Evaluation of the MY TIME After School STEM Program
At Granger Middle School and Fischer Middle School
Indian Prairie School District 204

And

Bednarcik Junior High School
Oswego School District 308

Prepared by
Jane L. Davis, DVM, MS

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In the spring and fall semesters of 2014, Aurora University's Institute for Collaboration developed a six unit After School STEM Program which was implemented at Granger and Fischer Middle Schools of Indian Prairie School District 204, and Bednarcik Junior High of Oswego School District 308. Each unit consisted of four lessons, delivered one day a week over the course of three to four weeks.

CURRICULUM DEVELOPMENT

Each unit was prepared using Aurora University faculty, area teachers, and community partners consisting of area industries and nonprofit organizations with an expertise in science education. These units have become a part of the curriculum for the John C. Dunham STEM Partnership School at Aurora University, which serves students in grades 3-8. These collaboratively developed units are aligned to the Next Generation Science Standards, the Common Core Standards in Mathematics, and best practices in inquiry-based learning. The units are also based on the supply chain process involved in manufacturing, which has broad implications throughout the STEM fields. Delivering these units in Middle Schools and a Junior High in school districts associated with the John C. Dunham STEM School has enabled the partnership to broaden the impact of the collaboratively designed curriculum throughout the community, and given access to an increased number of students with a broader range of interests and abilities.

PARTICIPANTS

The lessons were presented by a team consisting of Aurora University faculty, professional educators from one of the school districts involved in the John C. Dunham STEM Partnership School, and Aurora University undergraduate students who served as student leaders. Approximately 142 students were impacted by the curriculum lessons in the spring semester and 160 in the fall semester which may represent a duplicate count. These students were enrolled as part of their involvement in Communities in Schools which provides after school experiences to middle school students in the Aurora area. Many of these students are considered at risk for academic and behavioral problems. Neither the students nor their families chose STEM as part of the curriculum beyond permission to participate in the Communities In School's My Time After School Program.

EVALUATION PLAN

Evaluation consisted of both quantitative and qualitative data. For the qualitative experience evaluation of the children, students were asked before and after the unit

- If they liked mathematics
- If they liked science,
- If they wanted to take another after school class in mathematics and science
- What type of career they were interested in

To quantitatively measure gains in content knowledge, students were asked five questions on the most important themes from each unit. Students were presented this material as "questionnaires" and told there was no grade given for the evaluation. This was done to reduce test anxiety and to maintain the enjoyable and "safe" learning environment. Results of these content questions were evaluated using an independent T test for unequal variances, or a paired T test when possible. Aurora University faculty and school district teachers were involved in focus groups to explore their experiences within the program.

Aurora University faculty, school district teachers, and Aurora University student leaders were surveyed on their attitudes about and confidence in providing STEM education. They were also invited to attend focus groups. Survey and focus group questions may be found in Appendices A, B, and C.

SPRING 2014 PROGRAM

STRUCTURE AND FUNCTION

Sixth, seventh and eighth graders were given enriched curriculum based on the unit of Structure and Function of Organisms. The essential questions addressed included:

- "How do the individual structures in the system contribute to the overall functioning of the whole organism?"
- "What are the similarities and differences in the structure of systems and how they function in organisms?"
- "What are ways cardiologists repair the circulatory system?"

The goals of this unit are for students to continue to increase their understanding of the relationship between form and function. Students learned the importance of substructures to the overall function of organisms and investigated the similarities and differences of systems in plants and animals. They also investigated the function of the circulatory system in a human using a torso model. In each session the unit was delivered, students showed statistically significant gains in their content knowledge. ($P=<0.05$) (See Graph 1). Several students in the three middle school programs also showed increased interest in careers that require a STEM education and in taking another after school class with STEM content.

ENERGY AND MATTER

Enriched curriculum was implemented in Energy and Matter for grades six, seven, and eight in the middle school programs.

The essential question addressed was:

- "What is stuff made of?"

Goals included having students explore the properties of different materials. To explore the nature of matter, students modeled atoms and their interactions. To learn more about the properties and uses of metals, electrical conductivity was compared between different materials. To expand the material science connection to non-metals, polymer superballs were created by students.

This unit also showed the students made statistically significant gains in content knowledge throughout the unit. (P=<0.05) (See Graph 1). Though students did not often report changing their minds about potential careers, those who did identified a STEM career as their new choice. Several also identified a preference for taking another STEM related after school class in the future.

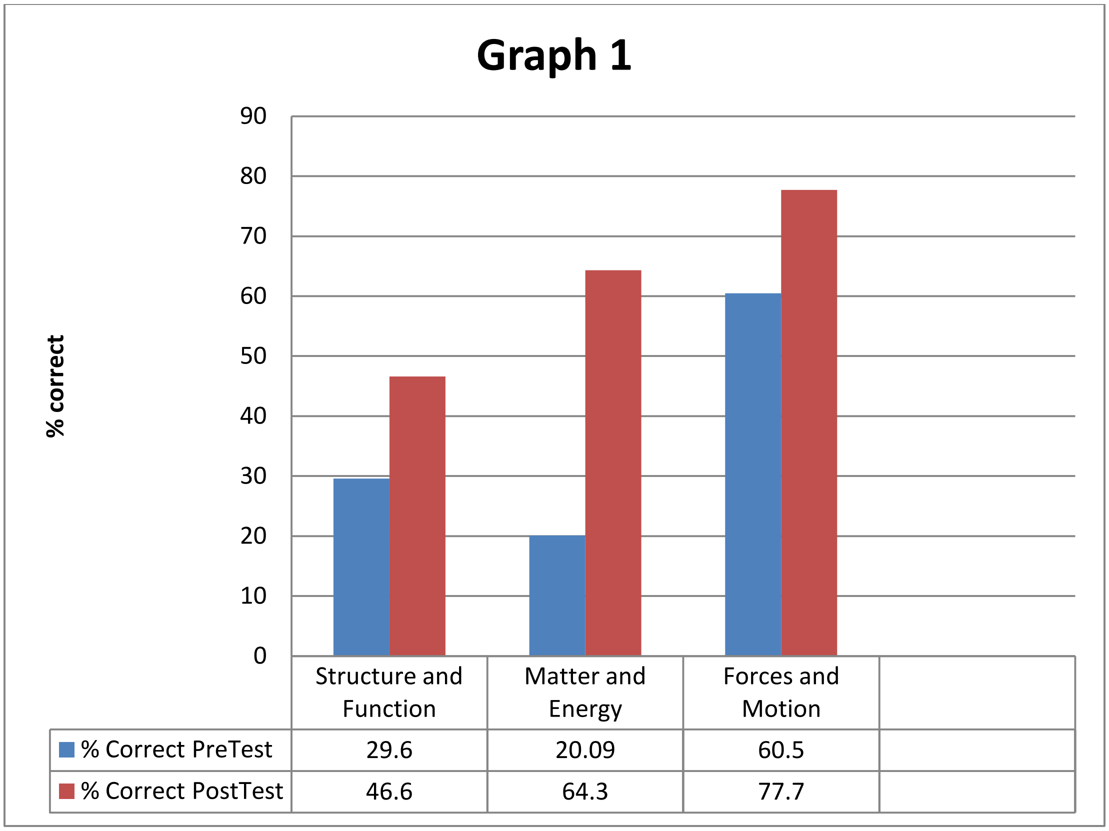
FORCES AND MOTION

Students from sixth, seventh and eighth grades were given after school curriculum enriched in concepts involving forces and motion in the theme of Materials of Sports. The essential questions explored were

- "How do we describe motion?"
- "What material properties affect motion?"

The goals of the unit include helping students develop a deeper understanding of the forces that cause the motion of an object within the context of various games; helping students become proficient in using tools to collect measurement data and the language to describe their observations, and predict motion and the effects of gravity on moving objects. Students also observed energy transfer between potential and kinetic energies and learned that energy cannot be created or destroyed, but can change in form. Activities included comparison of rebound heights of balls made of different materials, fabricating a ball, and determining the factors that affect energy transfer.

Students showed gains in content knowledge, but they were not statistically significant. (See Graph) Student interest in STEM careers increased over the course of the units, as did their interest in taking further mathematics and science classes.



Graph 1 - Spring Semester Content Knowledge Gained
Percent Correct Pre and Post Test

FALL 2014 PROGRAM

ECOSYSTEMS AND ADAPTATIONS

This program provided students with a relatable experience of how things in nature evolve by investigating biomimicry and the soles of shoes.

The essential questions explored include:

- How does biomimicry impact design?
- What does an organism need to adapt in an ecosystem?
- How do adaptations contribute to the survival of a species?

The students were asked to explore how shoes are chosen for a given activity and related knowledge acquired through experience and through classroom discussion on how different animals have different surface topographies present on their feet. After this, students were challenged to create a shoe surface that needed to adapt to a mountainous terrain. The shoe surfaces were 3D printed and grip tested; and, the results from the testing were discussed as a group. Finally, the scientific examples and evidences of physical and behavioral adaptations were collectively discussed.

Significant differences in pre and post content knowledge were reported for paired T tests. See Graph 2. ($P=<0.05$)Students had a greatly increased awareness of the potential uses for 3D printing, and were most intrigued by the technology's potential use in the field of prosthetics.

WEATHER AND CLIMATE

This program provided students with a relatable weather experience. Students explored the major concepts of weather, including temperature, precipitation, and wind. They were introduced to methods that humans have implemented to attempt to manage the weather, and critiqued the success of these attempts.

The essential question that formed the framework was:

- How can mankind manage weather to mitigate weather's negative effects?

Students then had the opportunity to generate their own ideas about how to "tame the weather." Students were introduced to weather concepts, including atmospheric layers, clouds, and the water cycle. The students then participated in a hands-on experiment relating to the water cycle. The concepts of climate zones and the formation of storms were discussed. Tornado formation was explored and the students created "water" tornadoes. Through the tornado activity force and other physical principles were investigated as they related to weather. Discussions were held about mechanisms that have been used to alter the weather. Students then investigated ways in which humans could use aspects of the weather to help mankind. Students designed and created solar boxes and presented their ideas.

Statistically significant content gains were made at two of the three locations using a T test with equal variances.($P=<0.05$) See Graph 2.There was a notable increase in interest in mathematics and science careers, and in taking another mathematics or science related after school course.

SHAKE, RATTLE AND ROLL: THE RYTHMS OF THE EARTH

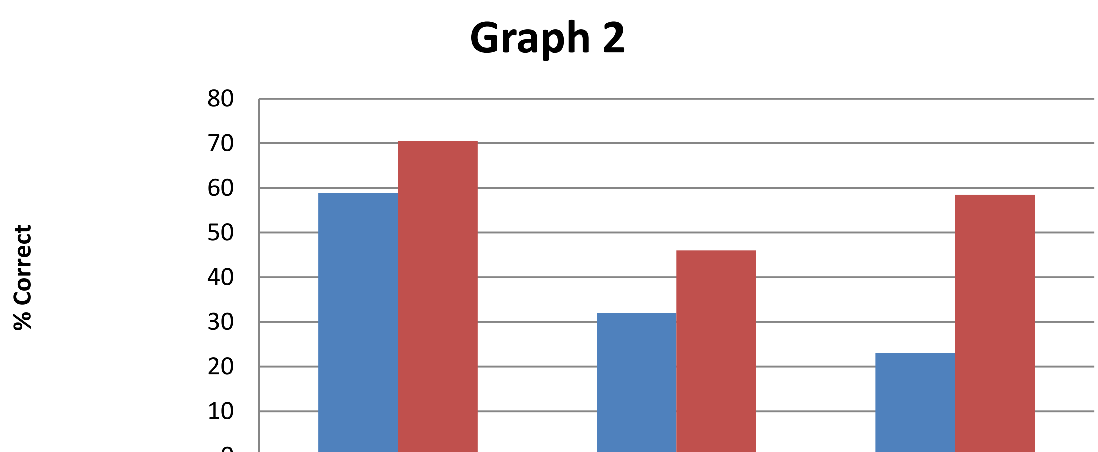
Students developed an understanding of earth's crust, types of minerals, and how rocks are formed.

The essential questions explored include:

- What is the rock cycle, what criterion is used to classify and characterize rocks and how are earth's rocks used in the world in which we live?
- What are the minerals, how do they form, how are minerals classified and what can minerals be used for?
- Why do earthquakes happen? What are seismic waves and how are they used to describe Earth's interior?

Students gained knowledge of the use minerals and rocks in our everyday lives. Students learned how to identify and characterize minerals based on physical properties such as hardness, color streak, cleavage, density and luster. Rocks were identified based on particle size, porosity, and reactivity with acids. Next, they learned how plate movement causes earthquakes, described the types of seismic waves, and explained how earthquakes are measured. Finally, students designed and built a structure which was tested on an earthquake simulator for stability and structural damage.

Significant gains in content knowledge were noted between the pre and posttests using a paired T test. (P=<0.01) See Graph 2. An increase in the number of students who liked mathematics and science was seen, as well as a slight increase in the number of students who hoped to take another class in mathematics or science related field.



	Ecosystems and Adaptaions	Weather and Climate	Shake Rattle and Roll: The Rythms of the Earth
% Correct Pretest	58.9	32	23.1
% Correct PostTest	70.5	46	58.5

Graph 2 - Fall Semester Content Knowledge Gained
Percent Correct Pre and Post Test

AURORA UNIVERSITY FACULTY, DISTRICT TEACHER, AND STUDENT LEADER EXPERIENCE

Three Aurora University faculty, eight school district teachers and fourteen Aurora University undergraduate student leaders were involved in the delivery of the program in the spring. The same

Aurora University faculty members were joined by five teachers and eight Aurora University undergraduates in the fall. Growth and development in content knowledge, interest in teaching STEM curriculum, and confidence in teaching STEM content took place at every level for the instructors, as measured by their survey and focus group responses. Undergraduate Aurora University student leaders felt adequately prepared for their positions, enjoyed working with Aurora University faculty and school district teachers, and felt that communication was efficient and helpful. They were far more aware of the commitment and preparation necessary to be a successful educator upon finishing the program. 87.5% of the respondents increased both their knowledge of and interest in STEM content.

Both the Aurora University faculty and the student leaders were grateful to have a school district teacher on the team who could provide developmentally appropriate learning experiences and classroom management techniques. In turn, the student leaders and school district teachers were helped a great deal by the content knowledge expertise of the Aurora University faculty. The connection between the student leaders and the faculty from Aurora University was also beneficial, as reported by both students and faculty in focus groups and survey responses. Student leaders found the children bright and well behaved, and the college students were well received by the children as reported by the Aurora University faculty and the school district teachers at focus groups, and as observed by the evaluator during three site visits. Faculty also had the opportunity to get to know undergraduates outside of the classroom, and mentor them in workplace and instructional skills which they reported as a very positive outcome during focus groups.

School district teachers responding to a survey (see appendix) felt more confident about teaching STEM content as a result of teaching in this program. Respondents also reported either an increase in STEM content knowledge, or appreciation for the opportunity to revisit areas that they had some familiarity with in the past. Several commented that they had carried the lessons over into their own classroom. District teachers also appreciated that “everything was available for hands-on experiences” and that having the materials organized was of tremendous help to them. Both the faculty and district teachers recognized that it was difficult to maintain the attention of some of the children who were assigned to the program, and that those with a pre-existing interest in the STEM fields benefited the most.

Aurora University faculty and school district teachers were satisfied with the curriculum, and district teachers had success implementing portions of it in their own classrooms.

DISCUSSION

Implementing the curriculum for the John C. Dunham STEM Partnership School at the middle school level in an after school format presented several challenges. The students had not self-selected into a STEM based program; in fact, many were required to participate. In addition, parents had not expressed an interest in their child participating in a STEM-based program for their students. Possibly related to these issues was the inconsistent attendance for the program. Some programs had a high attendance of thirty and a low of six students over the course of a unit. This made planning for materials and staffing difficult. It also made rigorously matched pre- and post-testing of every participant impossible.

However, once engaged, students did make gains in content knowledge, and develop awareness of STEM related careers. Students were provided with role models at several different career and educational levels consistently providing STEM awareness, content knowledge, and support for exploration. As one of the Aurora University student leaders describes, “We passed out a survey and one of the questions asked if they liked science and math, and a little girl told me she didn’t know how to answer because she liked science but she didn’t like math. At that moment I really understood how imperative STEM is to help these students understand and become more comfortable with these topics.”

The faculty, teachers and student leaders from Aurora University all thought scheduling continued to be an issue, as students were often taken from the classroom for other activities or a second presentation was scheduled before the STEM program was complete. They also felt that responsibility for student discipline should be clear, and all instructors should be actively engaged in classroom management. All also agreed that the sessions could be longer and a dedicated space would be very helpful, as would access to technology support in the different buildings.

Student leaders especially enjoyed connecting with the younger students, and wanted to facilitate that connection by introducing themselves and having a chance to explain their path to a career in mathematics or the sciences. Aurora University student leaders also felt more empowered the more they knew about the lesson and their role in the instruction. All were very enthusiastic about continuing to participate in the program.

CONCLUSION

Impacting 302 students, which may represent a duplicate count, many of whom are considered high risk for academic and behavioral problems, the six units of STEM curriculum were delivered for three middle schools. Committed instructors at different levels of expertise increased content knowledge, interest in STEM careers, and developed multigenerational relationships between STEM professionals, educators, and students. Aurora University student leaders increased both their STEM content knowledge and their knowledge of STEM education as reported in focus groups and via surveys. Aurora University faculty members worked with school district teachers and the student leaders to implement the curriculum units, and were pleased with the curriculum development, as were school district teachers, who also reported increased STEM content knowledge and confidence in teaching STEM curriculum.

APPENDICES

APPENDIX A

Survey Questions for Faculty and Teachers

1. Do you feel like you learned STEM content while teaching in this program?

2. Do you feel more confident about teaching STEM content as a result of teaching in this program?

3. What aspects do you feel went well with the course?

4. What aspects do you believe could be improved in the course?

5. What do you feel made the greatest impact?

6. What comments would you like to make about the curriculum?

7. Are there stories or anecdotes about the experience you found meaningful?

8. What else would you like us to know about the experience?

APPENDIX B

Survey Questions for Student Leaders

1. Entering into my position as a Student Leader, I felt that I had been adequately trained to respond to the learning needs of middle school students.

2. Entering into my position as a Student Leader, I felt that I had been adequately trained to manage the behavior challenges of middle school students.

3. Entering into my position as a Student Leader, I felt sufficiently prepared to respond to the economic, social, family, and ethical issues that often present when working with students from a high needs school.

4. During my participation as a Student Leader, I felt that the communication amongst professionals (other Student Leaders, AU Staff, CIS Staff, and Teacher Facilitators) was helpful and efficient.

5. During my participation as a Student Leader, I felt that my role and the roles of other professionals (AU Staff, CIS Staff, and Teacher Facilitators) were clearly outlined and adhered to.

6. Following my participation as a Student Leader, I feel better prepared to respond to the learning needs of middle school students.

7. Following my participation as a Student Leader, I feel better prepared to manage the behavior challenges of middle school students.

8. Following my participation as a Student Leader, I am better prepared to teach middle school students, particularly in the areas of math and science.

9. Following my participation as a Student Leader, I feel more aware of the amount of preparation necessary to be a successful educator.

10. Following my participation as a Student Leader, I feel more confident about my ability to be a successful educator.

11. I increased my knowledge about STEM content.

12. I increased my interest about STEM content.

13. What aspects of the course do you think went especially well?

14. What aspects of the course that you were involved in could be improved?

15. Do you have any anecdotes or stories that would help describe your experience?

16. Did you enjoy your experience?

APPENDIX C

Focus Group Questions

Focus Group Questions for Teachers

1. What do you think went well in the After School STEM Program?
2. What would you like to improve about the program?
3. What do you think had the most impact?
4. What else would you like to tell us?

Focus Group Questions for Student Leaders

1. What do you think went well in the After School STEM Program?
2. What would you like to improve about the program?
3. Did working in the program make you more interested in science?
4. Did working in the program make you more interested in teaching science?
5. Given the opportunity, would you like to participate in the program again?
6. What else would you like to tell us?