

## Developing an Integrated Mathematics and Human Factors Engineering Curriculum for Middle School Students

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### Abstract

In this work-in-progress study, we detail our research project that focuses on developing, implementing, and assessing an integrated mathematics and human factors engineering curriculum for middle school students. The curriculum will integrate mathematics and human factors engineering topics to specifically increase young students' awareness of math in engineering applications as well as career opportunities. The curriculum will be grounded in evidence-based teaching methods and pedagogy. It will first be developed and created in a teachers' workshop and then piloted in an informal environment, a weeklong summer camp for middle school students. Then it will be offered as an ongoing after school activity. Finally, it will be transitioned into a 4-week core module that is team taught by middle school math teachers. This research will provide: (1) critical insights about the learning outcomes of middle school students who are exposed to an engineering curriculum in an informal environment and (2) an evaluated example of an engineering curriculum for middle school students.

### Keywords

Mathematics, industrial engineering, middle school, curricula

### Introduction

To produce more engineers to meet future workforce demands, we must increase students' interest and understanding of career opportunities in science and engineering<sup>1,2</sup>. Informal learning environments like summer camps have been shown to increase students' knowledge and interests in science, technology, engineering, and mathematics (STEM) to encourage them to pursue STEM careers<sup>3-6</sup>. Yet, informal environments tend to lack an established, guiding curriculum that helps students understand how math is applied in science and engineering while also exposing them to specific engineering principles, disciplines, applications, and career opportunities.

As a discipline, industrial engineering, which includes human factors, has been characterized as an "inviteful" type of engineering major<sup>7</sup> with career opportunities in healthcare, operations, ergonomics and more. In addition, industrial engineering has been shown to have mass appeal to various demographic groups such as women and minorities<sup>8,9</sup>. Consequently, creating an engineering curriculum based on a discipline that offers many facets of opportunities in various career areas and is attractive to various demographics may appeal to younger students. In addition, human factors engineering contexts can be designed to teach and reinforce content areas that are central to middle school mathematics (i.e., percentages, rates, ratios, proportionality and data variability). It can also be used to teach basic physics of motion

and force. Thus, a human factors engineering middle school curriculum that integrates mathematics can increase middle school students' understanding of applied math in human factors applications and their interest in engineering and engineering careers.

In this exploratory research project and study, we will develop, implement, and assess an integrated mathematics and human factors engineering curriculum for middle school students. The curriculum will be grounded in evidence-based teaching methods and pedagogy. It will integrate mathematics and human factors engineering topics to specifically increase young students' awareness of math in engineering applications as well as career opportunities. Yet, the key curriculum design challenge will be to ensure that common core skills are all naturally at the heart of the curriculum and not added as a secondary objective. As the STEM Integration in K-12 Education reports, "more integration is not necessarily better."<sup>10</sup>

Our project will be guided by recommendations 5, 6, 7 and 8 from that report that should guide the development of integrated STEM experiences. Designers of integrated STEM education initiatives need to:

- 5) be explicit about the goals they aim to achieve and design the integrated STEM experience purposefully to achieve these goals.
- 6) make STEM connections explicit to students.
- 7) attend to the learning goals and learning progression in the individual STEM subjects.
- 8) provide professional development that is designed as partnerships among educators, STEM professionals, and researchers.

In this work-in-progress paper, we provide details about our preliminary project and research study and our proposed research methods in the process of developing and assessing a middle school math and human factors engineering curriculum.

## Developing the Curriculum

There are several aspects involved in developing our integrated mathematics and human factors engineering curriculum for middle school students. First, the curriculum will be developed and created in joint collaboration by middle school math teachers and experienced education professors in a teachers' workshop. The developed curriculum will then be piloted in an informal environment, a weeklong summer camp for middle school students. Then it will be offered as an ongoing after school activity. Finally, it will be transitioned into a 4-week core module that is team taught by middle school science and math teachers. This last stage is critical. The potential for bringing engineering into middle school dramatically increases if the contexts used teach and reinforce core middle school math, science and language arts skills. The opportunity to interest a broader segment of the population in STEM careers is dramatically enhanced if STEM learning is a natural and exciting part of the curriculum and not an add-on. This project will demonstrate the potential for an integrated approach to accomplish this. The study's research questions are: (1) what are the learning outcomes and attitudinal changes for middle school students who participate in a mathematics and human factors engineering curriculum-based camp and (2) what are the attitudinal changes of middle school teachers who learn to develop and teach a mathematics and human factors engineering curriculum-based camp for middle school students?

## Proposed Methods

Our research inquiry will employ an explanatory mixed methods research design using quantitative (pre- and post- surveys) and qualitative (pre- and post- interviews, observations) methods<sup>11</sup>. Survey and interview protocols will be based on existing theoretical frameworks grounded in learning theory. The sample population will consist of middle school students who have been taught using the developed curriculum as well as the teachers of the curriculum. Data will be statistically analyzed and thematically coded and analyzed to produce the most emergent themes about the curriculum and learning outcomes and attitudinal changes of the participants. This project will be externally evaluated in terms of ability to engage student interest in the science and mathematics studied. It will also be evaluated in terms of its ability to develop and enhance several common core math skills for grades 6-8 using pre-and post- surveys.

## Anticipated Outcomes

In developing, implementing, and assessing an integrated mathematics and human factors engineering curriculum for middle school students, we will be able to increase the population's knowledge about mathematics and engineering as well as measure their learning outcomes. In addition, this research will provide: (1) critical insights about the learning outcomes of middle school students who are exposed to an engineering curriculum in an informal environment and (2) an evaluated example of an engineering curriculum for middle school students. The curriculum may be reproduced and used in various formal and informal contexts to teach middle school students about engineering. This may result in helping to increase secondary students' interests and participation in pursuing engineering careers to help meet future engineering workforce demands.

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## **2017 ASEE Zone II Conference**

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Kenneth Chelst is Director of Engineering Management in the ISE Department at Wayne State University in Detroit, Michigan. He received the Ph.D. degree in operations research from M.I.T. For more than 20 years he has worked with professors of math education and classroom teachers to develop meaningful real-world mathematics curriculum. He has co-authored three books for high school mathematics, When will I use this? Volume I: Algebraic Modeling, Volume II: Probabilistic Decision Making and Does this line ever move? Everyday applications of operations research. Dr. Chelst is an expert in applied mathematical modeling with special expertise in emergency service management and engineering management.