Using Lego BricQ Motion to Teach Science Concepts in Force and Motion

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February 28, 2022

The Institutional Review Board of the University of Tennessee at Chattanooga (FWA00004149) has approved this research project #21-059.

Abstract

This program focused on exploring science and mathematics content and pedagogy for elementary and middle grades, pre-service teachers, including those students preparing to teach in regular and exceptional education classrooms. A total of 31 individuals participated in one or more workshops. The activities contained within the Lego BricQ Motion Essential kit and the Lego BricQ Motion Prime kit comprised the content of the workshops, and emphasized force and motion concepts. All activities were correlated to kindergarten through eighth-grade Tennessee academic standards for science, mathematics, and English language arts. The program timeline included three spring 2021 Saturday sessions and two spring 2022 Saturday sessions.

Participants indicated the need for classroom-based activities to be taught through active methods and to be related to real-world concepts.

The program was funded through the Tennessee Space Grant Consortium.

Introduction

As a method to reinforce science pedagogy and skills, Lego BricQ Motion kits were selected for use with pre-service elementary, middle grades, and exceptional education teachers. The Essential and Prime kits emphasize concepts and procedures related to force and motion, and use gears, levers, and pulleys. They do not contain any robotic-driven mechanisms. Participants responded to a two-item survey to determine what concepts and procedures were learned through the activities and what the perceived use of the activities would be in an educational setting.

Review of Literature

Teaching and Learning Force and Motion Concepts

Studies have shown that concepts related to Newton's laws of motion can, and should, be taught in different ways than those that were utilized for previous generations. For example, Chang et al. (2014) found that the modern applications of these laws have evolved from what were previously defined as classic examples. They reasoned that modern teachers should use these updated understandings when teaching students.

One way to ensure that these concepts are communicated effectively to students is to incorporate them into special activities in which the students participate. One group of teachers designed a variety of activities to teach Newton's laws of motion that were based upon using tennis balls in various ways. Following these activities, participants recorded their observations, considering the movement of the tennis balls and attempting to apply this knowledge on a broader scale (Stevens-Smith & Fones, 2002). In another project, students launched bottle rockets to investigate how velocity and energy propelled them through the air (Hughes et al., 2017).

Varying methods will change the delivery of these concepts within the classroom. One study expanded lessons on Newton's laws of motion to a multi-step process involving a quiz to gauge initial understanding, open classroom discussion, and working through theoretical scenarios, among other methods. Using these methods to communicate concepts resulted in significant improvements in student understanding of Newton's laws of motion (Antwi, 2015).

Developing creative and useful ways to teach these concepts to students is important because this has been identified as a problem area for future teachers. In one study, future science teachers were given a test concerning, both, the laws of motion and practical applications of the laws of motion. Results showed that knowledge concerning the laws of motion was a significant area of weakness for these teachers when compared to other areas of content knowledge (Saglam-Arslan & Devecioglu, 2010).

Methods for Teaching Science to Generation Z Learners

One way in which Generation Z (Gen Z) learners are different from those in previous generations is that they can benefit from, and appreciate, educational content that is delivered in alternative ways. They enjoy content that is delivered in a variety of formats, e.g., through group projects or viewing educational videos (Shorey et al., 2021). There has, also, been a change in the way that learning can be structured, such as allowing the students to learn independently and using the classroom as a place to experiment and apply knowledge (Chicioreanu & Amza, 2018). The learning styles of Gen Z students have, also, evolved over time. While many students are still more visual learners, Gen Z students, generally, prefer to get hands-on experience with information that they can use in practical ways (Azman et al., 2021; Shatto & Erwin, 2016).

Gen Z students, generally, prefer hands-on learning to more traditional learning. Studies have shown that these students prefer to have an element of active participation as opposed to

absorbing information passively (Shorey et al., 2021). This “learn by doing” approach to education can be valuable in providing these students with more practical knowledge that they will use beyond the school environment (Chicioreanu & Amza, 2018; Shatto & Erwin, 2018). These students are idealistic and would prefer to learn skills that they can use to improve the world around them, instead of learning skills for the purpose of earning money in the future (Carter, 2018).

Gen Z students see value in learning real-world skills. As previously mentioned, Gen Z students want to use the skills they learn in a way that makes the world a better place, rather than, solely, for finding a job that gives them enough money on which to live (Carter, 2018). These students have a desire to find purpose in the things they are learning, which means that utilizing real-world examples in lessons designed for them may improve engagement. It may, also, be useful to incorporate educational videos into the curriculum for these students. These videos can teach specific concepts to students. More importantly, teaching the students how to find educational information, through platforms such as YouTube, could help them seek new knowledge to augment what is a part of their education (Shatto & Erwin, 2016).

Methods

The Lego BricQ Motion kits (Lego Education, 2021), both Essential and Prime, were selected for workshop use with pre-service teachers to explore concepts related to teaching science and mathematics, and, specifically, concepts related to force and motion. Lego BricQ Motion Essential contains two curriculum units (“Train to Win,” for grades K-2; and “Winning with Science,” for grades 3-5) and Lego BricQ Motion Prime contains one curriculum unit (“Science of Sports,” for grades 6-8). In online documentation, Lego Education presents a correlation for unit activities with Next Generation Science standards, Common Core standards

for mathematics and English language arts, and International Society for Technology in Education standards. For this program, unit activities were further correlated to Tennessee academic standards (see the Appendix).

Pre-service teachers were recruited for participation through courses in which they were enrolled. A few recent graduates were recruited, as well. A total of 31 individuals participated in one or more workshop sessions across three workshops held during spring semester 2021 and two workshops held during spring semester 2022. Although an individual was able to attend one or more workshops, no individual had repeated attendance for a specific unit (i.e., participants from 2021 did not attend an identical session in 2022). Each workshop was scheduled for 6 contact hours. Each participant received a kit and a stipend. Figure 1 presents the number of individuals who participated in each workshop and the number of individuals who provided data for each workshop. A few participants were unable to attend through the data collection process. Through a written survey, participants were asked to respond to the following two items:

1. List two things that were learned through the activities.
2. How will you use one or more of the activities in an educational setting?

Figure 1
Number of Participants for Each BricQ Motion Workshop

Unit	BricQ Motion Essential, "Train to Win" (7 lessons)		BricQ Motion Essential, "Winning with Science" (7 lessons)		BricQ Motion Prime, "Science of Sports" (7 lessons)
Date	Spring 2021	Spring 2022	Spring 2021	Spring 2022	Spring 2021
Participants	17	4	12	9	9
Surveyed	17	4	9	8	4
n for Unit	21		17		4

Results

Concepts Learned through the Activities

Grades K-2

One of the workshops (offered twice) was designed for future teachers who would teach at the early elementary school level, specifically from kindergarten through grade 2. Following the completion of the workshop, participants were asked to list two concepts that they learned while completing the activities through the workshop. Trends were identified by finding commonalities in the responses. The most common takeaway from the workshop was that teachers have the ability to implement alternative activities in the classroom, with 8 of the 21 respondents identifying this as one of the lessons they learned. There were other concepts and methods identified by the participants as being major takeaways from the workshop, including that Lego kits can be used to teach the concepts of push and pull, and that Lego kits can be used to teach lessons in multiple subjects, with each of these being identified as major takeaways in 7 of the 21 responses. Other common takeaways included that these lessons can be adapted for multiple grade levels (6 of the 21 responses), and that these lessons can be used to teach about forces beyond just push and pull (5 of the 21 responses). One respondent specifically indicated that they learned "ways for students to explore push and pull in hands-on ways," while another reported that they "learned how to use manipulatives to display force and motion."

Grades 3-5

One of the workshops (offered twice) was designed for future teachers who would be teaching at the upper elementary school level, specifically within grades 3 through 5. Following the completion of this workshop, participants were asked to list two concepts that they learned while completing the activities through the workshop. By finding commonalities in these

responses, trends were identified in what the participants viewed as the most valuable takeaways from the workshop. The most common takeaway reported by the participants was that Lego kits can be used to teach important scientific concepts, with 7 of the 17 respondents mentioning this as one of their major takeaways. Other takeaways dealt with what would be useful in teaching concepts related to motion, with 4 of the 17 respondents mentioning this as one of their major takeaways. Multiple respondents indicated that this workshop provided valuable information about weight, gravity, and the way wheels function, with 4 of the 17, 2 of the 17, and 2 of the 17 respondents identifying these as major takeaways, respectively. One respondent specifically mentioned that they learned "how to incorporate Legos into activities about motion," while another indicated that they "learned ways to use Legos to demonstrate physical science."

Grades 6-8

One workshop was designed for future teachers who would be teaching at the middle school level, specifically from grades 6 through 8. Following the completion of the workshop, participants were asked to list two concepts that they learned while completing the activities through the workshop. There was only one commonality identified among the different responses, with two of the four respondents indicating that learning about how propellers function was one of their major takeaways from the workshop. One respondent specifically indicated that they learned "that objects can actually move toward the wind if they are powered to do so with propellers." Another participant indicated that they learned "about motion and the awesomeness of Legos."

How Activities Will be Used in an Educational Setting

Grades K-2

Participants in this workshop were asked how they might use the activities in an educational setting. The most common classroom use for these activities, identified by the participants, was to teach the concepts of push and pull, with 5 of the 21 participants reporting that they intended to use these activities in this way. Additionally, 7 of the 21 participants mentioned a specific Lego activity that they intended to use in their classroom. One respondent specifically indicated that they planned to "use the hockey activity in a lesson using 5E [model – engage, explore, explain, elaborate, evaluate] to teach and explore push/pull forces," while another intended to "use the tightrope activity to show students how to balance things."

Grades 3-5

Participants in this workshop were asked how they might use these activities in an educational setting. One of the most common classroom uses for these activities, identified by the participants, was to allow students the opportunity to build structures out of the Legos, with 5 of the 17 respondents indicating that they would use the activities in this way. Another identified use for these activities was to teach students about weight, with 4 of the 17 respondents indicating that they would use the activities in this way. Other intended uses for these activities included teaching about force and motion and teaching about gravity, with 3 of the 17 and 2 of the 17 respondents indicating that they would use the activities in these ways, respectively. One participant indicated that they planned to "use the bobsled lesson to show how weight can alter speed," while another reported that that they would "use the weightlifter activity in class to demonstrate pulleys and gear ratios."

Grades 6-8

Participants in this workshop were asked how they might use these activities in an educational setting. There was only one commonality identified among the responses, with two of the four respondents indicating that these activities would be useful for teaching Newton's laws of motion. One respondent indicated that that they could use the gymnast activity "to teach pendulum [concept]s and Newton's laws of motion."

Discussion

The results are aligned with information concerning the teaching of Newton's laws of motion. One important commonality that was noted is that teachers should be using updated methods to teach Newton's laws in ways that are different from how the concepts were previously taught. Participants in all three sets of workshops indicated that these Lego activities would be useful in teaching the laws of motion, and that they intended to use these methods in their future careers.

It was also discussed that designing activities that applied Newton's laws of motion can be a useful way to help students engage with this content. The lessons in all three sets of workshops contained similar activities in which students would use Legos to build and modify a mechanism that would illustrate some aspect of Newton's laws of motion.

Future teachers have been shown to have a deficit in knowledge concerning Newton's laws of motion. This workshop series was useful, not only in providing participants with new ways to teach these concepts, but, also, in providing the future teachers, themselves, with knowledge on these topics.

The results from the workshops are, also, aligned with some of the characteristics of Gen Z learners, as identified through the literature review. One characteristic that was identified was

that Gen Z learners appreciate the opportunity to be provided with educational content in alternative ways. The most common takeaway from both the kindergarten-grade 2 and grades 3-5 workshops was that alternative activities, such as the ones utilizing Lego BricQ Motion kits, can be effective ways to create educational lessons in an alternative and engaging way.

Another characteristic of Gen Z learners that was identified was that they prefer to actively participate in hands-on learning. The participants in the kindergarten-grade 2 workshops noted that these activities could be a way for the students to be creative through hands-on activities, while the participants in the grades 3-5 and grades 6-8 workshops indicated that they intended to use these activities to allow students the opportunity to build something by themselves.

A third characteristic that was identified was that Gen Z learners prefer to learn about concepts they can apply to the real world. Eight participants in the kindergarten-grade 2 workshops indicated that they would use some of the specific Lego activities that were included in the workshop, each of which takes scientific concepts, such as weight or force, and applies the concepts to real-world situations, like playing a sport or driving a car. The most common takeaway reported by participants in the grades 6-8 workshop was that they learned valuable information on the functioning of propellers.

The kits were selected to have long-term use in the classroom. Activities were correlated to standards, and emphasized active learning, use of relevant materials, connections between content areas, and deeper understanding of science and mathematics concepts. It is important to develop meaningful learning environments for teachers as a model to use for creating such environments in their classrooms.

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Appendix

Correlation of Activities to Tennessee Academic Standards

Standards - Lego BricQ Motion Essential

Train to Win Lessons (Kindergarten-Grade 2) (Lego Education, 2021)

1. Dog Obstacle Course
    - Science - TN 2.PS2, 2.PS3
    - Science - TN K.ETS1, 1.ETS1, 2.ETS1
    - ELA - TN K.SL.CC.2, 1.SL.CC.2, 2.SL.CC.2
    - Lesson extension – ELA - TN K.W.TTP.2, 1.W.TTP.2, 2.W.TTP.2
2. Get Up and Dance
    - Science - TN 2.PS2, 2.PS3
    - ELA - TN K.SL.CC.2, 1.SL.CC.2, 2.SL.CC.2
    - Lesson extension – Mathematics - TN 1.G.A.3
3. Hockey Practice
    - Science - TN 2.PS2, 2.PS3
    - ELA - TN K.SL.CC.2, 1.SL.CC.2, 2.SL.CC.2
    - Lesson extension - Mathematics - TN 1.OA.A.1
4. Push Car Derby
    - Science - TN 2.PS2, 2.PS3
    - ELA - TN K.SL.CC.2, 1.SL.CC.2, 2.SL.CC.2
    - Lesson extension - Mathematics - TN 1.MD.A.1, 1.MD.A.2
5. Tightrope Walker
    - Science - TN 2.PS2, 2.PS3
    - ELA - TN K.SL.CC.2, 1.SL.CC.2, 2.SL.CC.2
    - Lesson extension - Mathematics - TN 2.OA.A.1, 2.OA.B.2
6. Sail Car
    - Science - TN 2.PS2, 2.PS3
    - ELA - TN K.SL.CC.2, 1.SL.CC.2, 2.SL.CC.2
    - Lesson extension - Mathematics - TN MP1
7. Relay Race
    - Science - TN 2.PS2, 2.PS3
    - Science - TN K.ETS1, 1.ETS1, 2.ETS1
    - ELA - TN K.SL.CC.2, 1.SL.CC.2, 2.SL.CC.2
    - Lesson extension - Mathematics - TN MP1

Standards - Lego BricQ Motion Essential

Winning with Science Lessons (Grades 3-5) (Lego Education, 2021)

1. Track and Field
    - Science - TN 3.PS3, 5.PS2
    - Science - TN 3.ETS1, 4.ETS1, 5.ETS1
    - ELA - TN 3.SL.CC.1, 4.SL.CC.1, 5.SL.CC.1
    - Lesson extension - Mathematics - TN 3.MD.C.7b
2. Race Car
    - Science - TN 3.PS3, 5.PS2
    - Science - TN 3.ETS1, 4.ETS1, 5.ETS1
    - ELA - TN 3.SL.CC.1, 4.SL.CC.1, 5.SL.CC.1
    - Lesson extension - Mathematics - TN 3.MD.A.2
3. Free Throw
    - Science - TN 3.PS3, 5.PS2
    - ELA - TN 3.SL.CC.1, 4.SL.CC.1, 5.SL.CC.1
    - Lesson extension - Mathematics - TN 3.MD.B.4
4. Bobsled
    - Science - TN 3.PS3, 5.PS2
    - ELA - TN 3.SL.CC.1, 4.SL.CC.1, 5.SL.CC.1
    - Lesson extension - Mathematics - TN 3.MD.B.4
5. Weightlifter
    - Science - TN 4.PS3, 5.PS2
    - ELA - TN 3.SL.CC.1, 4.SL.CC.1, 5.SL.CC.1
    - Lesson extension - Mathematics - TN 3.MD.A.2
6. Gravity Car Derby
    - Science - TN 4.PS3, 5.PS2
    - ELA - TN 3.SL.CC.1, 4.SL.CC.1, 5.SL.CC.1
    - Lesson extension – ELA - TN 3.W.TTP.2, 4.W.TTP.2, 5.W.TTP2
7. Cheering Crowd
    - Science - TN 4.PS3, 5.PS2
    - ELA - TN 3.SL.CC.1, 4.SL.CC.1, 5.SL.CC.1
    - Lesson extension – ELA - TN 3.SL.PKI.4, 4.SL.PKI.4, 5.SL.PKI.4

Standards - Lego BricQ Motion Prime

Science of Sports (Grades 6-8) (Lego Education, 2021)

1. Pass the Ball
    - Science - TN 4.PS3, 5.PS2, 6.PS3, 8.PS2
    - Science - TN 4.ETS1, 5.ETS1, 6.ETS1, 8.ETS1
    - ELA - TN 6.SL.PKI.4, 7.SL.PKI.4, 8.SL.PKI.4
    - Lesson extension - Mathematics - 6.RP.A.1
2. Gymnast
    - Science - TN 4.PS3, 5.PS2, 6.PS3, 8.PS2
    - ELA - TN 6.SL.CC.1, 7.SL.CC.1, 8.SL.CC.1
    - Lesson extension - Mathematics - TN 6.SP.B.4
3. Ski Slope
    - Science - TN 4.PS3, 5.PS2, 6.PS3, 8.PS2
    - ELA - TN 6.SL.PKI.4, 7.SL.PKI.4, 8.SL.PKI.4
    - Lesson extension - Mathematics - TN 6.EE.B.7
4. Free Kick
    - Science - TN 4.PS3, 5.PS2, 6.PS3, 8.PS2
    - ELA - TN 6.SL.PKI.4, 7.SL.PKI.4, 8.SL.PKI.4
    - Lesson extension - Mathematics - TN 6.RP.A.1
5. Land Yacht
    - Science - TN 4.PS3, 5.PS2, 6.PS3, 8.PS2
    - ELA - TN 6.SL.PKI.4, 7.SL.PKI.4, 8.SL.PKI.4
    - Lesson extension - Mathematics - TN 6.G.A.1
6. Propeller Car
    - Science - TN 4.PS3, 5.PS2, 6.PS3, 8.PS2
    - ELA - TN 3.RI.KID.3, 4.RI.KID.3
    - Lesson extension - Mathematics - TN 6.RP.A.1
7. Strike the Ball
    - Science - TN 4.PS3, 5.PS2, 6.PS3, 8.PS2
    - ELA - TN 6.SL.PKI.4, 7.SL.PKI.4, 8.SL.PKI.4
    - Lesson extension - Mathematics - TN 6.SP.B.5