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SAE AWIM Evaluation
Executive Summary

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SUBMITTED TO

SAE International

May 2010

EXECUTIVE SUMMARY

A World in Motion (AWIM) is a physical science program, developed by SAE International in 1990, which aims to promote science and mathematics literacy of students in grades four through 10 by providing curriculum materials for authentic engineering design activities in the classroom that support a multidisciplinary, cooperative working experience. In 2005, Goodman Research Group, Inc. (GRG), a research firm specializing in the evaluation of educational programs, materials, and services, began a five year, two-part multi-method evaluation to examine the long-term impact of the AWIM program on students and teachers. The study was designed to address the following research questions.

1) How does participation in AWIM affects students' Science, Technology, Engineering, and Math (STEM) attitudes, knowledge, and achievement, and how does it affect their interest in pursuing a STEM-related career?
2) How does participation in AWIM influence teachers' attitudes and approaches to teaching science?
3) How does the involvement of industry volunteers influence the experience, both for students and for teachers?

After a retrospective study of AWIM teachers and industry volunteers who had used AWIM in the past five years, a five-year longitudinal evaluation examined the short- and long-term effects of AWIM use on students and teachers.

In the 2005-2006 Academic Year 33 teachers from schools across the United States and Canada, and their students in grades five, seven, and eight, were assigned to one of three experimental conditions, including two treatment groups and one control group:

1) **Veteran Teachers:** Had used AWIM in the past, and would use AWIM during the 2005-2006 Academic Year
2) **Novice Teachers:** Ordered AWIM for the first time, had never used it before, and would use AWIM during the 2005-2006 Academic Year
3) **Control Group Teachers:** Ordered AWIM for the first time, had never used it before, and would wait until the 2006-2007 year to use AWIM

The sample comprised 17 Veteran teachers, nine Novice teachers, and seven Control group teachers. Approximately twice as many 5th grade teachers as 7th and 8th grade teachers completed the study. Challenges used were: JetToy (Grade 5, youngest cohort), Motorized Toy (Grade 7, middle cohort), and Glider (Grade 8, oldest cohort).

In all, GRG collected teacher data twice, and student data at six time points, including the initial intervention year (pre and post surveys) and four follow-up years. GRG retained a portion of students from each of 29 schools, with one to 43 students per school, over the course of the four follow-up years. During the first year, GRG also conducted classroom observations in eight schools and interviewed 11 teachers by phone.

The demographic distribution of students in the study over the course of five years remained stable. About half were girls and half were boys, most identified themselves as non-Hispanic, about three quarters were White, and just under one-quarter were Black or African American. On average, students ranged from 10 to 14 years of age (youngest cohort), 12 to 16 years (middle cohort) and 13 to 17 years (oldest cohort). These proportions held true for each year of the study.

This document summarizes key findings and recommendations from the longitudinal study.

KEY FINDINGS

Participation in one AWIM Challenge, including working in student teams to complete an authentic engineering design experience, is enough to start students on a path of knowledge and interest in engineering.

In the short term, students demonstrated content learning as a result of their participation in AWIM challenge activities.

Student performance on two assessments embedded in the curriculum indicated an increased understanding of specific content presented. Building the JetToy, students increased understanding of factors that influence speed and distance, with a particular mastery of the effect of nozzle size. Building the Motorized Toy, students showed increased understanding of how to calculate gear ratios. Building the Glider, students showed increased understanding of mechanisms of flight.

The longer term added value to student enrichment and learning of SAE's AWIM curriculum is specifically in the area of engineering.

According to the 2009 report, *Engineering in K-12 Education: Understanding the Status and Improving the Prospects* (Katehi, Pearson & Feder, 2009), while formal engineering education in K-12 classrooms is a growing area, there is much to be learned about the effects and effectiveness of various curricula.

In the current study, students who used AWIM for four to six weeks, on average, showed stronger **understanding of engineering** and greater increases in **attitudes toward engineering** over time, than students who were not exposed to AWIM.

At each follow up after the intervention year, AWIM students included more depth of understanding in their descriptions of what engineers do. For example, there was more use of the words, "design," "problem" and "solve" in their responses. Students who used AWIM also showed greater increases in attitudes toward engineers and engineering over time than did students who did not use AWIM.

AWIM is most effective in changing attitudes among students who enjoy and value the AWIM experience. Having an experienced teacher lead the activities enhances students' self-reported enjoyment and learning.

Greater increases in science, math, and engineering (SME) attitudes were seen over time among students who reported a more positive experience with AWIM in terms of the extent to which they enjoyed the activities and how much they felt they learned from the experience.

Particularly teachers with prior AWIM experience perceived that students enjoyed learning about STEM topics and appeared interested in learning more in the future. Students of veteran AWIM teachers, and students in the youngest cohorts, gave higher ratings for having "fun" with the AWIM activities.

The involvement of an industry volunteer during AWIM activities leads to strong student knowledge of engineering that is sustained over time.

Students who recalled the presence of a volunteer had higher overall engineering knowledge scores than did students who did not recall a volunteer's visit. Teachers also perceived a positive impact of the volunteer's visit. Veteran teachers, many of whom had worked with the same volunteer over multiple years, attributed slightly more positive student reactions to the volunteer than did novice teachers.

Use of AWIM, particularly repeated use, increases teachers' confidence and comfort with teaching science in innovative ways.

The quantity and quality of information provided by the AWIM program increases teachers' confidence for teaching in general, increases their comfort with physical science concepts in particular, and encourages them to push the envelope with their teaching practices and style. The effects are cumulative, benefitting teachers and students.

Beyond use of the AWIM curriculum, other variables that affected student outcomes included student characteristics and out of school experiences including social and academic support at home.

AWIM exposure had the greatest impact on the engineering attitudes of the youngest cohort of boys who were told they would make good scientists, received more support form home, and who engaged in more out of school time (OST) STEM experiences.

Over time, younger students expressed more interest in STEM and a STEM-related career. Younger students also took increasingly more STEM classes over time and described plans for STEM-related majors, than did students in the older cohorts.

During the course of the study, boys showed more interest in working in a STEM-related field. Conversely girls, more than boys, described a STEM-related job they might have at 30 years old, corresponding with national trends

RECOMMENDATIONS FOR AWIM CURRICULUM

Based on short term findings in the first year of the longitudinal study, GRG recommended that SAE include in the teacher's manual, and on the AWIM web site, specific strategies for teachers to adapt the curriculum to fit their needs. Recommendations were also made for highlighting: 1) the value of involving an industry professional in at least a few of the Challenge activities, and 2) data on the cumulative effects of AWIM, with the aim of encouraging teachers to continue with the program and use it with students each year.

In the intervening years, SAE has redesigned and enhanced the AWIM website, and incorporated many of the recommendations. The web site now offers the full curriculum, access to the teacher's manuals, information about conferences, workshops, research, and news about the program. ***GRG recommends AWIM include an additional "research literature" section that would present relevant articles about the state of K-12 engineering, and predictors of STEM outcomes.***

After following this group of students for four more years, GRG presents similar recommendations, now with a stronger understanding and emphasis on how significantly the above also affects the students. When teachers are more comfortable with conducting the AWIM Challenge activities and with including volunteers, students benefit greatly. They enjoy the experience more, they learn more about engineering, and their interest in STEM related courses and careers increase.

GRG recommends that SAE continue to highlight on the website the value of teachers' repeated use of the curriculum, teachers' working with a volunteer, as well as efforts to involve others outside of the classroom with the AWIM Challenge experience. Data revealed the importance of students receiving science-related encouragement, both from teachers and parents, and of participating in OST STEM experiences. Over the course of the study, the actual number of OST STEM experiences did not increase, yet, students with more such experiences showed increased gains in nearly every AWIM student outcome of interest, particularly STEM-related attitudes and career interests.

GRG recommends AWIM provide suggestions and specific strategies to involve students' parents in the Challenge activities. Both school and home activities can include parent participation, parents can be invited to the classroom or school for an AWIM event, and extension activities can be offered that would encourage STEM interest at home or in the community (e.g., at libraries or museums).

GRG recommends AWIM incorporate strategies to connect deliberately the in-school classroom activities to out-of-school programs, clubs, and events. Classroom teachers can collaborate with afterschool group leaders to design extensions from the classroom to afterschool programs, perhaps turning the toy vehicle into a science fair project and/or submitting it to a competition.

RECOMMENDATIONS FOR FUTURE RESEARCH

As SAE International moves forward with the AWIM curriculum, creating new Challenges and modifying web resources and teacher and volunteer trainings, additional research will provide insight for future decisions regarding additions to the curriculum and/or website and prospective proposals to funding agencies.

Continued Follow-up with a Sample from the Current Study

Beyond the AWIM activities, factors that strongly predicted STEM-related pursuits were: science-related encouragement, OST STEM experiences, age, and gender. Moreover, students' ratings of interest in STEM careers did not always match their stated ideas about jobs they might have at age 30. Future research that follows students in, and possibly beyond, college to their entry into the workforce will present a strong picture of the AWIM students' actual STEM-related paths.

The fourth follow-up survey for the current study was administered online; 174 students completed the survey. A new study could be designed, with permission from these students and their parents, to follow as many of them as possible for the next several years. Asking about their STEM-related experiences in and out of school, their college major, and their actual career and/or graduate school choices, we could then examine in more depth the relationship between reported interest and plans in high school and actual choices and behaviors. GRG has already developed a relationship with these students, and their parents, and has a mechanism in place to contact them for subsequent research.

Empirical Research Study Based on Current Findings

The current longitudinal study was the first evaluation of AWIM using an experimental design. The research questions addressed reflected an exploratory pursuit. Given current findings, future research can include specific hypotheses.

Based on findings about the influence of students' science-related encouragement and their out of school experience, SAE might predict that students who participate in AWIM activities both in an out of the classroom would show greater gains in the outcomes of interest than would students who participate only in the classroom.

Other factors to examine might include specific parental involvement, discussion of science-related career choices in school and at home, and a more detailed look at volunteers' involvement.

Now that a precedent has been set for conducting science-based research of AWIM activities, especially given the current culture of interest in the implementation and effectiveness of engineering education, SAE is well-positioned to continue this type of exploration of the effects of AWIM on students.