# Using Pedometers in Elementary Science and Mathematics Methods Courses

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**Abstract**

This study broadens the knowledge base about how to use pedometers to further pre-service teachers' (PT) understanding of measurement: a key concept in science and mathematics education at the elementary level. Two groups of elementary PT-one enrolled in a science methods and the other enrolled in a mathematics methods course at a major university in the MidAtlantic region of United States- completed instruction on how to use pedometers as a technology tool to teach mathematics and science. Lesson plans developed by the PT were collected, and a 40-item instrument to measure attitudes about pedometers, mathematics and science was administered at the end of each course. Data, measurement, and number were the most common mathematics standards targeted by PT lesson plans. No statistically significant differences were found between PT enrolled in science and mathematics methods courses on their perceptions of technology and pedometers as a technology tool. However, PT in the science methods course rated more highly ($F = 4.90$, $p = .03$) science-mathematics integration. Future research should examine more extensively a coordinated pedometer experience where the same cohort of PT pose questions and collect data in science methods, then analyze/represent that data in math methods.

**Keywords:** Pedometers, Pre-service teachers, Mathematics and science integration

## 1. Introduction

Elementary teacher education programs are in great need of consolidating the content and pedagogy courses to meet the requirements of living in the 21st Century. Meaningful mathematics instruction needs a subject matter context and oftentimes there is insufficient time for science instruction. Thus, elementary school teachers need to be able to create integrated mathematics and science instruction. TheK-12 "STEM" education emphasis also supports this contention . One of the difficulties faced by methods instructors is to model and provide a tool for pre-service teachers (hereafter referred to as PT) to make connections between mathematics and science content. Cooperation between mathematics and science method instructors could help to resolve this problem that currently is straining both elementary and higher education. The purpose of this study was to investigate mathematics/science integration through the use of a "novel" source of technology (digital pedometers) and examine the utility of a "real world" teaching context for mathematics/science integration. We also wanted to explore how science and mathematics methods faculty could collaborate through their methods courses to connect mathematics content knowledge and science content knowledge using pedometers in a coherent teaching context. In particular we focused on answering the following research questions:

(1). What is the scope of content standards that PT set forth in lesson plans that utilize pedometers in elementary science and mathematics instruction?

(2). What are PTs' perceptions about using pedometers as a technology tool in teaching elementary school?

(3). What are the future directions in terms of collaboration between mathematics and science instructors?

## 2. Rationale for Using Technology to Contexualize Science and Mathematics

For almost 20 years, education polices and professional standards in the United States have urged post-secondary faculty to integrate technology into PT education programs (NAS, 1996, NCATE, 2008; NCLB, 2001; ISTE, 2007). Underlying reasons suggest that technology motivates students to engage in the learning process and also reduces their cognitive load from complicated data collection and computation, thus facilitating focus on developing problem solving skills and conceptual understanding (NRC, 1996; NCTM, 2000; Pea, 1987; Schwartz & Beichner, 1999; Taylor, Casto, & Walls, 2007). In response to the call for technology integration, most teacher education programs adopted at least one course focused on the use of instructional technology. Critiques of these technology courses often voiced concerns about the isolation of technology from the specific content area (e.g., mathematics and science) and difficulty of application in public school classroom settings (Clift, Mullen, Levin, & Larson, 2001; Lederman, & Neiss, 2000; Neiss, 2005; Liu, Ku, & Falvo, et al. , 2004). Failure to apply technology in the context of meaningful content has limited the growth of PT's awareness of the potential of technology in teaching mathematics and science. Several researchers have suggested that the best way to encourage technology integration in teacher education programs is to model the effective use of technology in both didactic and clinical settings and mentor pre-service teachers for technology skills acquisition (Carlson, & Gooden, 1999). According to Rye et al. (2005), pedometers are excellent technology tools to contextualize mathematics and science in a real world setting to develop relevant concepts. For example, each student can utilize a pedometer to collect data on the number of steps s/he takes daily and pool their data with classmates to create a dataset for inspection by the whole class. Students can investigate how much energy it takes to walk a mile by using a pedometer that estimates kilocalorie (kcal) expenditure. Conceivably, this would be more motivating and relevant for developing mathematics and science concepts than using calculators to check for calculation mistakes or developing a PowerPoint presentation about mathematics/science integration.

## 3. Science and Mathematics Connections

Pangrazi, Beighle, and Sidman (2007) set forth guidance and a variety of activities for using pedometers in elementary through secondary physical education, including applications for developing concepts and skills in mathematics, science, and other disciplines. Rye et al. (2005) describe how pedometers can be connected to most of the National Science Education Standards [NSES] (NAS, 1996). NSES point to the essentiality of mathematics as a tool for doing science and calls for coordination of the science and mathematics programs to enhance students' applications of mathematics in science and their understandings of mathematics. The Principles and Standards for School Mathematics (PSSM) (NCTM, 2000) articulate the importance of science-content as well as processes (e.g., prediction and measurement)-as a context to study mathematics. Moscovici and Newton (2006) refer to the latter as contextual mathematics. They report that both the NSES and PSSM include a focus on inquiry and problem solving.

Measurement, unit conversion, representation, and controlled investigations (especially the concept of variables) are some of the processes central to both disciplines at the elementary level, and help to illustrate the natural connections between science and mathematics (Moscovici & Newton, 2006; Vasquez-Mireles & West, 2007). Pedometers can be employed in all of these processes. In their historical analysis of integrating science and mathematics education, Berlin and Lee (2005) conclude that reform documents (e.g., NCTM 2000, NRC 1996) from both disciplines clearly advocate for making connections and that more empirical research on integration endeavors is needed, including teacher professional development. Based on a review of research about science and mathematics integration, Pang and Good (2000) surface 10 issues for further research; among these are connections between teacher preparation on integration and actual classroom practice. Vasquez-Mireles and West (2007) contend that an obstacle to such practice is finding the time to plan and implement such instruction. However, at the elementary level, curriculum integration of mathematics and science may actually save instructional time, result in more science being taught, and promote meaningful learning and retrieval of knowledge (Ohana, 2004). Providing pre-service teachers with mathematics-science integrated lesson planning experiences may affect positive dispositions and build confidence about planning and implementing such instruction. Pedometers can serve as a technology tool for such integration and through activities that are "real world," i.e., walking. Although not central to our paper, pedometer utilization also incorporates "fun" movement into science and mathematics instruction, which pertains to national concerns about children getting sufficient physical activity as well as opportunities to network with physical and health educators (Lee, Wechsler, & Balling, 2006; Rye & Smolski, 2007; Strong et al., 2005).

## 4. Methods

The current study was carried out during Fall, 2007, at a major research institution in the Mid-Atlantic region of the United States. An emphasis of the teacher education program at this institution is to employ research based practices in the preparation of school teachers. One initiative taken by methods instructors was collaborative planning of lessons that address integration of mathematics, science and technology. Through the collaborations between mathematics and science method instructors, a constructivist approach that emphasizes inquiry and problem solving was applied.

### *4.1 Participants*

A total of 44 students majoring in elementary education, hereafter referred to as pre-service teachers (PT), participated in the study. We are not trying to capture the students' population characteristics at this University. We chose these 44 students because both science and mathematics instructors had these students in their courses (Gay, Mills, & Airasian, 2009).

### *4.2 Intervention*

Initial efforts in 2004 to integrate pedometers into elementary science and mathematics methods courses were inspired by a college worksite walking initiative and an externally funded project that provided science and mathematics enrichment through pedometer utilization to secondary students (Rye et al., 2005). These initial efforts were directed toward one class of approximately 15 elementary PT who were all enrolled in a science methods and a mathematics methods course. Here, the science and mathematics methods instructors worked collaboratively to develop activities that could span both courses. In the current study (Fall, 2007), there was some variation in the types of activities and order in which they were introduced by the mathematics and science methods instructors, however, early on each instructor included an openended exploration that allowed PT to "try out" the pedometers, e.g., Where is the best place to wear the pedometer? What influences the accuracy of the pedometer? The instructors used pedometers to introduce a learning cycle or guided discovery lesson model spanning two class periods. Samples of introductory and follow-up activities that were employed by the instructors are described below. These activities, for the most part, utilized only step count data; the distance and stop watch features of the pedometers that we used present numerous other possibilities, e.g., unit conversion (feet to meters, miles to kilometers) and rate (speed) of walking. PT also were exposed to other instructional technologies and related applications, like spreadsheet and graphic organizer software as well as webquests and global positioning system units.

4.2.1 Introductory Activities

(1). Cross-Disciplinary Connection.

PT examined a brief literary "historical" passage related to walking. Here, an excerpt from Michener's (1985) book Texas was employed, which portrayed an adolescent boy in the 16th Century ordered to manually keep track of his total steps day after day in order to ascertain the distance traveled by a troop of explorers. The passage explicitly relates science to literature and mathematics. The instructor asks the PT what the boy is "desperate" for (a pedometer, of course). Questions were posed about how to figure out the boy's stride length in feet, given the number of steps he walked and distance traveled in leagues (1 league = 4.83 kilometers [3 miles]; see Rye, Richards, Mauk, et al., 2007, for more detail).

(2). Explorations.

PT were asked to "fiddle" with the pedometer for a specified time and form questions about the pedometers. In the science method class, an exploratory homework assignment was given, where PT were asked to derive answers to their questions, such as "What influences the accuracy of the pedometer." (PT were not instructed as to where to position/wear the pedometer prior to the exploration.) Example questions posed pertained to how should the pedometer be worn to make it record more accurately and what could be taught using pedometers. The mathematics instructor asked PT to think about any mathematics content that could be addressed by pedometers.

4.2.2 Follow-up Activities

(1). Accuracy.

The science instructor asked PT to share/discuss answers to the homework exploratory activities. The instructor subsequently posed the question, "How accurate is the pedometer when I wear it in the location recommended by the manufacturer?" Here, PT collected and recorded data about their individual manual and pedometer derived step counts. They pooled their data anonymously with classmates and compared individual to group accuracy.

(2). Measurement Estimates and Predictions.

PT were asked to make estimates/predictions of the number of steps needed to travel a specified distance. Subsequently, they were to walk that distance and compare the predictions to the pedometer recorded step counts (e.g., PT walked to, around the perimeter, and back from a close by tennis court).

(3). Descriptive Statistics and Representations.

PT were engaged in calculating the descriptive statistics of mean, median and mode for pooled (anonymous) stride length data. The instructors and PT generated and discussed visual representations of the analyzed data, such as bar graphs, stem and leaf plots, and box and whisker plots.

*4.3 Data Sources*

Data were collected from lesson plans (qualitative) and responses to a survey (quantitative) in both methods classes during the semester.

4.3.1 Lesson plan

During the semester, each participant designed a lesson that incorporated pedometers to teach mathematics and science in their field placement after the intervention. All lessons were examined for adherence to National Council of Teachers of Mathematics (NCTM, 2000) standards and National Science Education Standards (NRC, 1996) as well as the inclusion of content and pedometers emphasized in the intervention. The analysis used qualitative methods for a document analysis of secondary data sources (Miles & Huberman, 1994; Patton, 1990). The following is the lesson plan assignment description.

*Design a lesson plan to integrate pedometers to teach mathematics and science. Before planning the activity, think about the 5 content standards we have discussed so far, Number and Operation, Algebra, Geometry, Measurement, Probability and Statistics. Please identify at least one standard to which your lesson is related. Links to NCTM (National Council of Teachers of Mathematics) standards and NSES (National Science Education Standards are provided. http://standards.nctm.org/document/appendix/numb.htm, http://www.nap.edu/openbook.php?record_id=4962*

*The lesson plan should contain the items below:*

a. objectives (1-2)

b. NCTM standards (1-2)National Science standards (1-2)

c. Activity: brief procedures for what you should do and the students would do to meet the objective include any safety precautions.

d. Final wrap up: final discussion of utility of pedometers and how activities are related to national standards.

4.3.2 Survey on Technology and Integration of Mathematics and Science Content

The survey attempted to ascertain PTs' awareness and perceptions related to technology in general, pedometers as a technology tool, and pedometers as a tool to integrate mathematics and science. The instrument was developed by one of the authors and informed by a mathematic attitude inventory (Sandman, 1979). This instrument was a 40-item, multi-dimensional self-rating scale to investigate participants' attitudes towards integration of mathematics and science using pedometers /technology. PT were asked to respond on a semantic differential scale to reflect the extent to which each statement described their feelings (A = strongly disagree to E = strongly agree). The survey was administered in the methods course at the end of semester.

*4.4 Data Analysis*

The data came from two sources: lesson plans that were developed by PT in science and mathematics methods courses; a mathematics, science and technology integration survey (a 40-item self-rating scale)administered in mathematics and science methods courses by graduate students without the instructors present in classes. All lesson plans were coded and analyzed by the authors independently. Since trustworthiness is important, we used code and recode strategies to address this critical issue (Lincoln, & Guba, 1985). SPSS (11.5) was utilized for analyzing the survey data. A total of 44 PT completed the survey; however, two students did not answer all of the questions, so we only analyzed 42 students' answers. Tables 1-2 provide the Multivariate Analysis of Variances (MANOVA) results for equality of covariance matrices and Levene's test of equality of error variances of the participants, respectively. Each student is an independent observation, thus the MANOVA requirement of independence was met. Thus, the MANOVA analysis was conducted without any violations of the assumptions.

< INSERT TABLE 1 & TABLE 2 HERE >

## 5. Results

What is the scope of content standards that PT set forth in lesson plans that utilize pedometers in elementary science and mathematics instruction? What are PT's perceptions about using pedometers as a technology tool to teach elementary students? What are the future directions in terms of collaboration between mathematics and science instructors? We are going to answer these questions in this section.

*5.1 Lesson Plans*

Analyses from 22 lesson plans (44 students were paired to develop the lesson plan) indicate that all of the lesson plans successfully applied pedometers as a technology tool to facilitate developing problem solving skills in a real world situation. The scope of the content spans three mathematics standards including measurement, data analysis, and number (figure 1) and four science standards including unifying concepts and process in science, science in personal and social perspectives, science and technology, science as inquiry (figure 2). Few differences were noted in the procedures for the activities in the lessons developed by PT in the mathematics and science methods courses. However, all of the lessons developed by the science methods PT included mathematics and science standards; only one of the lesson plans developed by PT in the mathematics methods course included both mathematics and science standards.

< INSERT FIGURE 1 & FIGURE 2 HERE >

Five of the lessons developed in the mathematics methods class engaged students in learning about measurement attributes of objects and applying appropriate techniques to determine measurements. Two lesson plans focused on figuring out a strategy to measure a certain distance. Two lesson plans even engaged students in proportional reasoning to find out the distance between two cities on a map. One of the lesson plans asked the students to figure out how many steps it would take a child to walk from Fairmont, WV to Los Angeles, CA by using a map and a pedometer. One lesson discussed the conversion between the metric system and English system. A total of four lesson plans developed in the science method class dealt with the distance measurement. Two lesson plans asked students to find a method to measure the perimeter of an irregular shape (school building). One lesson plan discussed how many steps would be in a fixed distance unit (e.g., mile). One lesson plan brought in United States Civil War era history by asking students to figure out how many steps an African American would have needed to walk to reach the North through the underground railway.

A total of six mathematics methods lesson plans addressed how to use different graphs to represent data collected during a period of time. For example: How many feet would a student walk in a school week? Who will walk the farthest? Which day will they have the most steps recorded? What is the most appropriate graph for this data? A total of six science lesson plans also focused on data analysis. Four of these science plans asked students how to use hypothesis testing to test the accuracy of the pedometers, e.g., exploring how different variables (running, crawling, crab walking) influence the accuracy of pedometers. The remaining lessons dealt with data representation, e.g., how to use a bar graph to represent the number of miles every student walked in 10 minutes.

Five of the mathematics lesson plans also addressed an additional mathematics standard: number and operation. For example, one lesson had students use a pedometer as a step recorder to design different word problems based on real world experiences to reflect addition, subtraction, multiplication, and division. There was only one science lesson plan focusing on division by engaging students in determining the speed of walking using the distance and time measure feature of the pedometer.

*5.2 Survey*

There were no statistically significant differences between PT in the science and mathematics methods courses on their perceptions about technology (F=.64, P=.43) and the pedometer as a technology tool (F=3.0, P=.09). However, there was a statistically significant difference in terms of mathematics and science integration (F=4.90, P=.03): PT in the science methods course tended to rate mathematics and science integration higher (M=3.76 ) than PT in the mathematics method course (M=3.43). Further analysis of items on PTs' perceptions about pedometers as a technology tool revealed a slightly positive attitude (M=3.25), and that perception did not differ significantly between mathematics and science methods courses. The size of a significant effect was assessed using partial eta squares, with .02, .07, and .11 representing the effect sizes of technology, pedometers, mathematics and science connections, respectively. Though effect size is small according to Cohen's criterion (1977), it is recognized by researchers that effect size in the social sciences are usually small (Light and Pillimer,1984).

< INSERT TABLE 3 HERE >

## 6. Conclusion

This study on the application of pedometers in teaching mathematics and science methods reveals two major issues: (1) the scope of the content standards PT set forth in lesson plans that utilize pedometers in elementary science and mathematics instruction. (2) PT's perceptions about using pedometers to integrate mathematics and science in elementary schools.

Our findings agreed with other scholars (Moscovici & Newton, 2006; Vasquez-Mireles & West, 2007) findings about the content coverage. Specific mathematics standards, for example, measurement and data analysis, are common mathematics concepts covered in the lesson plans developed by PTs. Meanwhile, science and technology is the most common covered science standard. The lesson plan analysis suggests that pedometers are valuable tools to connect several important mathematics and science concepts in elementary education. This finding provides a solution to concerns raised by researchers (Berlin & Lee, 2005; Pang & Good, 2000) about the lack of empirical research on integration endeavors in teacher education program. This study also responds to the criticism of lack of contextual support to integrate technology into teacher education programs-and especially science and mathematics (Clift, Mullen, Levin, & Larson, 2001; Leserman, & Neiss, 2000; Neiss, 2005; Liu, Ku, & Falvo, et al., 2004).

The PT lesson plans and survey results provide insight into the potential utility of the pedometer as a tool for mathematics and science integration. The lesson plans developed by PT in this study show that pedometers could be used as a technology tool to teach several important mathematics concepts as well as some science concepts, even though the connection between mathematics and science could be strengthened in the mathematics methods course. This study also reveals that PT in the science and mathematics methods courses were not significantly different in terms of viewing technology as a teaching tool in general and pedometers as a technology tool. The collaboration between university instructors in mathematics and science methods courses provided a model for future exploration on mentoring PT for technology acquisition, in this case the learning and utilizing of pedometers as a meaningful context to teach mathematics and science. This is also a challenge put forth by the 21st century learning objectives.

The gap between PT perceptions on content integration between the mathematics and science methods courses was reported from the survey results (statistically significantly different) as well as the lesson plan analysis. Possible reasons could be the differences in the nature of the subjects of mathematics and science study. We agree with Moscovici and Newton (2006) that science could be a context to study mathematics, while using mathematics as a context to teach science is not easy. In addition, the teaching experiences of methods course instructors could compound the results since the mathematics instructor only has two-years of teaching experiences in higher education while the science instructor has more than 10 years of teaching experiences in higher education. However, exploring the reasons that caused the differences between these students will lead us to the next study.

## 7. Future Directions

The use of pedometer technology appeared novel to the PT. Additionally, their exposure to this tool was limited to either science or mathematics methods. We currently are examining a scenario in which the same cohort of PT receives an extended and coordinated exposure across their science and mathematics methods courses. It would be ideal to provide

PT with more exposure to applications of this tool by having the same cohort of students in both science and mathematics methods courses. Here, PT will engage more so in setting forth investigations and collecting data in the science methods course; in mathematics methods, they subsequently would focus on data analysis and representation. Another possibility that may be empowering to PT would be to follow up on the lesson plans they developed. Brief presentations/discussions could ensue on ways to enhance each lesson, and the class could choose one (or some combination of activities from several lessons) to actually teach the lessons in the course. PT are required to partner and conduct a "mini-inservice" for their classmates in the science methods course, and the previous could be a part of one of these assignments. Practicum settings of PT represent another possibility for the lessons they develop, which would provide an opportunity for course instructors to first network with host teachers on the possibilities for using pedometers for science/mathematics instruction in their classroom and/or collaboratively with other teachers, e.g., physical education.

The survey about technology utilization suggested that PT need to be further guided to view the pedometer as a technology tool. Additionally, only one of the lesson plans that were analyzed from the mathematics methods students addressed the science standards. In order to encourage more so the integration of mathematics, science and technology, the instructors plan to examine in more detail the alignment of pedometers to the science (NAS, 1996), mathematics (NCTM, 2000), and technology (ISTE, 2007) national standards and make explicit to PT the relationship of pedometers to these standards.

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Table 1. Box's Test of Equality of Covariance Matrices

| | |
|---|---:|
| Box's M | 3.273 |
| F | .501 |
| df1 | 6 |
| df2 | 11288.735 |
| Sig. | .808 |

Note. Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

Table 2. Levene's Test of Equality of Error Variances(a)

| | F | df1 | df2 | Sig. |
|---|---|---|---|---|
| Technology | .030 | 1 | 40 | .864 |
| Ped | .406 | 1 | 40 | .528 |
| Math-sci | 1.116 | 1 | 40 | .297 |

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

Table 3. Tests of Between-Subjects Effects

a

| Source | Dependent Variable | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | Technology | 1 | 36.21 | .64 | .43 | .02 |
| | Ped | 1 | 37.82 | 3.00 | .09 | .07 |
| | Math-sci | 1 | 62.65 | 4.90 | .03 | .11 |
| Intercept | Technology | 1 | 199626.88 | 3510.28 | .00 | .99 |
| | Ped | 1 | 16678.20 | 1318.96 | .00 | .97 |
| | Math-sci | 1 | 30951.03 | 2419.21 | .00 | .98 |
| class | Technology | 1 | 36.21 | .64 | .43 | .02 |
| | Ped | 1 | 37.82 | 3.00 | .09 | .07 |
| | Math-sci | 1 | 62.65 | 4.90 | .03 | .11 |
| Error | Technology | 40 | 56.87 | | | |
| | Ped | 40 | 12.65 | | | |
| | Math-sci | 40 | 12.80 | | | |
| Total | Technology | 42 | | | | |
| | Ped | 42 | | | | |
| | Math-sci | 42 | | | | |
| Corrected Total | Technology | 41 | | | | |
| | Ped | 41 | | | | |
| | Math-sci | 41 | | | | |

Computed using alpha = .05

b R Squared = .016 (Adjusted R Squared = -.009)

c R Squared = .070 (Adjusted R Squared = .046)

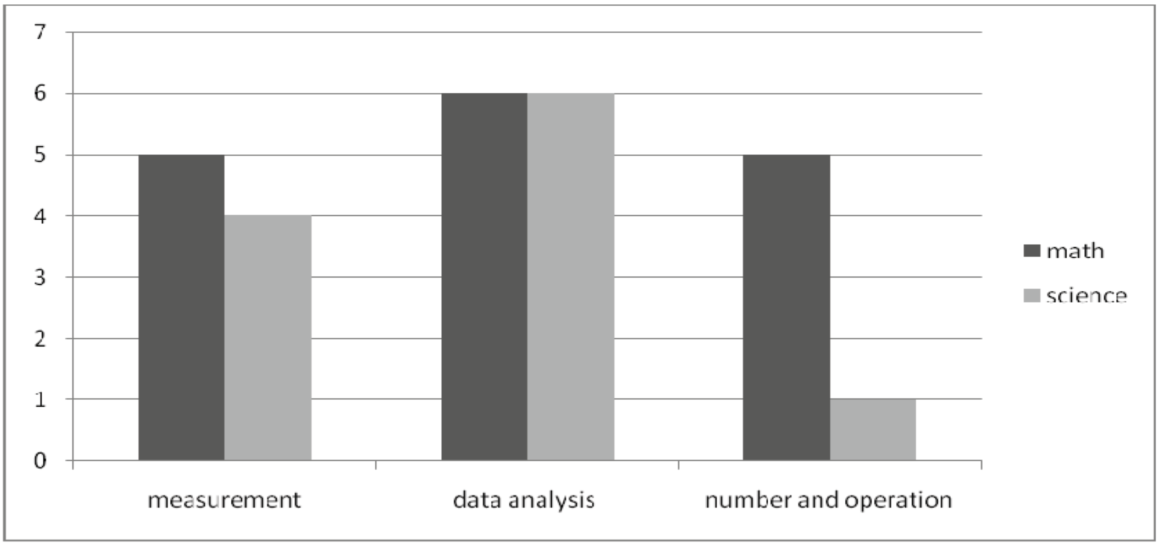


Figure 1. Distribution of mathematics content standards in mathematics and science PT lesson plans (some lesson plans span more than one mathematics standards)

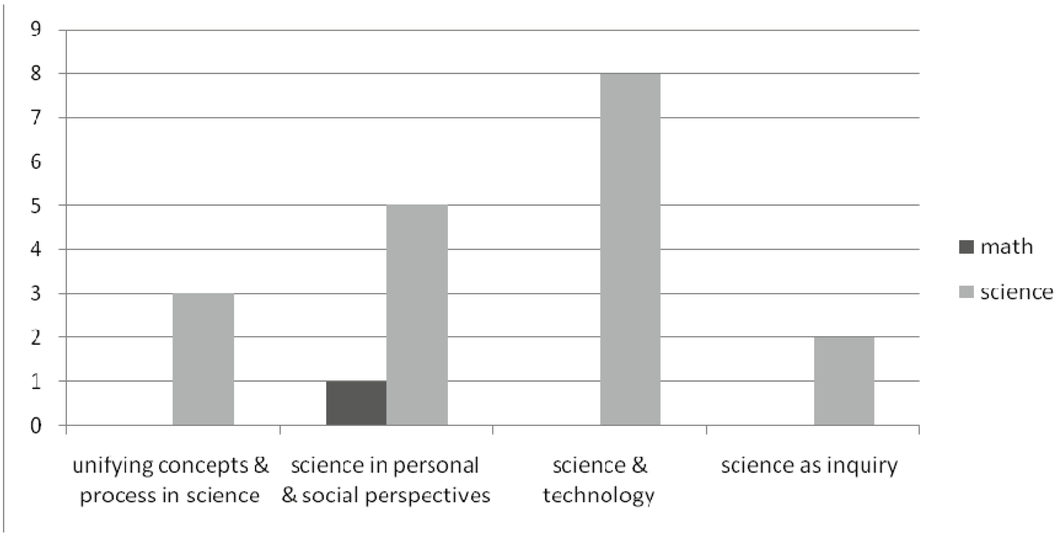


Figure 2. Distribution of science content standards in mathematics and science PT lesson plans (note: some lesson plans span more than one science standards)