Engineering Our Future New Jersey: Middle School Program

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Abstract

Engineering Our Future New Jersey (EOFNJ) is a collaborative effort between Stevens Institute of Technology, New Jersey Department of Education, the Museum of Science, Boston, and other partners to bring exemplary technology and pre-engineering curricula to mainstream New Jersey K-12 education. The goal of the Engineering Our Future New Jersey project is to ensure that all K-12 students in New Jersey experience pre-engineering curricula, with a focus on innovation, as a required component of their elementary, middle, and high school education within the next five years.

The EOFNJ program is transitioning from the pilot phase into a state-wide implementation phase. This paper will provide an overview of the EOFNJ program, describe the current program efforts, describe the exemplary curricula used at the middle school level in the EOFNJ program, and offer preliminary evaluation results of the middle school pilot study.

1.0 Introduction

Engineering Our Future New Jersey (EOFNJ) is an initiative of Stevens Institute of Technology's Center for Innovation in Engineering and Science Education (CIESE) to promote pre-engineering and technology education in elementary, middle, and high schools throughout New Jersey. With support from Verizon Communications and the National Science Foundation, CIESE will provide professional development to 2,000 K-12 teachers throughout New Jersey in the next three years.

Working with curriculum partners such as the Museum of Science, Boston, which has developed exemplary elementary and secondary-level pre-engineering curricula and with the Society of Automotive Engineers, for middle school curricula, Stevens will provide teacher professional development, technical assistance, and in-class support to participating schools. Other partners, including the New Jersey Department of Education, are engaged in this outreach effort.

This paper will discuss the EOFNJ efforts in the middle-school grades, including the pilot testing of Society of Automotive Engineer's *A World in Motion* curriculum. The elementary school-level EOFNJ efforts are detailed in a separate paper.

2.0 Middle School EOFNJ Efforts – *A World in Motion*

Phase 1, the first year of EOFNJ, the middle school efforts focused on piloting one of the Society of Automotive Engineer's modules *A World in Motion – Challenge 2 curriculum* in eleven middle schools throughout the state of New Jersey.

A World in Motion – Challenge 2 (AWIM) is an example of an exemplary curriculum that creates an exciting learning environment by bringing authentic engineering design experiences into the classroom. The AWIM program brings math and science principles to life through highly interactive learning experiences that incorporate the laws of physics, motion, flight, and electronics. The AWIM curriculum is designed around current national math, science, and technology student learning standards.

There are three AWIM "Challenges." We chose to use Challenge 2, whose premise is that a company named "Mobility Toys, Inc." is searching for new ideas for its Globe Rangers line of toys. The learning starts when students receive a "Request for Proposals" inviting design teams to design simple, mechanically propelled toys that appeal to children between the ages of 6-10. Learning activities throughout the challenge revolve around intense exploration of hands-on materials and community resources. Activities weave together science, mathematics, technology, teamwork and communication skills, reinforcing key concepts such as force, motion, gears and gear trains, ratio, and others. Student design teams pool their talents to create a successful prototype and make a final presentation of their design rationale. Teachers guide students through a six-phase engineering design process: Set goals, Build knowledge, Design, Build and test, Finalize the model, and Present.

2.1 Middle School Pilot Study

Prior to the start of the pilot study, the AWIM Challenge 2 curriculum was reviewed by the CIESE staff to align the materials with New Jersey Core Curriculum Content Standards and identify areas in the curriculum that may need clarification or additional support materials to assist classroom teachers with the implementation of Challenge 2 in classrooms. In order to make the curriculum useful to as wide a range of teachers as possible, the existing eight-week Challenge 2 curriculum was condensed by CIESE and AWIM staff into five curriculum units that could be taught over four weeks.

The schools and teachers that participated in the pilot study were recruited from across the entire state of New Jersey. The recruitment goals were to 1) obtain enough participating schools to create a valid pilot study, 2) ensure the school administration participation and support of the use of AWIM Challenge 2 curriculum materials in their schools, and 3) engage schools within the entire socio-economic spectrum represented in New Jersey, with an emphasis on the lower performing districts.

Once selected for the program, the teachers were expected to complete the following tasks:

- Attend a two-day teacher training session, (held December 1 and 2, 2005).
- Deliver (teach) the selected modules as presented during the December workshops to their students at some point during the project timeframe of January – June 2006.
- Receive Stevens/CIESE representatives into classrooms to support and observe implementation.
- Administer pre-tests and post-tests to students.
- Participate in a focus group about the effectiveness of the unit.
- Complete surveys regarding the implementation of the materials.

Upon completion of all the tasks outlined above, participating teachers received a $300.00 stipend for their efforts.

All participating pilot teachers received enough AWIM Student Kits and support materials to implement the curriculum with all their students at no cost. The cost of the kits was subsidized by the Society of Automotive Engineers Foundation. The AWIM Student Kits include the necessary parts (vehicle frame, motor, gears, axles, bushings, spacers and drive collars) for students to design and construct a chassis for their motorized toy. The teachers also received AWIM Teacher Kits (spring scales, AC adapter), a complete AWIM Challenge 2 curriculum binder, videos and posters as classroom support materials.

The pilot began with a professional development workshop conducted at Stevens Institute of Technology on December 1 -2, 2005. The two-day workshop was attended by twelve teachers from eleven New Jersey schools, representing grades 6, 7 and 8. Two teachers (from one school) dropped out of the program soon after the professional development workshop and are not included in the pilot data detailed in the Results section.

The workshop included an overview of the EOFNJ program, the AWIM Challenge 2 curriculum, the science, engineering, technology and literacy skills necessary for successful completion of the project, and time for the teachers to design and assemble a toy of their own from the AWIM Challenge 2 Student Kit materials.

To allow for flexibility with individualized teaching plans, the AWIM Challenge 2 implementation period ran from January through June 2006. The CIESE staff assisted pilot teachers with the scheduling and implementation of the AWIM Challenge 2 curriculum. In addition, each teacher received two school site visits by CIESE staff to observe students using the materials or assist in the teaching of the materials.

The pilot teachers were responsible for completing online surveys, administering pre- and post-tests with students, and participating in a focus group in June 2006 to discuss the implementation and success and failures working with the curriculum.

2.2 Middle School Pilot Study Results

The AWIM Challenge 2 pilot project evaluation was conducted by Dr. Susan Lowes of Teachers College, Columbia University, and had several components. The pilot study teachers were asked to complete a short survey at the end of each of the five units and another survey after the curriculum had been completed. In addition, although the curriculum as written had a number of embedded assessments, it had no pre- or post-tests. Therefore one pre-assessment on gears (adapted from a much more complex study by Dan Schwartz and John Black on mental models of physical systems) [1] and two pre-post assessments on engineering and technology were added. The two pre-post assessments on engineering and technology were adopted from the Museum of Science's Boston Engineering Is Elementary curriculum, used with the EOFNJ elementary-level pilot project discussed in a separate paper.

The first major finding of the evaluation was that the curriculum is extremely flexible. It was used in high-achieving classrooms, lower achieving classrooms, with Special Education students, and with ESL student; it was used primarily as a whole-class curriculum but also as a pull-out enrichment experience. Teachers were able to---and did—adapt it to the needs of their subject areas, curriculum content, and student learning levels. The project activities allowed students to contribute in different ways, from design (of the "company" logos) to keeping design logs, to building and testing equipment.

The second major finding was that the teachers uniformly reported that their students loved the activities, and that this was equally true of boys and girls. Although several teachers reported that although some of the girls were reluctant at first, they found that in the end the girls were just as competitive as the boys.

The pre-test of understanding of gears showed that few of the students in 6th, 7^{th}, and 8^{th} grade understood open-chain and long-chain gear configurations. The results for the test that elicited student conceptions of what an engineer does showed that these conceptions expanded between pre- and post-test so that they not only included a longer list of engineering tasks but were much more likely to include the fact that engineers "work in teams" and "read about inventions," both of which are likely to have been a direct result of their experiences during the AWIM project.

The evaluation of the pilot was designed to elicit problems as well as successes. The questions addressed, with the assessment to date, are as follows:

<u>Curriculum design and implementation</u>
Question: Can the adapted and condensed AWIM curriculum be implemented successfully? Is it logical and coherent from a teaching point of view? Can it be implemented in the allotted time?
Answer: As noted above, the curriculum was flexible enough for the teachers to adapt it to their needs. However, all reported that they either took more than the allotted time or they cut some items in order to make it fit. CIESE is reviewing the timeframe for each of the activities to make it more manageable.

Question: What additions do teachers feel they need to make to the AWIM curriculum in order to use it with their students? What other changes do they make and for what reasons?
Answer: Overall, the teachers made very few changes and there was no particular pattern to the changes they did make. However, many teachers came up with innovative ideas, including worksheets and templates, which have been added to the curriculum and/or to the project website, for use by teachers in the future.

Question: How familiar are teachers with the concepts covered in the AWIM curriculum? How many of them do they already teach? How does the AWIM curriculum fit with their existing school curricula? Does it replace parts of the syllabus, or is it an addition?
Answer: None of the pilot teachers reported that they already teach all the concepts covered in the curriculum. For some, the curriculum was a different way to cover existing material. For others, it was an excellent follow-up to the more basic material they already teach.

Student learning
Question: Does the AWIM curriculum increase student interest in physical science/engineering?
Answer: Although the evaluation did not address this directly, as noted above, all the teachers reported that the students were enthusiastic about their projects.

Question: Are there gender differences in interest in the AWIM curriculum, final projects/designs, and pre-post assessments of learning?
Answer: The fact that the curriculum combined many different skills in addition to building cars was a plus in attracting girls, who seem to have done most of the poster designing and car decorating. In addition, as noted above, the teachers reported that, once an initial hesitation was overcome, the girls liked the construction process.

2.3 Future AWIM Challenge 2 Implementation

The New Jersey AWIM Challenge 2 project implementation will continue to be supported by CIESE and the SAE Foundation for at least the next two school years. CIESE will continue to partner with school districts and offer professional development sessions in various locations around New Jersey to adequately prepare teachers to implement the curriculum in their respective classrooms. The SAE Foundation has committed to continue underwriting the costs for the AWIM Student and Teacher Kits and supporting materials in exchange for supplying evaluation data on the materials.

3.0 Conclusion

The pilot Engineering Our Future New Jersey program met with great success with middle-school grade levels throughout New Jersey. The expansion plans of the EOFNJ program are underway and include: 1) continued support of the Museum of Science, Boston, and Society of Automotive Engineer’s curricula as it is implemented in additional schools across the state of New Jersey, 2) professional development for an additional 2,000 K-12 New Jersey classroom teachers in the next two years, 3) expanded engineering curricula offerings, and 4) development of engineering curricula for high schools. The entire effort will bring us closer to the overall project goal: to ensure that all K-12 students in New Jersey experience pre-engineering curricula, with a focus on innovation, as a required component of their elementary, middle, and high school education within the next five years.

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Bibliographic Information

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