Journal of Pre-College Engineering Education Research (J-PEER)

Volume 9 | Issue 1 Article 1

2019

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Recommended Citation
Bowen, B., & Peterson, B. (2018). Exploring Authenticity Through an Engineering-Based Context in a Project-Based Learning Mathematics Activity. *Journal of Pre-College Engineering Education Research (J-PEER), 9*(1), Article 1.
https://doi.org/10.7771/2157-9288.1073

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Keywords

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Document Type

Article

Cover Page Footnote

We would like to acknowledge North Dakota State University students Taylor Peterson and Pake Hagen for their contribution to the research.

Available online at http://docs.lib.purdue.edu/jpeer

Journal of Pre-College Engineering Education Research 9:1 (2019) 1–10

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Abstract

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Introduction

When the No Child Left Behind Act (NCLB) was signed in 2002, it ushered in an era of high-stakes testing. While the policy was in place, the American Federation of Teachers reported that students in heavily tested grades spent over 110 hours per year doing test prep and up to 50 hours per year taking the tests themselves, totaling roughly 15% of their instructional time (Nelson, 2013). Increased focus on testing had a profoundly negative impact on the quality of education available to students (Herman & Golan, 1991; Herman & Golan, 1993; Zellmer, Frontier, & Pheifer, 2006). However, in 2015, the Every Student Succeeds Act (ESSA) superseded NCLB as the federal legislation that governs elementary and secondary education in America. ESSA redistributed power back to states and school districts, creating new opportunities and flexibility when it comes to testing and interventions (National Association of Secondary School Principals, 2018).

Project-Based Learning

As education works to reconnect student learning to something more than standardized testing, project-based learning (PBL) has become a popular way to increase student engagement while providing more authentic applications of student knowledge. This is especially true at the middle school level, where the stakes are not perceived to be as high as in the 9–12 arena. PBL is a comprehensive approach to classroom teaching and learning designed to engage students in an investigation of real-life problems through the design of their own artifacts (Blumenfeld et al., 1991; Krajcik et al., 1998; Schneider, Krajcik, Marx, & Soloway, 2002; Solomon, 2003). In PBL "the doing and the learning are inextricable," as the process of artifact creation is the act of constructing the knowledge (Blumenfeld et al., 1991, p. 372). PBL is student-centered; it allows students to learn and to solve problems while teachers, who design the curriculum, play the roles of facilitators, process evaluators, and co-learners (Lou, Liu, Shih, & Tseng, 2011). It is a powerful pedagogy that emphasizes student learning (Major & Palmer, 2001) by transforming "classrooms into active learning environments as students investigate significant questions and take responsibility for their learning while collaborating" (Krajcik et al., 1998, p. 496).

While research regarding PBL is bountiful, little has been done to connect this body of research with student perceptions regarding its classroom application, especially concerning authenticity and student engagement (Kramarski, Mevarech, & Arami, 2002). Increased student engagement is often a deciding factor for teachers who opt to try PBL (Blumenfeld et al., 1991; Bowen & DeLuca, 2015; Bowen, DeLuca, & Franzen, 2016; Bowen & Shume, 2018; Bryson & Hand, 2007). Student engagement is a complex but "highly desirable goal with positive outcomes for all parties" (Bryson & Hand, 2007, p. 354); it is a web of students' thoughts, feelings, and behaviors surrounding their school experiences, built around relevance, autonomy, collaboration, and authenticity (Taylor et al., 2016). Relevance, autonomy, and collaboration are terms more clearly defined and agreed upon in comparison to authenticity. Research shows that using authentic lessons in the classroom is an important component of student engagement: When students are given the opportunity to participate in authentic experiences, they feel a sense of purpose and ownership over their learning (Bowen, 2014; Skinner & Pitzer, 2012). Given this clear connection, one would think that PBL was being used regularly in classrooms across all content and grade levels. However, this is not the case. For instance, even though many mathematics educators believe there needs to be more authentic-focused activities in the classroom (Bottge & Hasselbring, 1993; Keng & Kian, 2010; National Council of Teachers of Mathematics, 2009; Stepien & Gallagher, 1993), authentic tasks are rarely performed during mathematic lessons (Kramarski et al., 2002). The following literature review aims to provide a clearer definition of what it means to use authentic activities.

Authentic Activities in Mathematics

The term authenticity is pervasive in literature, but ill-defined (Strobel, Wang, Weber, & Dyehouse, 2013). Most research identifies the most important component of authenticity as having real-world relevance (Lombardi, 2007; Reeves, Herrington, & Oliver, 2002). The importance of authenticity is not just that students see the practical application of the context, but that they use the content in the same manner as they would within that context (Bowen & Shume, 2018). Understanding the value of the content-specific material is only one part of the experience. One of the reasons that conventional education is inauthentic is because the work carries no intrinsic value to the students beyond success in the classroom (Newman, Marks, & Gamoran, 1996).

Within mathematics education specifically, Weiss, Herbst, and Chen (2009) summarize four examples of authentic activities typically described by researchers. These include activities based on real-world context, context within the discipline, actual practice reflecting that of working mathematicians, and the methods of mathematical implementation by students. This was not the first discussion regarding mathematics and authentic activities, as the current train of thought can be traced back at least 15 years when Schwartz (1995) pointed out that the "difference between authentic use of mathematics and artificial practice rests in the children's view of the purposes for which the mathematics is used" (p. 580). Ultimately, authenticity is about how the student perceives the purpose for which the mathematical concept is being used. Therefore, this research uses the following operational definition for authentic activities: Authentic activities relate the problem-solver to the problem, and only apply to situations in which the student can place the problem within a meaningful context (Kramarski et al., 2002). Students are more likely to engage in the classroom activities if they feel the lessons and concepts directly apply to them and will be useful in their own lives. It is also important that students not only know the information, but can use the information in a practical application (Cotic & Zulijan, 2009).

As awareness for student engagement in mathematics activities increases, there needs to be more understanding of how integrating engineering-based concepts in the classroom not only increases students' learning, but also their perceived importance of connecting mathematical ideas with real-world contexts. This idea is supported with the release of Common Core State Standards and an increased emphasis placed on 21st century skills (Partnership for 21st Century Skills, 2009). The fourth standard for mathematical practice, model with mathematics, as described by the Common Core State Standards for Mathematics, states, "Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace" (National Governors Association Center for Best Practices, 2010). There is an increased need to connect mathematical content to authentic contexts. Additionally, incorporating real-world problems into the classroom creates an opportunity to introduce students to the world of work in a functional way. Coursework that has career awareness activities or skills integrated into the curriculum (e.g., Colston, Thomas, Ley, Ivey, & Utley, 2017; Ernst, Bottomley, Parry, & Lavelle, 2011; Ernst & Bowen, 2014) is an effective career intervention and provides connection to increased student engagement through both relevance and authenticity. By experiencing different aspects and tasks associated with specific careers through active engagement, children gain important knowledge about themselves and potential careers in an authentic manner, thus providing them the necessary input to make a sound decision in the future.

While there is sufficient research focused on student achievement and student perceptions of mathematics from the effects of problem-based learning (Cotic & Zulijan, 2009; Kramarski et al., 2002), there is little research based on separating the authentic component as a measure of outcomes (Kramarski et al., 2002). Due to the lack of research in this area, this study focused on introducing the authentic component to the experimental group, while both the control and experimental groups received problem-based activities. Rather than focus on the more general question of whether problem-based activities create a difference in student achievement and perceptions, this study focused on using an engineering-based context to incorporate task authenticity, or the authentic aspect of the hands-on experience. "This type of authenticity focuses on constructivist type learning environments in which students may be challenged to make decisions in practical contexts" and answers the question, "*What makes a task authentic?*" (Wang, Dyehouse, Weber, & Strobel, 2012, p. 9). The terms activity and task are synonymous for the purpose of this study. The research is framed around two research questions:

1. Does using an engineering-focused authentic activity result in higher student achievement, as measured on a post-test of concepts, in learning the concept of slope and y-intercept compared to a non-authentic activity in a seventh-grade mathematics classroom?
2. Does using an engineering-focused authentic activity result in an increased perception of the importance of the concept of slope compared to a non-authentic activity in a seventh-grade mathematics classroom?

Methodology

The research was conducted in four seventh-grade mathematics classrooms at a STEM-focused middle school in the upper Midwest of the United States. Students self-selected to be part of a lottery for entrance into the middle school; the percentage of overall applicants is calculated for each elementary school, and then schools are assigned that percentage of slots in the lottery for the incoming class. There was not a significant difference in ethnicity of students at the school, as the community in this area is primarily white.

Once accepted into the middle school, students were assigned to one of three different levels of math classes using previous MAP test scores. MAP stands for Measures of Academic Progress and measures student achievement on the Northwest Evaluation Association tests, which demonstrates what a student has learned and can do with approximately 50% accuracy within a subject area (Northwest Evaluation Association, 2015). However, during the week of this study, the students were rearranged so that each class had mixed-ability groupings. The students were stratified by the teacher to ensure that each class would have equal representation from all levels. The students were then divided into groups of three by the teacher so that, to the extent possible, each group had a student from a different ability level. This was done to keep uniformity among the ability groups, giving each student the opportunity to work with peers from other ability levels. The result was four classes consisting of mixed-ability students. These classes were then randomly divided into two different groups: control and experimental. Student and parental consent forms were collected, resulting in the control group having 27 and the experimental group having 26 participants.

The data collection process consisted of two instruments. First, an academic-based math test was used to determine if connecting the math concept to a real-world application would impact student achievement. The second instrument was an exploratory survey, which included basic questions to measure students' perception of the importance of knowing the slope concept and how it might be needed to solve future problems. The research study began with both the control and experimental groups receiving the same initial teacher-led instruction. During the first two days, the teacher presented a traditional lesson on the concept of slope. The topics included slope, y-intercept, and how to calculate values using these concepts. After the second day of teacher-led instruction, each student was given a traditional pre-test to measure their understanding of the material, along with a pre-survey to measure their perceptions about the importance of knowing about slope.

Control Group

On day three of the study, students in the control group took part in a math lab to demonstrate the practical application of the material. For the lab, students measured one stair, handrail, and ramp located around the school. The students then calculated the slope of each of these structures and explained the location of the intercept point. Each lab activity had prompts to guide the work of measuring and calculating in a logical order. After the lab was complete, the researchers reviewed the labs with the student groups and facilitated a class discussion about slope, and what the students learned from the lab activity. After this activity, students were given the post-test and post-survey.

Experimental Group

The experimental group treatment was structured around the concept of authenticity for content delivery; that is, as a means to attach relevance to the concept of slope and demonstrate how it might be used to design engineering structures and solve engineering-related problems. The treatment was delivered in three parts, beginning on day three. The first part involved a PowerPoint presentation along with guiding questions to facilitate classroom discussion. Students were presented information about different types of engineering structures and how slope is used in the design of these structures. The students were then shown examples of structures they see and use daily that included the concept of slope in the design. Discussion regarding safety and the importance of properly designed stairs, handrails, and ramps was intentionally integrated into part one. Information was distributed about building code specifications and how slope is used in engineering design to create safe environments for walking up and down these structures. Once this portion of the treatment was complete, the students completed the same lab activity as the control group.

The second part of the treatment included practical application of the building code information by comparing it to the data collected during the stair lab. After measuring one example each of a stair, handrail, and ramp, students had to compare their results to the building code specifications. The activity required students to determine whether the structures they measured did or did not comply with the given building codes, and to justify their answer. Students then participated in a classroom discussion to review the building code information and how the students determined if their findings were in compliance with the building codes.

The third and final part of the treatment involved providing students real-world-based scenarios that included the concept of slope. Students were provided basic materials that represented blocks, including decks of playing cards, packages of index cards, assembled mailing boxes, and other various stackable materials. The students were then instructed to build a stair-like structure that represented the answer to a scenario. A few examples of the scenarios included: "An engineer needs to design an expert ski slope. At one ski resort, a trail with a slope of -1.33 is considered a black diamond hill. Use the supplied materials to construct a stair-like structure to represent the required slope" and "A local museum is building a small model of the Leaning Tower of Pisa for a display. The Tower leans at a slope of 10 and stands 190 feet tall. Use the supplied materials to construct a stair-like structure to represent the required slope of the tower." These scenarios were meant to be a quick method for the groups to demonstrate their understanding of slope, as well as how to apply it to a practical situation through demonstration. This was followed up with small-group and then whole-class discussion about the lab and design-problem activities. Students then took the post-test and post-survey.

Instruments

The following section describes the traditional assessment and the survey used in the research project.

Traditional test. Traditional math tests were used in order to determine if the treatment received by the experimental group made a difference in the students' ability to obtain a better understanding of the content knowledge. The test consisted of seven questions, with six of the questions being graded on two different parts. A sample question demonstrating the two different parts is shown below:

> Question #. (a) Find the slope of the line through the points A = (2, -4) and B = (6,6).
> Slope = ___________
> (b) Is the slope positive, negative, zero, or undefined? (circle one)
> A. positive B. negativeC. zero D. undefined

These questions involved identifying, labeling, or calculating both the slope and the *y*-intercept of an equation or graph. Therefore, questions were scored based on whether or not they answered each part correctly. One of the questions asked the students to identify the definition of slope, and as such only contained one part to be scored. Each part of the questions was graded with a value of one point to indicate a fully correct answer, or a zero to indicate a fully incorrect answer. The highest possible score for the concepts of slope and *y*-intercept was six each, with a total possible score of thirteen.

The pre- and post-tests were structured the same way with the same level of difficulty for each question. The tests were developed using sample tests provided by the Teacher of Record; it was then reviewed by a math education faculty member to ensure readability and to verify no significant differences in difficulty between the pre- and post-test. Each question had a similar structure, and only those parts of the questions which did not affect the difficulty, such as numerical values and positioning of lines on the graph, were changed; so, the pre- and post-tests represented the same level of difficulty.

Survey. The pre- and post-surveys were designed to compare four simple questions to measure the students' perceptions of the importance of knowing about slope and if they would need to use it in the future, either during a career or to solve general problems. After the survey was written by the researchers, two additional faculty members reviewed the survey and gave feedback on the wording and addressed validity concerns. The questions in the survey that were analyzed are as follows:

1. I understand the concept of slope.
2. It is important to know about slope.
3. will need to use slope in my career one day.

4. Knowing about slope will help me solve problems in the real world.

According to Krosnick and Presser (2010, p. 264), the most valuable advice from hundreds of methodology textbooks can be summarized in just eight points:

1. Use simple, familiar words (avoid technical terms, jargon, and slang);
2. Use simple syntax;
3. Avoid words with ambiguous meanings, i.e., aim for wording that all respondents will interpret in the same way;
4. Strive for wording that is specific and concrete (as opposed to general and abstract);
5. Make response options exhaustive and mutually exclusive;
6. Avoid leading or loaded questions that push respondents toward an answer;
7. Ask about one thing at a time (avoid double-barreled questions); and
8. Avoid questions with single or double negations.

While simple, this four-question survey meets the eight points outlined by Krosnick and Presser (2010). The survey was designed with a Likert scale with values from 1–5 representing strongly disagree, disagree, neutral, agree, and strongly agree, respectively. The survey's Flesch Reading Ease Score, a 94.2, indicates that the questionnaire would be easily readable for a first grader (Flesch, 1948). Its short length also fits the attention span of even a below-average middle school student, which is important in trying to curb satisficing—that is, the process in which a respondent may take subtle or dramatic shortcuts rather than make the effort necessary to provide optimal answers (Krosnick, 1991, as cited in Krosnick & Presser, 2010). The likelihood of satisficing is determined by three major factors: task difficulty, respondent ability, and respondent motivation (Krosnick, 1991, as cited in Krosnick & Presser, 2010). By keeping task difficulty low, matching the task to the ability level of even the lowest students, and keeping motivation high by ensuring questions are of personal importance, all while considering respondent fatigue, the self-reported survey results are more likely to be optimized for accuracy.

Results

The statistical program SAS was used to conduct a series of statistical tests related to the two research questions, all using an $\alpha = 0.05$ level. Unless otherwise indicated, the statistical analysis passed the test for equal variances and the pooled variance method was used; if the test failed, the Satterthwaite variance method was used instead. The following section reports the results of the statistical analyses of data collected from both the surveys and academic assessments. Of 53 participants, 47 students had a complete data set and were used in the analysis.

Tables 1–3 report the results of the statistical analysis of the content knowledge test to answer our first research question: Does using an engineering-focused authentic activity result in a higher student achievement in learning the concept of slope and *y*-intercept compared to a non-authentic activity in a seventh-grade mathematics classroom? Table 1 shows the descriptive statistics for the difference in the means of the test scores.

A paired-samples *t*-test was used to determine whether there was a statistically significant mean difference of the academic achievement on pre- and post-tests on the concept

Table 1
Descriptive statistics for difference in means of test scores within groups.

Test Item	Group	*N*	Min	Max	*M*	*SD*	*SE*
Total Score	Cont.	27	-4	5	0.815	2.167	0.417
	Exp.	20	-3	9	1.050	2.460	0.550
Slope	Cont.	27	-3	3	0.333	1.301	0.250
	Exp.	20	-2	4	0.400	1.429	0.320
y-intercept	Cont.	27	-2	2	-0.111	1.086	0.209
	Exp.	20	-2	5	0.050	1.849	0.413

Cont. = Control; Exp. = Experimental.

Table 2
Statistical analysis for difference in means of test scores within groups.

Test Item	Group	*df*	*t*-value	*p*-value
Total Score	Cont.	26	1.95	0.0615
	Exp.	19	1.91	0.0715
Slope	Cont.	26	1.33	0.1946
	Exp.	19	1.25	0.2258
y-intercept	Cont.	26	-0.53	0.5995
	Exp.	19	0.12	0.9050

of slope and y-intercept (see Table 2). There were no outliers in the data, as assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box. The assumption of normality was not violated for either group's assessment scores, as assessed by Shapiro-Wilk's test (control $p = .92$, experimental $p = .94$). Control group participants increased their test scores by a mean of .815 overall ($SD = 2.167$); this was not a statistically significant difference ($p > .05$). The control group made gains in questions on slope ($M = .33$, $SD = 1.301$), though these were not statistically significant ($p > .05$). There was a slight decrease in points related to y-intercept ($M = -.111$, $SD = 1.086$); this decrease was not statistically significant for the control group either ($p > .05$). The experimental group increased their test scores for total score ($M = 1.05$, $SD = 2.460$), slope ($M = .400$, $SD = 1.429$), and y-intercept ($M = .050$, $SD = 1.849$); none of these gains were statistically significant ($p > .05$ for all three).

Table 3
Statistical analysis for difference in means of test scores between groups.

Test Item	***df***	***t*-value**	***p*-value**
Total Score	45	-0.35	0.7299
Slope	45	-0.17	0.8684
y-intercept[1]	28.59	-0.35	0.7306

[1]*Did not pass test for equal variance.*

An independent-samples t-test was run to determine if there were differences in academic achievement between the two groups (see Table 3). There were no outliers in the data, as assessed by inspection of a boxplot. Test scores for each group were normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$), and there was homogeneity of variances, as assessed by Levene's test for equality of variances ($p = .67$). The academic growth of the experimental group outpaced the control group in both slope and y-intercept questions, as well as in overall score, as measured by post-test score minus pre-test score difference; however, none of these differences were statistically significant ($p > .05$).

Tables 4–6 report the results of the statistical analysis of the surveys to answer our second research question: Does using an engineering-focused authentic activity result in an increased perception of the importance of the concept of slope compared to a non-authentic activity in a seventh-grade mathematics classroom? The survey results were analyzed via a paired t-test to determine if there was a significant difference in the overall survey score, as well as for each individual question. Similar to the test score analysis, a paired t-test was first performed to determine if there was a significant difference in the means of the pre- and post-survey questions for each of the two groups separately. This was followed by a t-test to determine if there was a change in students' perceptions of the

Table 4
Descriptive statistics for difference in means of survey scores within groups.

Survey Item	**Group**	***N***	**Min**	**Max**	***M***	***SD***	***SE***
Total Score	Cont.	25	-6	4	-0.440	2.200	0.440
	Exp.	19	-3	6	0.947	1.985	0.456
Q 1	Cont.	25	-2	4	0.120	1.236	0.247
	Exp.	19	-1	2	0.474	0.697	0.160
Q 2	Cont.	25	-2	1	-0.160	0.746	0.149
	Exp.	19	-2	1	0.105	0.658	0.151
Q 3	Cont.	25	-2	1	-0.200	0.866	0.173
	Exp.	19	-2	1	-0.263	0.806	0.185
Q 4	Cont.	25	-2	1	-0.200	0.707	0.141
	Exp.	19	-2	4	0.632	1.165	0.267

Table 5
Statistical analysis for difference in means of survey scores within group.

Survey Item	**Group**	***df***	***t*-value**	***p*-value**
Total Score	Cont.	24	-1.00	0.3273
	Exp.	18	2.08	0.0521
Q 1	Cont.	24	0.49	0.6317
	Exp.	18	2.96	0.0083*
Q 2	Cont.	24	-1.07	0.2943
	Exp.	18	0.70	0.4994
Q 3	Cont.	24	-1.15	0.2596
	Exp.	18	-1.42	0.1716
Q 4	Cont.	24	-1.41	0.1701
	Exp.	18	2.36	0.0296*

*Significant at $\alpha = .05$.

Table 6
Statistical analysis for difference in means of survey scores between groups.

Survey Item	*df*	*t*-value	*p*-value
Total Score	42	-2.16	0.0366*
Question 1[1]	39.15	-1.20	0.2367
Question 2	42	-1.23	0.2262
Question 3	42	0.25	0.8062
Question 4[1]	27.86	-2.75	0.0103*

*Significant at $\alpha = 0.05$.
[1]Did not pass test for equal variance.

importance of knowing about slope when comparing the two groups. Table 4 shows the descriptive statistics for the difference in the means of the survey questions.

A paired-samples *t*-test was used to determine whether there was a statistically significant mean difference in the overall survey score, as well as for each individual question (see Table 5). There were no outliers in the data, as assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box. The assumption of normality was violated for both groups' overall scores and individual question response, as assessed by Shapiro-Wilk's test ($p < .05$), except for Question 3. However, as non-normality does not affect Type I error rates substantially and a paired-samples *t*-test is considered robust in this regard, the test was considered adequate.

Control group participants' survey scores had a decreased mean of -.44 overall ($SD = 2.2$); this was not a statistically significant difference ($p > .05$). The control group made gains on Question 1 ($M = .12$, $SD = 1.236$); this change was not statistically significant ($p > .05$). Responses for questions two through four all decreased for the control group ($M_{q2} = .120$, $SD = .746$; $M_{q3} = -.200$, $SD = .866$; $M_{q4} = -.200$, $SD = .707$); none of these changes were statistically significant ($p > .05$). In comparison, the experimental group survey responses increased for both total score and three of the four individual questions ($M = .947$, $SD = 1.985$; $M_{q1} = .474$, $SD = .697$; $M_{q2} = .105$, $SD = .658$; $M_{q3} = -.263$, $SD = .806$; $M_{q4} = .632$, $SD = .1.165$); the increase in survey scores for question one and question four were both statistically significant at the $\alpha = 0.05$ level ($p < .05$).

Table 6 shows the results when comparing the two groups. When comparing the two groups, the difference in means in the total survey score, as well as for Question 4, were significant at the $\alpha = 0.05$ level ($p = <.05$).

Discussion

Regarding the test scores, there was a greater increase in the difference in means of the experimental group when analyzing each group separately for the total score, slope, and *y*-intercept concepts, but not at a statistically significant level, likely due to the relatively small population in the study. The increase for both groups is most likely due to having additional practice with the concepts between the pre-test, given after the teacher-led instruction, and the post-test. When comparing the two scores between groups, there was no significance in the difference in means between the pre- and post-test scores for each of the total score, slope, and *y*-intercept concepts. These results show that the impact of using task authentic work was not large enough within this sample size to make a significant difference in the two groups' academic test scores.

The lack of statistically significant growth for both groups in the paired *t*-test, which compared pre- and post-test scores, is notable. This could be from one of three possibilities: first, that the students came into the lesson with a higher-than-expected baseline knowledge of slope and *y*-intercept; second, that the lesson provided to both groups is not as effective as anticipated; or third, that the assessment itself is not measuring the intended concept. The measurement could be skewed due to any number or combination of factors. For instance, the type of test (multiple choice leads to inflated scores from test-taking strategies), quantity of questions (test fatigue or a lack of opportunity to showcase knowledge), or the format (being set differently than what was worked on in class) all could have played a role in the accuracy of the test itself. As the tests were based on previous assessments and confirmed as appropriate by a math education subject matter expert, it is unlikely that the test itself was the problem. It is more likely that additional populations and classrooms should be included in a follow-up study; preferably one that has additional subject matter experts guiding the lesson material. Given that, while not statistically significant in this study, the mean test scores for the experimental group were higher in each category as compared to those for the control group, additional research is recommended to see if academic achievement can be enhanced through incorporating task authenticity into lessons. It is possible that with alternative mathematical concepts, or just a more robust population, the technique could prove effective.

Regarding students' increased perception of the importance of the concept of slope, the change in the experimental group survey scores for Question 1 ("I understand the concept of slope.") and Question 4 ("Knowing about slope will help me solve problems in the real world.") were significantly different from their pre-survey responses. This demonstrates that the treatment had a significant effect on the experimental group, in regard to their understanding of the concept of slope, as well as their perception that the knowledge will one day help them solve problems in the real world. Similar growth was not statistically significant for the control group, meaning that there is value in the task authentic approach. This is further supported by the analysis between groups, which shows a significant difference in the means of the survey scores for the total score and Question 4 ("Knowing about slope will help me solve problems in the real world."). The fact that the overall significance comes mostly from a single question speaks to the extent to which students' thinking changed regarding slope's utility in the real world. This shows that there is value in task authenticity; the students that participated in the experimental group better grasped how math relates to their world, as compared to their understanding prior to the lesson (paired t-test $p < .05$) and also to that of their counterparts in the control group (between-group t-test $p < .05$).

Logically, it makes sense that having additional real-world examples for the uses of slope would have an influence on students' beliefs concerning its usefulness. While it could be the increased quantity of examples, it is more likely the context itself that makes the difference. This is supported by the survey results, which showed a positive change to students relating the concept to the real world. For convenience, this study measured items around the school, providing a real-world context with which to apply the mathematical concepts. In this case, the relevance was inferred but not explicitly addressed. However, the next step would be to provide autonomy and allow students to self-select something that both aligns with the assigned standard and is meaningful to them to apply the math toward. This next step would afford students the opportunity to internalize the relevance further.

Threats

Inherent in all classroom-based studies is a certain amount of variability in teaching practices between treatment groups. Differences in subject characteristics is an internal validity concern to all studies, and nearly half of studies do not address it properly (Horton et al., 1993). However, given that the Teacher of Record was the same for each class in this instance, the threat was controlled for as best as possible. The teacher was aware that, aside from the treatment, class materials were meant to be presented in as similar a way as possible. Given that the Teacher of Record was aware of this expectation, and that the researchers did not note any inconsistencies, the factors relating to variability in teaching practices that might have affected outcomes should be equivalent across intervention conditions, and do not pose major threats to the internal validity of the present study.

The Hawthorne effect is a concern for all field experiments, present in 48% (Horton et al., 1993); it can be defined as "the problem in field experiments that subjects' knowledge that they are in an experiment modifies their behavior from what it would have been without the knowledge" (Adair, 1984, p. 334). When applied to teaching situations like those in this study, the Hawthorne effect can have positive implications. Simply stated, "when a person becomes convinced that what he is doing is important, he will try to do it better" (Armenti & Wheeler, 1978, p. 123). In this context, students may have thought the content was more relevant because the school went to the trouble of regrouping classes, and because there was a special teacher (and researchers) present. So even if the Hawthorne effect was to be of concern for student scores, it would be even across all groups and awareness of experiment participation would be evenly distributed between all the students (Adair, 1984). Another topic of interest when discussing possible validity threats would be that of time allocation. While one group did have slightly more time with the content, approximately 15 minutes, the times were similar enough that it is unlikely to have made a difference in students' perceptions. It is something to be considered, however, when building out future studies.

Conclusion

Wang et al. (2012) stated that "More research is necessary about which authenticity dimensions are more beneficial for the desired learning outcomes and program goals" (p. 17). This study contributes to this request, providing research on one of Wang et al.'s (2012) identified types of authenticity—task authenticity. There is a general understanding in education that making content more relevant for students will increase their engagement and, in turn, increase their learning. As Schwartz (1995) said, "Mathematics supports inquiry, construction of models, and expression of ideas when it is used in the curriculum" (p. 580). These results confirm this assumption, showing that incorporating relevance by introducing authentic engineering-related material during a hands-on activity increases students' perception of the importance of the concept of slope. While academic gains were not statistically significant at this time, there is practical significance to consider. Adjusting teaching practices to increase students' engagement and their perceptions about the importance of learned materials should be an integral component of instructional practice; this aligns with existing literature. Using authentic material to show the relevance of engineering-based content within the context of a math lesson increases students' perception of the importance of learning the material.

This study found that students perceived the concept of slope as relevant to the real world following the treatment. This does not infer lasting effects, which have yet to be determined and should be addressed by future research. In addition to further exploring task authenticity, with a larger and more diverse population if possible, future research should move toward long-term and/or impact authenticity studies; "Impact authenticity focuses on the use of students' products in contexts outside their own classroom, is tied to community's or industry's need, demonstrates cultural significance and pertains to events or issues in society" (Strobel et al., 2013, p. 150).

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