EEGRC Poster: Improving Pre-service Elementary Teachers' Nature of Engineering Views with the Use of EV3 Robotics

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Erdogan Kaya is a PhD student in science education at University of Nevada, Las Vegas. He is working as a graduate assistant and teaching science methods courses. Prior to beginning the PhD program, he received his MS degree in computer science and engineering. He coached robotics teams and was awarded several grants that promote Science, Technology, Engineering, and Mathematics (STEM). He has been volunteering in many education outreach programs including Science Fair and Robotics programs such as First Robotics competitions. Over the past four years, he published several journal papers and presented at national and international conferences. Areas of research interest include science and technology education, STEM, and robotics in science education.

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Anna Newley received a B.A. degree in Elementary Education from Arizona State University. She was an employee with the Tempe Elementary School District as a kindergarten, and second grade teacher, and instructional assistant until 2012. From 2012 to the current, she has been employed with the Sonoran Schools District. Presently, at Sonoran Science Academy-Phoenix, she is a fifth grade teacher. She is the contact for several grants awarded to the school. Mrs. Newley coaches the exploratory robotics club for grades 5-8, the Elementary Science Olympiad team, and the competitive high school robotics team, FTC. She contributed to international published papers, national proceedings, and is the process of writing several children's books. This summer she will present a workshop on robotics for elementary school students.

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Hasan Deniz is an Associate Professor of Science Education at University of Nevada Las Vegas. He teaches undergraduate, masters, and doctoral level courses in science education program at University of Nevada Las Vegas. His research agenda includes epistemological beliefs in science and evolution education. He is recently engaged in professional development activities supported by several grants targeting to increase elementary teachers' knowledge and skills to integrate science, language arts, and engineering education within the context of Next Generation Science Standards.

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Ezgi Yesilyurt is a PhD student in curriculum and instruction/science education at University of Nevada, Las Vegas. She is working as a graduate assistant and teaching science methods courses. She received her MS degree and BS degree in elementary science education. She participated European Union Projects in which she conducted series of professional development programs for in-service science teachers. Areas of research interest are engineering education, inquiry learning and evolution education.

Improving Pre-service Elementary Teachers' Nature of Engineering Views with the Use of EV3 Robotics (EEGRC Poster)

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ABSTRACT

The need for engineering education for K-12 students is an ever-present concern of makers of educational policy in the United States. With the release of Next Generation Science Standards (NGSS), engineering design is raised to the level of scientific inquiry. Both pre-service teachers and in-service teachers should be exposed to engineering design through professional development programs and modification of existing science teacher education courses before they are asked to integrate engineering design to their science teaching. The aim of this paper is to document to what extent pre-service elementary teachers improve their nature of engineering (NOE) views after taking an undergraduate level elementary science teaching methods course. This course was modified to make it more compatible with the Next Generation Science Standards. The course in its modified form includes engineering design component. Specifically, the engineering design component was addressed with the use of educational robotics. The pre-service elementary teachers, with no earlier educational robotics experience, were introduced to the engineering design through educational robotics challenges. Pre-service teachers' NOE views were assessed at the beginning and at the end of the methods course to determine whether they improved their NOE views. NGSS aligned challenges with the Mindstorms EV3 educational robotics kit were used to explicitly teach pre-service elementary teachers about NOE. Because of the popularity of First Lego League (FLL) competition in engaging elementary students to engineering fields, researchers used materials associated with this successful program during the course. Simultaneously, pre-service teachers reflected on how these lessons could apply to their future students' understanding of NOE views. In this study, we conceptualized NOE views as engineering design ideas are tentative, subjective, socially and culturally embedded, depends on human imagination and creativity, requires social collaboration and, subject to empirical tests. We found that pre-service elementary teachers improved their NOE views across these NOE aspects. We also found anecdotal evidence that pre-service teachers felt more confident to integrate engineering design into their future science teaching.

INTRODUCTION

To meet the demand for engineering professionals, the United States needs more focus on STEM teacher training to keep its leading role in the world. Since most high school students have already made career decisions by their senior year, and students are influenced by their teachers, creating interest in engineering should start as early as elementary school to motivate students to consider a career in STEM. However, it is rare for elementary teachers to introduce engineering. Perhaps teachers do not have the confidence, or they are not well-equipped with knowledge and skills necessary to integrate engineering, but due to changes in the rigor of educational standards, teacher professional development in STEM must be considered. Comprehensive training for educators is essential since teachers have been assigned the purpose of developing academic skills for college success, and also later in the competitive job market. If teachers are prepared, then their students will become equipped for the challenging tasks that take place in the real world. The increasing demands for STEM professionals, and the release of Next Generation Science Standards (NGSS) compels teachers to update their curriculum knowledge to provide students with the skill set to fulfill those needs. As states adopt NGSS, universities take the initiative to prepare pre-service and in-service teachers. Through integration of engineering in science methods courses, educators are building upon the skills they currently have to increase student success. Robotics education combines engineering and science, in a way that also motivates students towards STEM careers. Robotics is a unique technology platform for increasing student interest in engineering. It was observed that students advanced in problem solving and engineering skills by using robotics in the classroom. Due to its strong nature of instant feedback, and evidence of improved cognitive skills, robotics is one of the successful programs that take place in school curriculums to support student's academic demands in STEM. In a broader sense, robotics can be integrated into curriculum to teach students engineering concepts. However, comprehensive science standards, sufficient materials, and teacher training are essential elements if a program is to be successful.

PURPOSE OF THE STUDY

We propose that with the help of EV3 robots, PSTs, with no experience in engineering, can easily attain the skills and confidence needed to integrate engineering into elementary science classes. Teachers have influence over the perceptions of their students; and although they have a powerful potential to sway students towards STEM careers, there is only some emphasis in engineering in middle and high school. Conversely, at the elementary level, engineering education is generally underestimated and neglected for the sake of other subjects. Additionally, there is extensive research about educational robotics in engineering education. However, there is scarcely any attention in elementary school settings. For these reasons, we need more trained and well-equipped elementary educators that can teach engineering to their students. The purpose of this study is two-fold. Our primary purpose is to describe our engineering unit organized around educational robotics and our secondary purpose is to examine changes in PSTs' NOE views after experiencing the engineering unit. We specifically examined to what extent the 3-week engineering unit organized around educational robotics improved PSTs' NOE views.

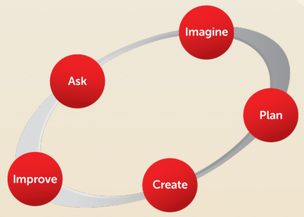

Figure 1. EiE Engineering Design Process. Retrieved from http://www.eie.org/sites/default/files/downloads/EiE/edp_basic.png

ENGINEERING DESIGN PROCESS and NATURE OF ENGINEERING

The Engineering Design Process (EDP) includes five steps: ask, imagine, plan, create, and improve (Figure 1). This cycle demonstrates that the EDP is not a linear, step-by-step method, but a never concluding, dynamic process. It emphasizes that engineers ask questions, communicate with people concerning their needs, test ideas, revise and improve their designs, and share their solutions with the community. Engineers discuss, debate, and adopt the most feasible solution; they don't work alone in an isolated cubicle. It is a creative and exciting process with a lot of human interaction. Everybody works together to constantly adjust their prototypes in order to solve problems.

These characteristics of the EDP are thoroughly described in the Nature of Engineering (NOE) views. Originally, authors were inspired by agreed-upon nature of science (NOS) aspects describe the relevant NOE aspects that are targeted in this study. While the aspects of NOS are well established in pre college education, NOE aspects are yet to be operationally defined given the greater emphasis on engineering in NGSS In our view, nature of engineering (NOE) aspects are similar to NOS aspects except the aspect of the EDP .

Figure 2. Lego Mindstorms Robotics Kit. Retrieved from http://robotsquare.com/wp-content/uploads/2012/02/NXTEducation-9797Box.jpg

PARTICIPANTS

Eleven PSTs participated in this study. All participants were female, with an average age of 21 years, and with varying degrees of engineering knowledge. PSTs' were enrolled in an elementary science teaching methods course offered at a university located in the southwestern United States during the Spring 2016 semester.

We conducted this study within the context of an elementary science teaching methods course designed for PSTs. This course lasted for 15 weeks and it included topics such as nature of science (NOS), students' misconceptions in science, concept mapping, teaching science through inquiry, 5-E lesson planning, integrating science, engineering and language arts, technology applications in elementary science-engineering teaching, assessment, NOE, and NGSS. We spent three weeks on this unit and it allowed us to address three of the nine major topics that we covered in the course: (a) technology applications in elementary science-engineering teaching, (b) NOE, and (c) NGSS.

DATA COLLECTION

Data collected through an open-ended pre- and post questionnaire designed to assess participants' NOE views. We modified *the Views of Nature of Science Version-C (VNOSC)* questionnaire to assess NOE views and we called this modified instrument *the Views of Nature of Engineering* (VNOE) questionnaire. Engineering notebooks, reflective essays, and instructor and PSTs observations were obtained as additional data sources. We then assigned codes (uninformed, partially informed, and fully informed) to the qualitative information independently, and then discussed discrepant results. Discrepant results were re-considered by referring back to the data more closely until consensus was achieved. We based our analysis on the descriptions of NOE aspects presented on the NOE poster (Figure 3). If a participant's response captured the meaning of the NOE aspect without any discrepancy we labeled this response as *fully informed.* If a participant's response captured the meaning of the NOE aspect with some discrepancy we labeled this response as *partially informed.* Finally, if a participant's response included conceptions opposite to the description of the NOE aspect we labeled this response as *uninformed.*

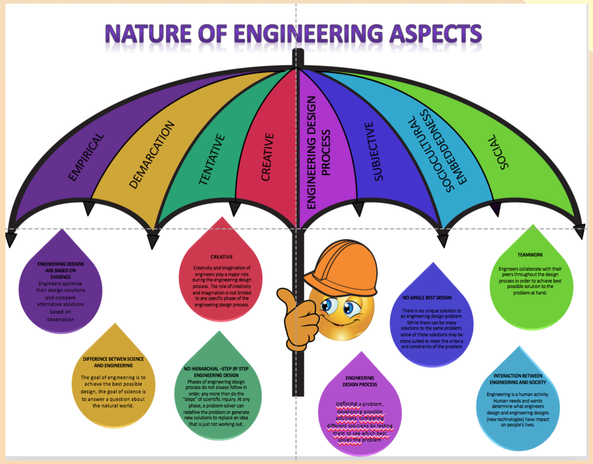

Figure 3. Nature of Engineering Aspects

RESULTS

Our participants changed their NOE views across five NOE aspects (Table 1). Overall, the number of PSTs who held *uninformed* or *partially informed* NOE views declined and the number of PSTs who held *informed* NOE views increased at the end of the engineering unit. According to the reflections, all PSTs enjoyed coding and building Lego robots (Figure 2). All of the participants decided to integrate robotics into their elementary science curriculum. They all mentioned the usefulness and practicality of robotics to engage elementary students, ease of use, and easy integration to other core subjects. All reflective essays were positive and encouraging about the inclusion of educational robotics in elementary classrooms, but they found the activities challenging. They expressed that elementary students should be introduced to engineering as early as possible. Their essays reflected that robotics is one of the best tools to introduce engineering and coding to STEM-savvy generations of the digital age.

Table 1. PSTs NOE Aspects Pre and Post Views.

Number and percentage of participants holding uninformed, partially informed, and fully informed NOE views across five NOE aspects

NOE Aspects	Demarcation		EDP		Tentativeness		Creativity		Social and Cultural	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Uninformed	3 (27%)	1 (9%)	4 (37%)	0 (0%)	2 (18%)	0 (0%)	3 (27%)	1 (9%)	5 (46%)	3 (27%)
Partially informed	8 (73%)	6 (54%)	7 (63%)	2 (18%)	6 (54%)	2 (18%)	5 (46%)	3 (27%)	6 (54%)	7 (63%)
Fully informed	0 (0%)	4 (37%)	0 (0%)	9 (82%)	3 (27%)	9 (82%)	3 (27%)	7 (64%)	0 (0%)	1 (9%)

CONCLUSION

We provided an account of how we introduced engineering design process into our elementary science teaching methods course, which was designed for PSTs. This research can be beneficial to science teacher educators who are planning to integrate engineering design into their elementary and/or secondary science teaching methods courses in an NGSS era. We explicitly introduced NOE aspects to PSTs and asked them to reflect upon their engineering design experiences from the perspective of NOE aspects. As a result of our pre- and post assessment of our participants' NOE views we found that they improved their NOE views. However, it should be kept in mind that we only had 11 PSTs in our study and we used a modified version of an open-ended NOS questionnaire to assess our participants' NOE views. Future studies should consider including more participants and using a more robust NOE questionnaire.

Preparing PSTs to teach engineering design in elementary classrooms can be a first step in the right direction to start developing engineering literacy among elementary students. This increased awareness about engineering literacy can trigger elementary students' interest in STEM careers and it can allow students to make more informed decisions about their career selections.