background

In the special education classroom, many students have difficulty expressing their learning simply through written exams. Some freeze up or need extra time and struggle when other students finish quickly. Non-traditional assessments of learning are key for students to show what they have learned. There are a myriad of ways students can express their learning; for example, students can use oral presentations, video presentations, written reports, interviews, and digital portfolios. In the past, I have had students give oral presentations on gas laws in chemistry and create digital notebooks using wiki pages. This year in my classroom, students created video presentations on the Doppler effect. To do this, they ran past their computers with noise making devices, such as a whistle brought in from home. They combined these recordings with written and spoken explanations into iMovie presentations to describe the Doppler effect. Students also showed and explained the creation of a real image with a curved mirror. To do this, they took an image from their phone and reflected it with a concave mirror in a dark room. Students had to explain how this image was formed due to the path of the light reflecting off of the curved mirror. Students created a commercial to sell a fictional flat mirror, which was only half of a person's body length, using a video commercial format. They gave evidence using a ray diagram to show why they only needed a mirror that was half as tall as the person who stood in front of it. They included this evidence in their video as a way to convince someone to buy their fictional mirror. Students also created paper xylophones by rolling up paper tubes, and created videos explaining how different pitches were heard. Finally, students recorded on video the creation of scary Halloween

shadows and calculated the magnification of their shadows. These examples are only a few of the ways my students have expressed their learning in non-traditional assessments. These assessments have been a very positive way for my students implement non-traditional mathematical problem solving as they are able to explain themselves in a context which they have control of. As you can see, many of my students' non-traditional projects have often been video presentations. As far as non-video based projects, I have had students design rollercoasters, egg drop safety devices, baking soda and vinegar cars, bridges, and much more. However, once we were halfway through the school year, I noticed the students began to feel I was overusing the video format. More than a few students began to complain about having to create another video. In this project I tested a new design challenge. I aimed to determine whether designing a board game had an impact on student motivation and achievement. In the past, students have explained how a circuit works in a video format. In the videos submitted last school year, students did not seem motivated to produce a quality product, possibly due to the way they were again asked to present their information in a video format. This classroom research project sought to determine if having students present information in a board game format could produce longer engagement time in the classroom, and more excitement, motivation, and achievement.

Focus Question

This research focused on whether allowing students to create board games could positively affect student motivation to learn. Can a board game design challenge bring

more student motivation and therefore better quality of learning? This breaks down into two parts:

- 1) Did grades on performance assessments improve when the format in which students demonstrated their learning was changed to the creation of a board game?
- 2) Did engagement time with the assignment improve when the format in which students demonstrated their learning was given more to student choice?

CONCEPTUAL FRAMEWORK

Open-ended problem solving has the potential to engage even the most stubborn students in the classroom. Whether it be making a public service announcement on a video, designing a car safety device, or building a rollercoaster, adding a design aspect to solve a problem allows students to get creative. For example, in a grammar school in Newark, students were challenged to hold up a stack of books with a single piece of paper (D'Antonio, 2007). Students reported that this had been their class' favorite activity. This was because the students were provided with the opportunity to apply what they had learned to a very open-ended design activity (D'Antonio, 2007). In addition, the instructors also experimented with having students design their own board games, but the most popular activity was the Single Piece of Paper Challenge because it was fun and got students creative juices flowing (D'Antonio, 2007).

Motivation and Gaming

The power of fun and play in design challenges cannot be overrated. Having fun and playing at least add to observations of higher student energy in the classroom

(D'Antonio, 2007), but they can also add to motivation to learn as well. Video games have been shown to be a powerful educational tool because the game triggers students' need to show competence and autonomy, especially in a social atmosphere (Denis, 2005). In addition, games have been shown to spike students' pleasure and desire, also known as lucid tension (Denis, 2005). Lucid tension is "the unstable whirlwind existing between pleasure and desire, chance and strategy, rules and freedom, reality and fiction. An increase in lucid tension draws students' motivation and arousal into the zone of proximal development" (Denis, 2005, p. 2).

Furthermore, games provide a relevant context for learning. Much project-based learning is based on the idea of students getting information on a "need-to-know basis". This context makes learning meaningful within a context that students find important (Wechselberger, 2009). Researchers believe that the motivational power of games comes from the power students can wield over their environment in conjunction with an element of challenge (Wechselberger, 2009). However, motivation may disappear when a game's structure or rules is a diminished part of the design. For example, Jeopardy style games or Trivial Pursuit games do not emphasize incorporation of the content into the rules of the game. Adding trivia to an existing game is called artificial gameplay or edutainment and students tend to see through artificial gameplay, which does not lead to better learning.

Designing a board game also is a spin on the common practice of collaborative learning and constructivism. Research has shown that designing a game creates more engagement than just playing one (Sandoz, 2016). This is because the process of

designing a board game brings discussion between group members as to what the rules can be, what materials are good to use, and how to win the game. This collaboration or discussion between students in designing a game brings students into conversations about the learning objectives that need no aid from a teacher, so they occur within the Zone of Proximal Development (Sandoz, 2016). The Zone of Proximal Development (ZPD) is not a geographical area but more a state of mind identified by educational theorist Lev Vygotsky. The ZPD is a state of mind in which student motivation is so great that students can work independently and collaboratively without aid from a teacher. Vygotsky's goal theory is that the ZPD is transitional to a new zone where students can work unaided by a teacher.

In designing a board game, collaboration has to delve into the realm of experimentation and trying new things together. Trial and error is key in game design (Pivec, 2003). Mistakes are to be expected but these mistakes are precisely the motivation that should drive game design further forward. Mistakes have consequences in game design but they occur in a safe atmosphere where they can be corrected and they lead to more collaboration and problem solving with group members (Pivec, 2003). Motivation can be destroyed if the teacher tells students exactly what kind of game to design. The teacher is not the mediator of knowledge any longer in constructivism, but is a partner in knowledge construction. Some guidance is needed from the teacher in terms of learning goals but the teacher should not make the rules of the board game. The level of challenge for the students should be appropriate, but it should leave room also for failure and redesign (Pivec, 2003).

Effective Design

There are many different kinds of board games. Teachers have often modified different games to suit the topics they teach. A universal modification for almost any board game to make it fit the subject content is to add questions that students need to answer before they make a move (Leon, 2017). Students may create (or design) questions to pair with any board game. However, this misses the best part of a board game as it does not effectively marry educational content with the structure of the game. Looking at this from the perspective of Bloom's taxonomy (Bloom, 1956), the questions that can be asked can only rise to level one or two in which students either remember facts or classify these facts into categories. Some questions for level one may ask students to remember facts or vocabulary. Level two questions may ask students to fill in a blank. However, providing students with the opportunity to build an original board game would fall under the top level of Bloom's taxonomy, Create. Denis and Jouvelot refer to a best design practice of "avoiding edutainment". They suggest that "The goal is to convey knowledge in interactions rather than static data" (Denis, 2005, p 2). Questions added on to an existing board game are not a very good way to spike intrinsic motivation and add no lucid tension to the experience of game design. Adding trivia questions misses the point of increasing collaborative learning and entering students into the zone of proximal development, because all it does is have students memorize or categorize facts. A better way to learn would be to modify the rules of a game so the interactions in the game represent the content that students are learning. This goes up to

the top of Bloom's taxonomy because students are forced to modify the actual board game to effectively create a whole new game, thus using the subject content to create.

Board games can be a great teaching tool because they have the ability to represent systematic knowledge in the form of a model. This is already being done in the gaming industry. In Monopoly, you learn how to buy and sell real estate. In chess, you learn how to plan a battle. The game of Risk models global military strategy. Sometimes it is best to teach something complex with multiple factors using this method. A board game naturally leads to outcomes that cannot always be anticipated ahead of time. One professor decided to model climate change in a board game. In this game, power companies competed to produce profitable clean energy and the game showed various ways policy changes can incentivize this. This board game created a model to help students think about creating climate policy and extend upon it (Castronova, 2015). Students can also think of new iterations to the game and the game can be played at various levels of complexity (Castronova, 2015).

In the realm of mathematics, board game design has proven especially fruitful. Another group of high school seniors designed a math probability game in which students must balance effects of ambitions, such as advancing up social classes (the game was humorously named "Barbie"). Ambitions have positive and negative effects, and students made the game players balance these effects by calculating complex probabilities. Their games were based on a board game (Incan Gold) in which you must decide when you have enough treasure to turn back home. The game also incorporated the Monty Hall problem, which the students studied in class. The problem asks students

to choose a prize behind one of three doors. If the students get the door wrong on their first choice, they are given another choice but they are also given the option to switch doors. The question is whether it is more advantageous to switch doors or stay with your original choice. Some students who traditionally struggled in the classroom setting were observed to thrive in this collaborative, open-ended atmosphere. They learned much better in this atmosphere than in a traditional classroom because there is really no room for simple memorization in the context of creating a board game, but rather deeper connection with the content is always required (Mayer, 2011). Mathematics can be especially difficult for students who struggle and may tend to try to memorize rather than attempting to truly understand concepts (Mayer, 2011).

In a school in the Philippines, mathematics students created six different board games to demonstrate their learning. Their work was based on the positive aspects of collaborative learning and project based learning over memorization. A game that focused on teaching probability only allowed students to move if they rolled a six or a one. Students incorporated math in two different ways. Students created cards with mathematical questions to pass check points in a race, and incorporated mathematical concepts into the actual mechanics of the game. Money management was incorporated in the game, *Mickey Mouse Math House*, because students had to manage coins, lands, and houses (Dio, 2015). Incorporating mathematical concepts into the mechanics of the game showed the greatest demonstration of learning, much more than simply creating mathematical questions which were superimposed onto games. This way of incorporating math knowledge was more beneficial because it showed the students

transferred their knowledge to a new context. In *Understanding by Design*, transfer is a key demonstration of learning (Grant & Wiggins, 2005), while creating math cards may show very little transfer since the cards can be so similar to a worksheet, just in a different physical format.

One board game designed by students demonstrated their ability to show how social class inequality develops. They did this not by superimposing social theories on a game but by incorporating economics and social theory into the mechanics of the game itself. The game was given a very clever name, “The Cards You’re Dealt”. In this game, the game players attempted to work their way to retirement which signified the end of the game. On the way, they encountered careers, cars, houses, children, etc. Game players would move the amount of spaces they rolled on a die. The die represented the element of luck or chance which is present in everyday life. However, to represent that some people are able to make their own luck because of the positive circumstances they are born into, the players were each assigned a class role at the beginning of the game. A high class role would always add three to each die roll. Some scenario cards like sickness were added to the game. A sick child forces certain lower classes to stay home from work while higher classes would have to spend some of their money but still get to work and keep their job. Other scenario cards showed legislation which could even the playing field throughout the game (Sandoz, 2016).

Ultimately, mechanics were the most important aspect of game design to evaluate learning. Wechselberger writes, “when it comes to knowledge acquisition through game based learning, educational content can effectively be overlooked” (Wechselberger, 2009,

p. 97). The key is to look at the mechanics of the game to see if students designed a game which demonstrates their learning. Simply adding math questions to a game of Sorry!, for example, demonstrates little learning and is really no different from a worksheet.

METHODOLOGY

At first I had my students begin the circuits unit as I would any school year in the past. I use a circuits instruction model known as the electron shuffle. The electron shuffle is a model where students can act out how a circuit works. Eisenkraft developed this model in his textbook *Active Physics*. In the electron shuffle the students represent the electrons and they pick up energy as they move past a battery. They get to the battery by moving around a wire. The wire is a piece of black tape on the floor. The energy at the battery is some five-year-old pretzels I keep in my cabinet just for this interactive experience. If the battery is 3 Volts, then students pick up 3 pretzels (joules) when they pass the battery. If the battery is 4 Volts then they pick up 4 joules when they pass the battery. Once they get to the light bulb they must drop off all of their energy at the bulb to return to the battery empty handed and receive more pretzels.

In order to ensure student success in interweaving the concepts of voltage and current in their board games, they first played a model circuit board game which I created. My model board game was inspired by the electron shuffle model of circuits instruction. My collaborative teacher, who has years of experience teaching special education, suggested the model to ensure students could create a good product. Students played the game I created and determined how I represented voltage, current, and bulb

brightness in similar ways that the electron shuffle represented voltage, current, and bulb brightness. Then, the creation of their own board game became a transfer task, in which students transferred knowledge from one context to another. Students determined how I represented voltage and current in my model board game first using the objects that existed in my game. For example, I used cups to represent electrons and little cut out letter J's to represent joules of energy instead of people representing electrons and pretzels representing energy as in the electron shuffle which we did in class. I required students to choose different objects to represent electrons and energy so that they ended up with a different definition of voltage based on the objects they chose, instead of definitions based on my choice of objects.

Students began to design their own board game after they played my model game. I gave the students the option to use my game as a model but part of their transfer task was to switch which objects represented electrons, energy, bulbs, batteries, etc.. Not all students used the model but my collaborative teacher observed that providing models have allowed his students to work independently and have better discussions with each other during collaborative learning. Students then proposed their own board games to me using a STUDENT QUESTIONNAIRE. The role of the questionnaire was to make sure students incorporated a battery and a light bulb as well as the main concepts of voltage, current, and bulb brightness into the rules of their game (Appendix E). My collaborative teacher and I filtered through the classroom while students filled out the questionnaire, and frequently conferenced with students to guide them to create a project proposal which incorporated current and voltage into an actual game. It was not sufficient for these

concepts to be ancillary to the game. They had to be wired into the rules of the game. Students worked in groups of two or three and created the actual board game. I provided dice, paper, and poster board to the students along with markers and colored pencils for decoration. Students brought other supplies from home. Once the board game was created, students played each others' games and then reported on a BOARD GAME REFLECTION SHEET (Appendix F) as to how their peers represented voltage, current, the light bulb, the battery and brightness.

I graded the board game on the same rubric as the previous version of the "How a Circuit Works Project," an activity performed last school year, in which students created a video. The GRADING RUBRIC addressed where electrons pick up energy, where they drop it off, what voltage is, and what current is (Appendix A). In this way, I had an objective measurement of learning from last year's video project to this year's board game project. I compared last year's student grades on video projects to this year's student grades on a BOARD GAME REFLECTION SHEET (Appendix F). I graded their answers on the reflection sheet according to the same GRADING RUBRIC (Appendix A) as the student videos from last year. The BOARD GAME REFLECTION SHEET (Appendix F) provided me great information on the student learning from the board game project because they had to complete a transfer task on each component from the GRADING RUBRIC (Appendix A). I performed a normalized gain calculation to compare sets of grades from the video project to sets of grades from the board game project to determine the extent of the effect of the board game project on achievement.

In addition, I measured the effect of the board game on student motivation in many ways. First, I measured students' motivation to complete a board game project with the PRE TREATMENT SURVEY to determine their perception of how a board game would affect their motivation to learn versus other types of projects they have completed (Appendix B). I asked the same Likert style questions on the survey both before and after treatment. After the treatment students were asked to retake the survey in the form of a POST TREATMENT SURVEY to measure how their motivation and engagement were affected by the creation of a board game (Appendix C). Students in all four classes took the survey. The surveys asked students to agree or disagree with statements on a five-point scale where *one* represents *Strongly Disagree*, *two: Disagree*, *three: Neutral*, *four: Agree*, and *five: Strongly Agree*. The surveys asked students about the process of creating a board game project, and if this improved student motivation to produce a better quality project than previous video based formats such as movies or commercials. The surveys then asked if the board game format helped them learn the concepts of voltage and current. Finally, it asked students if the project affected the amount of time they were engaged in the project as compared to a video or another format. I analyzed the Likert scale using a bar graph which looks for swings in percentages between levels of agreement or disagreement from before to after the board game project was performed.

Finally, I interviewed students to gain some qualitative knowledge on their motivation and time spent engaged with the board game assignment. I selected Students randomly from all four classes. I asked them interview questions after the treatment was

complete. INTERVIEW QUESTIONS addressed student motivation to produce a quality project (Appendix D). I took notes on student interviews to be read later for common themes.

Finally, I recorded observations as an additional qualitative measurement to compare with the responses gathered through the student interviews. I kept notes on student attitudes and motivation while they played their board games as a final celebration of their achievement.

Table 1
Data Triangulation Matrix

Main research question: Does creation of a board game to demonstrate learning increase student motivation and achievement?	Student Likert scale questionnaire on the motivation to produce a good product.	Compare students own opinions of the motivation in their work through interviews with the teacher.	
1) Will grades on performance assessments improve if the format in which students demonstrate their learning is changed to the creation of a board game?	Compare grades from two different school years, one with student choice and the other without, using the same rubrics.	Compare students own opinions of the quality of their work through interviews with the teacher.	Compare grades from previous activity (different topic) for the same students.
2) Will engagement time with the assignment improve if the format in which students demonstrate their learning is given more to student choice?	Student Likert scale questionnaire on the amount of time they spent on the assignment.	Teacher observation journal of students' engagement with the assignments.	Student interviews

DATA AND ANALYSIS

The GRADING RUBRIC (Appendix A) Comparing Student Grades in 2017 vs Student Grades in 2018 showed significant results in terms of students' understanding of the role of the light bulb and battery, and the definitions of current and voltage. After board games were constructed, students analyzed each others games and filled out the BOARD GAME REFLECTION SHEET (Appendix F) to asses their learning. The average grades from student grades in 2017 was a 75.39% ($N=38$); the average increased to 90.96% ($N=68$) in 2018, whereas the median increased from a 75% to a 95%. To better interpret this change in scores I performed a normalized gain calculation. The formula produced a .63 normalized gain which is medium to large. The improvement in achievement from grades was reflected in the motivation described and measured in interviews and survey responses as well. Below in Figure 1, a box and whisker plot is shown comparing grades in 2017 vs 2018. This plot shows that each quartile of students moved upwards in their achievement from the board game project. The highest achievers in the upper quartile were still somewhat affected as the Q1 85 moved up to match the maximum score of 100.

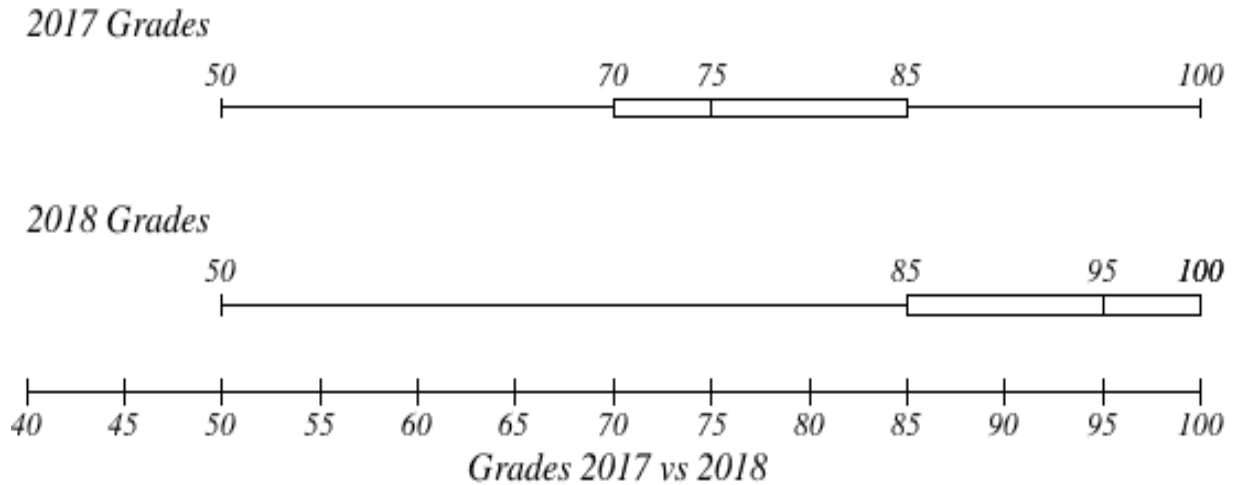


Figure 1: Score distributions of the GRADING RUBRIC from 2017 video assignment ($N= 33$) versus the 2018 board game assignment ($N=68$).

In addition to comparing my 2018 board game project grades to the 2017 grades, I also compared them to grades from a video project from the 2018 school year. This way I was able to compare a video project to the board game project for the identical group of students. The results of this comparison are below in Figure 2.

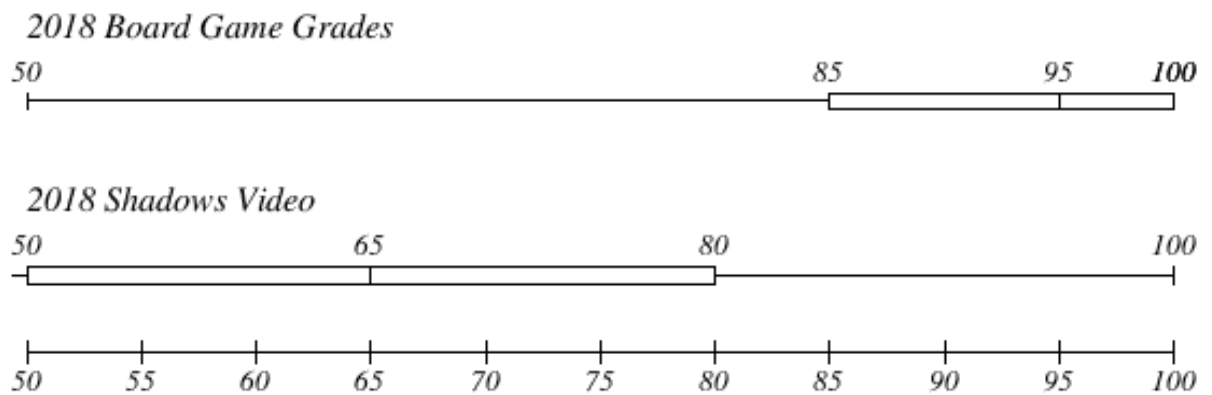


Figure 2: Score distributions of the grades from 2018 shadows video assignment ($N= 68$) versus the 2018 board game assignment ($N=68$).

The median score for students, shown in in Figure 2, improved from a 65 on the Shadows video assignment to a 95 on the Board Game Assignment, while the upper quartile went from an 80 to 100.

The Pre- and Post Treatment Likert Survey assessed students' motivation, perception of their own learning, and time engaged with the project. The results for Question One are shown graphically below in Figure 3. Question One asked students to agree or disagree with the following statement on a scale of one to five: "Demonstrating my learning in a board game rather than a video or another format will increase my motivation to produce a quality project." The results show that percentages before and after the project stayed relatively the same except there was a noticeable 20% shift from agree, four, to strongly agree, five. This change in student motivation was correlated with the highest quartile of grades moving from an 85-100 to all 100's. This also showed students changed their lack of certainty about the statements before doing the project, whereas now with experience designing the board game they had stronger opinions. Finally, there is also a 5% increase in ones. This amounts to about two or three more students believing the board game format did not motivate them to produce a quality project.

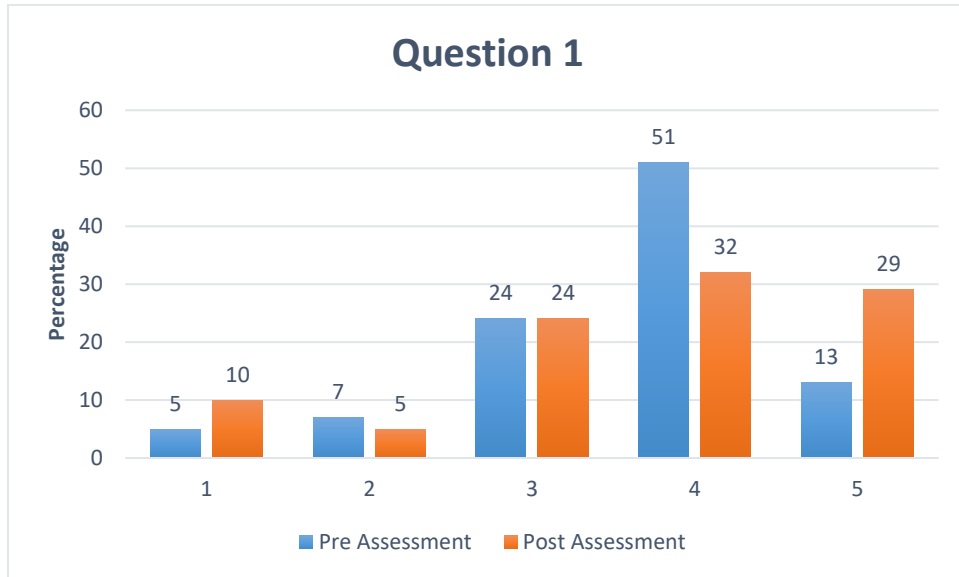


Figure 3: Question one pre- and post- treatment comparison, (N=68).

Students assessed their own learning in Question Two which seemed to show generally no change. Figure 4 below displays the results of Question Two. There seemed to be little to no change in the fours and fives. Before and after the project 64% of students at least agreed that their learning was better with a board game project than a video game format. There was also a 5% move from neutral responses to ones and twos. So again, two or three students became more sure that the board game project did not improve their learning as compared to a video project.

In Question Three students estimated the percentage of time they spent engaged on the board game project versus other video projects as shown in Figure 4 below. There was a noticeable 20% increase from neutrality, three, to strong agreement, five, that students spent more time engaged designing a board game than on a video. This is a key question that is also addressed in the interviews as well. Students were asked to focus on

the percent of time in class they spent engaged as opposed to the total time that the class spent on the project. It makes sense that students have a better idea of how much time they have spent on the assignment after it was complete.

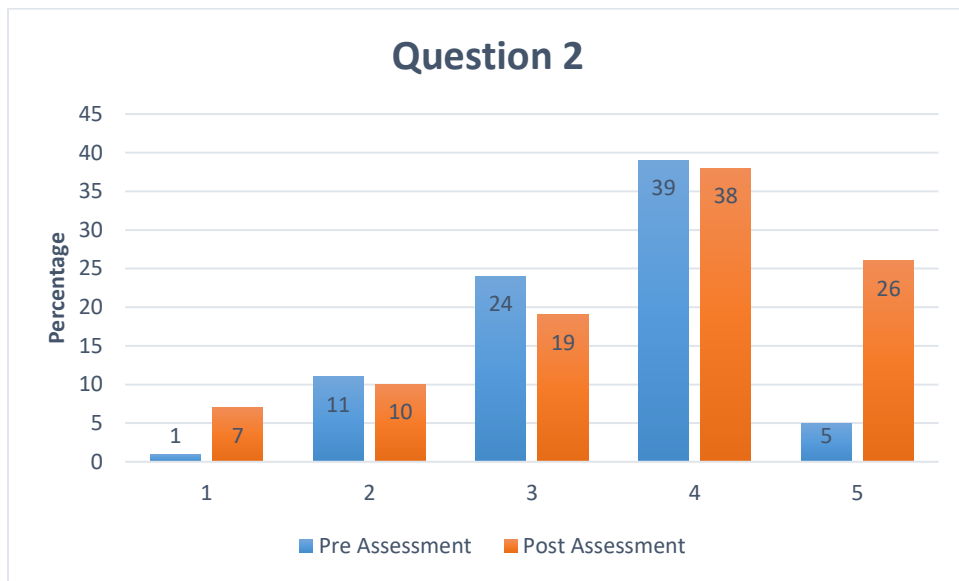


Figure 4: Question two pre- and post- treatment comparison, (N=68).

The results of Question Three are shown in Figure 5 below. Student reported their grades increased as they were better able to determine what happened in a circuit at the bulb and battery, and how current and voltage applied to these situations better in a board game than in a video.

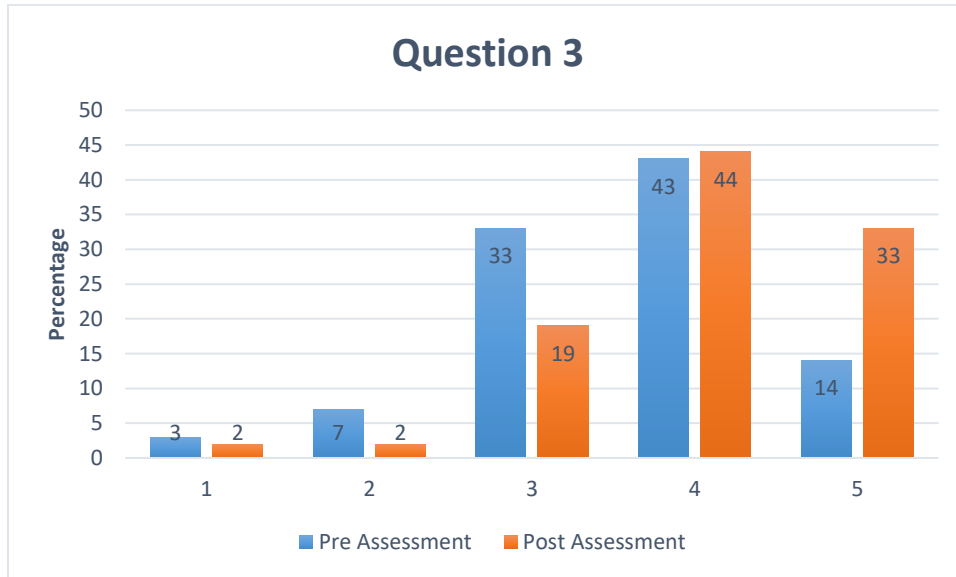


Figure 5: Question three pre- and post- yreatment comparison, (N=68).

One student (student one) supported the finding that the board game impacted student motivation by commenting, “The board game was something different, it was something to look forward to” (APPENDIX G). Another student (student two) commented, “There is more creative space than the other projects. Video had a set criterion. This had more legroom with what you can create, bend the rules of the project, and be more motivated to participate due to the creativity” (APPENDIX G).

A third student (student three) commented, “Personally the board game you can be more creative, creating the steps to the game designing the rules was fun” (APPENDIX G) I find this statement that “designing the rules was fun” is key to determining why students learned better through the board game project than through a video project. Designing the rules was motivating and also was the key to learning about voltage and current in a circuit. Furthermore, student two said something similar,

commenting, “you can bend the rules of the project”. This is exactly the exercise that causes the learning... bending the rules to edit the definitions of a bulb, a battery, current, and voltage into a new format.

Through my collaborative teacher and my observations and informal conversations with students we also found a focus on the connection between the rules of the game and the definitions of current and voltage. From the interviews, it became apparent that these conversations were exciting and engaging for the students, which further motivated them to achieve higher.

INTERPRETATION AND CONCLUSION

The objective of this action research was to determine if creation of a board game could improve student motivation. Students were interviewed at random, answered Likert scale questions, and were observed by teachers to to explain if their motivation had improved. Furthermore, my project sought to determine if student learning was improved through the use of a board game design project. In order to measure learning, students played each other’s board games and determined how classmates represented voltage, current, the battery, light bulb, and brightness in their original board game. Before they played another group’s board game, they had already determined how they would represent voltage, current, the battery, light bulb, and brightness in their own original board game, and they had determined how I had represented these terms in my own model board game.

When I measured student motivation, my Likert scales showed some clear conclusions. Students began by rating how they thought the board game project would

change their motivation in a PRE TREATMENT SURVEY. Then students retook the same survey after they had completed the project. I think this approach was instrumental in showing how students expected to be impacted by the project versus the actual impact. A significant portion of students were surprised that the project affected their motivation and time engaged on the project more than they even expected. Students were excited to do the project initially but after the project was completed students experienced higher motivation and engagement time than they had even initially suspected.

Students had a noticeable shift in Question One of the Likert scale. Specifically, there was a 20% shift of students from Four-Agree to Five-Strongly Agree with the statement, “Demonstrating my learning in a board game rather than a video or another format will increase my motivation to produce a quality project.” Students seemed to be more excited about this project than previous video based projects as seen from teacher observations. Students cited that they looked forward to coming to class in order to do the project and found the room for creativity was instrumental in their excitement about the project. Students found they could create the rules in this project and the context in which physics is learned. For example, they were able to make up their own definitions of voltage such as apples per basket instead of joules per coulomb. This creativity and sense of control increased student motivation a noticeable amount.

My goal for the project was not just to increase motivation for students but that this motivation would translate into improved student learning. I measured learning with the same rubric in this 2018 board game project that was used in the 2017 video based projects. I graded each set of projects according to the students’ ability to explain the

role of the battery, light bulb, voltage, and current in a circuit, and how these affect the brightness of light bulbs. Grades significantly improved from 2017's video based project to 2018's board game based project as seen in Figure 1 above and the normalized gain calculation. Grades went up in conjunction with the students' answers to Question Three of the Likert scale. Students were more confident because they spent a greater percentage of class time engaged on a board game project as compared to video based projects. The increased time spent on discussion of concepts such as voltage and current became apparent while I graded their BOARD GAME REFLECTION SHEET (Appendix F). Students were able to clearly identify the role of the light bulb and battery, and the definitions of current and voltage in their classmates' board games which they were seeing for the first time. The 2018 students who made the board game quickly picked up on new definitions of current and voltage in a completely original format. The normalized gain calculations, which are included in the data section, bear out that the board game project caused a larger percentage of time spent discussing physics principles, creating a higher level of achievement. It was truly impressive how well my 2018 students were able to pick up a new board game and determine how their classmates represented voltage and current. This adept skill is due to the 20% shift from one- strongly disagree, two-disagree, and three-neutral to five- strongly agree in Question Three of the Likert scale survey. This means a significant portion of students were surprised that now they strongly agreed with the statement, "Demonstrating my learning in a board game rather than a video or another format increased the amount of time I was

engaged in the project.” The increased motivation lead to increased time spent discussing physics, which lead to higher achievement of learning goals.

This increased motivation is comparable to the findings of Wechselberger who found that students exerting power over their environment leads to higher motivation and more work done in the Zone of Proximal Development (2009). It also echoes the work of Denis who found that it is essential that student must create the board game’s structure and rules to reflect their learning and not simply tag on trivia to an existing board game. Denis also found students have a need to show competence and autonomy, especially in a social atmosphere. This has truly impacted my teaching by giving me confidence that there are many good reasons to engage in creative project based learning such as designing a board game. A special education student is not always easy to engage, but giving them an opportunity to show their skills in a context they enjoy is something I want to use more to my advantage in the classroom.

VALUE

This study determined if play and design challenges were a motivating factor for students. More specifically, this study did not not explore artificial gameplay, in which the structure of the game had nothing to do with the content to be learned, but instead focused on authentically incorporating physics concepts into a board game. This study sought to verify if embedding learning objectives in the rules and structure of a board game helped motivate students and achieve the learning objectives.

This project has certainly affected the way I will teach in the future. But first, it has also reminded me that I have used the theories of constructionism and collaborative

learning successfully in the past as well. For example, at the end of each school year, we work on the concepts of conservation of energy with our students, concluding with a class trip to Great Adventure, a local amusement park, to analyze their roller coasters. Before we go to Great Adventure, we have students use energy to analyze how a roller coaster works. I have discovered that it is not be enough to simply hand out a quiz or have students hand in a lab report on how a roller coaster works. I need them to dig deeper to connect the content they are learning into a new creation of their own so they can make the rules by which they learn. I have had students create their own paper roller coasters and determine the change in energy as a marble rolls through their ride. Then groups of students designed and sold their own roller coaster to Great Adventure while using physics to back up their claims. This collaborative effort involved students discussing physics in groups in order to write a script and record a video pitch for Great Adventure. The project also uses the theory of constructionism in which students construct their own knowledge and the role of the teacher is to be a facilitator and work alongside the students. They construct their own knowledge while they write a script for their video in groups. The teacher encourages students to consider the theory of conservation of energy as evidence for all of their claims while they write the script.

The results of the board game project were encouraging as they reminded me of the roller coaster project and all of the the positive uses of collaborative learning and constructionism that I have employed effectively. The board game project also reminded me that my students can create more products to increase the lucid tension present in their collaborative learning. Lucid tension is defined as the “the unstable whirlwind existing

between pleasure and desire, chance and strategy, rules and freedom, reality and fiction. An increase in lucid tension draws students' motivation and arousal into the zone of proximal development" (Denis, 2005, p. 2). Collaborative learning activities are strengthened when students enter the Zone of Proximal Development because this motivates them to work independently from the teacher while having the support of their peers. I do not want to stop short at having students memorize facts but instead want to create an intimate understanding of physics. When students are able to create a product of their own their imagination they are drawn into the learning process and develop an inward desire to learn. It has always been challenging for me to have my special education students engage themselves willingly in the learning process, but a board game is a tangible product and it gives the students a feeling of ownership and control which I have observed to be lacking in their work on a video, quiz, or lab report.

Sometimes when my collaborative teacher and I sigh about a failed assignment, he would say to me, "They just don't care." The students I teach are not always concerned much with grades and while this can be a positive, it can also make teaching them challenging. This project was truly amazing because giving students this sense of autonomy and ownership over a creation of their own caused them to be motivated. I believe there are benefits to having students who have college aspirations take quizzes and tests, and write lab reports. I am not going to be eliminating these assignments from my class. I will continue to teach students how to study, because a student going to college needs this skill. However, I need to continue to develop my video assignments to spike excitement by giving students autonomy over their own learning environment. I

need to capitalize on the reasons why this project succeeded to continue to truly engage my students' creativity in all of my project based assignments.

Next school year, I want my students to evaluate all of my projects. First I will explain to the students my research from this past school year, showing that excitement, lucid tension, and student created learning contexts plays a large role in creating good projects. Next school year, I will post each project and ask the students to evaluate it according to excitement, lucid tension, and opportunity for student autonomy. Then I will ask them for suggestions on how to improve the project before it even begins. I will use their suggestions to modify the project before I officially introduce the assignment to the class.

Furthermore, I want students to evaluate each project using my Likert scale surveys developed in this board game project. I can re-appropriate those surveys onto other projects so students can evaluate these projects for motivation and engagement time. I also can conduct post project interviews to determine if each project spikes student autonomy, motivation, and lucid tension. Moving forward, I can assess and alter my lessons to fit my students and provide them with genuine and rich opportunities to learn.

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APPENDICES

APPENDIX A
GRADING RUBRIC

- 1) Show the the electron shuffle we did in class as a large group. including demonstrating... (8 pts)**
 - a. where the electrons pick up energy, and (4 pts)
 - b. where they drop it off. (4 pts)
- 2) Demonstrate the following using the electron shuffle: (6 pts)**
 - a. different voltages. (1 Volt, 2 Volt, etc.) (3 pts)
 - b. different currents. (1 Amp, 2 Apms, etc.) (3 pts)
- 3) Explain how every point in number 2 affect bulb brightness and why. (6 pts)**

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

APPENDIX B

PRE TREATMENT SURVEY

Name _____ Date _____
Period _____

Directions: Complete the likert scale questionnaire below. You may choose any number from 1-5.

- 1: Strongly Disagree
- 2: Disagree
- 3: Neutral
- 4: Agree
- 5: Strongly Agree

- 1) Demonstrating my learning in a board game rather than a video or another format will increase **my motivation** to produce a quality project.

1 2 3 4 5

- 2) Creating a board game can cause me to learn the concepts of Voltage and Current better rather than explaining them in a video.

1 2 3 4 5

- 3) Demonstrating my learning in a board game rather than a video or another format will increase **the amount of time I was engaged** in a project.

1 2 3 4 5

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

APPENDIX C
POST TREATMENT SURVEY

Name _____ Date _____
 Period _____

Directions: Complete the likert scale questionnaire below. You may choose any number from 1-5.

- 1: Strongly Disagree
- 2: Disagree
- 3: Neutral
- 4: Agree
- 5: Strongly Agree

- 1) Demonstrating my learning in a board game rather than a video or another format increased **my motivation** to produce a quality project.

1 2 3 4 5

- 2) Creating a board game caused me to learn the concepts of Voltage and Current better rather than explaining them in a video.

1 2 3 4 5

- 3) Demonstrating my learning in a board game rather than a video or another format increased **the amount of time I was engaged** in the project.

1 2 3 4 5

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

APPENDIX D
INTERVIEW QUESTIONS

Asked after the treatment.

- 1) This year we have done many types of projects. We have created commercials, scary movies, and played songs on xylophones. How does creating a board game compare in terms of motivation to the other videos we have produced?
- 2) Which project this year have you spent the most time engaged with the assignment? The xylophone? The board game? The mirror commercial or the scary shadows movie. Explain your answer.

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APPENDIX E
STUDENT QUESTIONNAIRE

Design your Board Game Sheet

**this must be approved by a teacher before you begin to build your board game.*

Group members' names:

1)

2)

- 1) What represents the electron in your board game? The teacher used cups to hold energy in it. Choose a different object.
- 2) What represents the joule of energy in your board game? The teacher used little letter j's to represent joules of energy. Choose a different object.
- 3) What represents the battery in your board game? The teacher used a battery cup.
- 4) What represents the light bulb in your board game? The teacher used a light bulb cup.
- 5) What will you use for **current** during your board game? The teacher used a dice roll each turn to move the electron around the board.
- 6) What is your definition of **voltage** in your board game based on the objects you chose for the electron and the joule of energy.
- 7) What is your definition of **current** in your board game based on the objects you chose?
- 8) Look at the the rule in The teacher's board game. Edit these rules to make your own board game rules which you will list below.

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

APPENDIX F

BOARD GAME REFLECTION SHEET

Name _____ Date _____
Period _____

Board Game Reflection Sheet (20 pts)

- 1) My group members are... (2 pts)
- 2) I played the game made by... (2 pts)
- 3) **BATTERY:** what object represented their battery? What did the game piece do when it got to this position? (3 pts)
- 4) **LIGHT BULB:** what object represented their light bulb? What did the game piece do when it got to this position? (3 pts)
- 5) **VOLTAGE:** In Kibala's game the voltage was measured by the amount of J's carried by each cup. How do you measure the voltage in the game you played today? (5 pts)
- 6) **CURRENT:** In Kibala's game the current was measured by the amount spaces the electrons move each turn, given by a dice roll. How do you determine the current in the game you played today? (5 pts)

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

APPENDIX G
INTERVIEW RESPONSES

Interview Responses:

Student 1:

- 1) Not as engaging as imovie. Less effort from some of his partners.
- 2) Spent entire block working on it. But this is because the work was lopsided.

Student 2:

- 1) More fun doing it than the other projects. Actually caused me to do more for the project.
- 2) More time engaged. Whole time.

Student 3:

- 1) More into it having fun playing the game. Motivating to be involved in the project
- 2) Same percentage of time engaged.

Student 4:

- 1) The board game was something different, it was something to look forward too.
- 2) Finished faster because they brought pieces from other board games. Enjoyed playing everyone's game. This affected the time they spent engaged with the project.

Student 5:

- 1) Liked it personally, not great with technology, way to participate where you can build it and liked typing what represents what. Not all online.
- 2) Equal amount of time engaged with it, got a lot of time to do it.

Student 6:

- 1) You get to choose the materials so you mind is opened up so a higher motivation. The example board game gave me a baseline and was motivating.
- 2) Board game!

Student 7:

- 1) Personally the board game you can be more creative, creating the steps to the game designing the rules was fun.
- 2) Shadow was a longer project so I spent more time engaged with it. Board game was awesome so they got off to it real early and finished a bit early.

Student 8:

- 1) There is more creative space than the other projects. Video had a set criterion. This had more legroom with what you can create, bend the rules of the project, and be more motivated to participate due to the creativity.
- Spent more time on videos, board game just had to draw, finished a little early