



## **A MATERIALS ENGINEER'S APPROACH TO EXPLAINING SCIENTIFIC PROBLEMS IN AN 8TH GRADE CLASSROOM: A CASE STUDY**

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# IOWA STATE UNIVERSITY SYMBI GK12 PROGRAM: A CASE STUDY OF THE MATERIALS SCIENCE ENGINEER'S APPROACH TOWARDS ADDRESSING COMPLEX SCIENTIFIC PROBLEMS IN THE 8<sup>TH</sup> GRADE CLASSROOM

## Abstract

The Des Moines public school system has partnered with Iowa State University to develop innovative and engaging STEM (Science, Technology, Engineering and Math) activities for middle school students through NSF's GK12 program. Iowa State's GK12 program, *Symbi*, pairs a senior graduate student (i.e., GK12 Fellow) with a middle school science teacher and classroom for the duration of an academic year. These GK12 Fellows engage the students by providing inquiry-based learning experiences and authentic demonstrations, which bring relevance by relating the science curriculum to real world challenges. Each Fellow's research background provides a unique backdrop for enhancing the classroom curricula. Here we present a case study showcasing the activities and interactions of one *Symbi* GK12 Fellow in the classroom who uses alternative ways to approach the science curriculum by addressing complex problems through the lens of a materials science engineer. In this case study, the primary research focus of the author, a GK12 Fellow, is on materials science and engineering, specifically polymers, a field completely absent from middle school curricula. By providing hands-on demonstrations and reliable scientific expertise, 8<sup>th</sup> grade students have the opportunity to experience science not as a collection of discreet units unrelated to each other but instead focus on how science and scientific thought is woven into everything around us. As a result, students expressed their enthusiasm and interest in the exciting concepts being brought to the classroom by the GK12 Fellow. These results suggest that middle school students benefit from taking an integrated approach to science using materials science engineering as the scaffolding for its implementation.

## Introduction

*"I want to persuade you to spend time in the classroom, talking and showing young people what it is that your work can mean, and what it means to you [...] to thinking about new creative ways to engage young people in science and engineering,"* – words from President Obama at the National Academy of Sciences on the 27<sup>th</sup> of April 2009 as he urged the scientific community to find ways to cultivate the next generation of scientists and engineers. A task that provides some hurdles considering these words came in the wake of growing concern for the lack of students pursuing degrees and careers in STEM (Science, Technology, Engineering and Math) related fields. According to the National Center for Educational Statistics, students who perform at or above the proficiency level in 8<sup>th</sup> grade science is fewer than 1 out of 3 students<sup>1</sup>. The national report card identified students from low income and underrepresented minority families as scoring significantly lower than the national average<sup>2</sup>. Furthermore, the public school students performed well below private and Catholic schools, especially in the inner city public school setting<sup>2</sup>. These scores demonstrate that K12 public science education in the United States is critically in need of new instructional approaches that provide students with opportunities to think like scientists and engineers. Additionally, the United States has an undersized pool of engineers to meet the needs of our society and economy<sup>3</sup>. If current trends do not change, the demand for engineers will surpass the supply of engineers in the US<sup>4</sup>.

To address the student STEM literacy and preparation for STEM careers, the National Science Foundation (NSF) funds the Graduate Stem Fellows in K-12 Education Program (GK-12). To help address these issues and those raised by the President, Iowa State University has partnered with the Des Moines Public Schools by incorporating STEM Ph.D. candidates as resident scientists/engineers in middle school classrooms with the goal of fostering students' interest in science and engineering. NSF funds several GK-12 programs at national universities. At each university specific and unique goals are developed and one goal for Iowa State University's GK-12 program, *Symbi*, is to increase K12 students' scientific literacy: that is, to increase student understanding of the relevance of STEM to real world challenges and to help them be more aware of STEM careers. The program's name *Symbi* was chosen for the symbiotic relationship between the fellows and the middle school students.

The lead author of this article is a *Symbi* GK12 Fellow and "resident engineer" who is majoring in materials science and engineering and conducting research on polymers. This resident engineer was paired with a middle school science teacher in the Des Moines Public School District, and spent one full day each week, for one academic year, in the science classroom. The resident engineer was able to provide a unique classroom experience by periodically introducing the students to aspects of his own research, including the use of biopolymers in material self-healing applications. Several activities were designed to provide students with opportunities to learn about the field of polymer science. These activities were related to and ultimately aligned with the science topics covered in the curriculum and provided relevance to real world issues and challenges. This study focused on the impact this fellow has had as a resident engineer on the students in his classroom.

## **Research questions**

In this case study, researchers were interested in the effects of a resident engineer on eighth grade students' enthusiasm and interest in science topics both in and out of the classroom. Specifically, this study asks whether the resident engineer improved the interest of students in science and engineering such that students recognized scientific ideas outside of the classroom and became more inquisitive in science class. The current study was guided by two basic research questions:

1. Do the classroom activities, demonstrations, and experiments provided by the resident engineer positively affect the attitudes of students toward science and engineering, both in and outside the classroom?
2. Do students find the concepts of science to be more integrated and applicable to real life?

## **Research design**

This case study focused on the demonstrations brought to the eighth grade classroom by the resident engineer during the first semester of the 2012-2013 school year. These experiments, demonstrations, and discussions were designed with the effort to engage students with science content in a way that broadens students' understanding of science not only in that specific field but also in other related fields — showing how scientific concepts flow through all facets of life. A sampling of the classroom demonstrations were as follows:

1. **Introduction to Materials** — The resident engineer introduced himself to the students with a sampling of scientific demonstrations revolving around materials science and specifically polymers, his field of study. These demonstrations involved, shape memory alloys, electromagnetism with magnet and copper pipe, and glass transition in polymers. Each demonstration was related back to real life applications such as dental braces, electric generators, and polymers such as tires, toys, and packaging respectively. The shape memory alloy was bent into a unique shape and a discussion about why metals bend followed. Then, the metal was placed in a pot of boiling water only to have the metal revert back to its original shape. Discussion about the reason and the benefits of its use in daily life took place.

For electromagnetism, neodymium magnets were simultaneously dropped down PVC and copper piping. Students were then asked to “discover” the reason why the magnet falls slower down the copper pipe by working through the differences between the metal and the plastic piping. Further discussion lead to how free moving electrons and magnets can be utilized with the information gleaned from the demonstration to develop the idea of an electric generator. Finally two rubber balls with different glass transition temperatures were presented to the class. At room temperature one bounces and one does not. Then each rubber ball is cooled and heated and then change in bounce (both height and sound) was observed. The data collected were discussed in how a polymer transitions from glass to rubbery through the glass transition temperature. The glass transition in polymers was the primary focus, as it presented an important part of the resident engineer’s research.

2. **Friction of Fluids** — In the forces and motion unit, a majority of science classes teach friction as a resistive force between two objects usually two solids. In class, the resident engineer worked to expand the students’ understanding of friction in fluids by experimenting with the viscosity of corn syrup, water, and combinations. Students dropped marbles down graduated cylinders filled with a given fluid. They then measured the amount of time it took the marble to reach the bottom of the cylinder. Additionally, another demonstration of viscosity with corn syrup and food coloring was used to show that mixing in extremely viscous materials can be difficult. The demonstration used the understanding of laminar flow to “spread” corn syrup and in one direction “mixing” it. Then reversing the direction, the corn syrup and food coloring is “unmixed” back to its original state<sup>5</sup>. Discussion was then developed around making plastic materials and how important viscosity can be for filling molds and other challenges viscosity might bring.
3. **Minute to Win It** — To demonstrate that forces and motion are all around us, the use of simple games from the television show “Minute to Win It” were utilized to provide students a fun hands-on demonstration of forces and motion. Students worked in small groups and rotated through stations where a single minute to win it game was sitting. In order to play the game, the students needed to identify three forces and motion vocabulary words and definitions that directly related to the solution before completing the game challenge. Students were then allowed to participate in the game for a minute in an attempt to complete the challenge as a reward for utilizing their vocabulary words. In the remaining moments, a brief discussion ensued about how forces and

motion concepts are so commonplace that people often do not even think about their use in everyday life.

4. **Car Accident Detective** — At the culmination of the forces and motion unit, students were asked to assume the role of private investigator in a simulated car accident. Students were given a packet of documents that provided the information they would need to solve the “who-done-it” aspect of the accident. Students were asked to use critical thinking skills in conjunction with their understanding of forces and motion to determine who was at fault and write a one-page paper outlining the evidence and rationale for who was at fault in the accident. The documents students were given provided them with eyewitness accounts, accident reports, accident schematics, tire tracks, weather reports, vehicle information, and stopping distances for cars with certain tires.
5. **Exploring Energy Consumption** — During the energy unit, students were introduced to many types of energy as well as the transfer of energy from one type to another. To further explain the concepts of conservation of energy through energy transfer, students were given a giant box full of packing peanuts (their energy). Students were then given the task to quickly pass the packing peanuts from one person to another down a chain. Any peanuts that fell to the floor were required to stay on the floor — those represented energy lost to the environment. Later, students counted up the packing peanuts that made it down the chain — those represented successful energy transfer. Students associated the notion of the conservation of energy by seeing that all the packing peanuts could be accounted for. Additionally, kilowatt meters were brought into the classroom and several appliances were measured to see how much energy was consumed by different objects such as hair dryers, microwaves, lights, power drills, and pencil sharpeners. A discussion was then led on energy use and utilization.

In order to evaluate the effect of the resident engineer in the classroom, focus group interviews were conducted with small groups of 8<sup>th</sup> grade students. The purpose of these focus groups was to assess the students’ attitudes towards science and engineering, both inside and outside the classroom. Two separate focus groups were conducted with students and each lasted approximately 45 minutes. The focus groups consisted of a total of seven students, one female and 6 male. A third party moderator facilitated the focus groups in order to remove as much partiality and bias as possible. Students were made aware the focus group was voluntary and no repercussions would happen for any type of answer or for choosing not to participate in the focus group. The moderator followed a structured interview process by asking a series of questions and allowed the participants to respond at will with their thoughts and comments pertaining to the questions.

### **Classroom demographics and context**

The resident engineer was paired with the eighth grade science class at a middle school in Des Moines, IA. The middle school has a total of 594 students, of which 190 were in the eighth grade science classroom that interacted with the resident engineer. The resident engineer joins the science classroom once a week on Fridays and brings in demonstrations, experiments, or other interesting science concepts for the students. The material presented and concepts brought by the resident engineer are often

associated to the curriculum and yet unique from the course itself. There are six class periods of science all lasting 42 minutes.

The student population of the middle school is 38% underrepresented minority families and 68.2% of all students qualify for the free or reduced lunch program. According to the Iowa Department of Education, those eligible for free or reduced lunch at the chosen middle school mirror the district in eligibility at 69.6% in the 2011-2012 school year<sup>6</sup>. However, these numbers are higher than the state and national average of 39% and 45% respectively<sup>6,7</sup>. These demographics are somewhat lower than the national average of 56% underrepresented minority families from the 2009-2010 National Center for Education Statistics (NCES) data<sup>7</sup>.

## Results

For each demonstration listed above, the students were extremely engaged and interested in the experiments and demonstrations. In fact, once the class was introduced to the notion of a resident scientist in the classroom, they are quite eager for what is happening Friday, constantly asking, “What are we doing Friday,” or “I wish it was Friday for cool science.” Over the semester, the resident engineer saw a tangible difference in the students and their interest in science. As the semester progressed, students began bringing questions into the classroom that they encountered about science at home. Even recently, students are starting to question things they hear in the news about science. In fact, after the energy transfer unit and talking about mechanical power, a student asked about coming up with a way of developing energy through the use of water in rivers while trying to think outside of the box. Often students make comments such as, “I wish you were here every day,” or “I use to think science was boring but you really show how cool it is.”

During the focus groups, students were asked several questions about their thoughts and experiences in science class. In the analysis of the interview transcripts several themes and findings clearly emerged related to the research questions. Students’ responses and comments focused on:

1. How much fun science class is when the resident engineer comes into the classroom.
2. How the resident engineer gives them a way to grasp the topics by not only providing definitions but also demonstrating the concepts in a tangible understanding way.
3. How they repeatedly highlight and remark about the demonstrations used in the classroom by the resident engineer.
4. How they are expressing an increased awareness of science outside of the classroom.

First, the students were asked about their thoughts and interest in the science classroom. Students were asked to expound on the similarities and differences in science, especially when the resident engineer comes to the classroom.

MODERATOR: *What makes learning science different than learning in other subjects?*

STUDENT 1: More things about science like it goes more in-depth about everything.

STUDENT 2: You can have more fun in science than any other subject.

STUDENT 3: Yeah, time flies by really fast.

MODERATOR: *Tell me, what makes science more fun than any of the other subjects?*

STUDENT 1: You are not just sitting there the whole time like in math or reading, we actually get up and do things.

STUDENT 2: You don't just sit there and not do anything. Science on Fridays you can get up to do cool things.

MODERATOR: *Do you get up and do science on Monday through Thursday?*

All STUDENTS: Sometimes.

STUDENT 4: But not necessarily and not like Friday.

MODERATOR: *But in general, you guys enjoy learning about science?*

All STUDENTS: Yeah.

STUDENT 5: I think that it is my favorite subject ... because we learn a lot more cool stuff in that class than any other.

In connection with these questions about “why do you like science” and “how is science different when the resident scientist comes”, many students focused on the way information was presented to them. Often, they felt the average class day they were given many definitions and had difficulty grasping the information whereas the resident engineer presented the information in a way that provided a demonstration or diagram that allowed the students to visualize and better understand the material. This can be seen in the following focus group responses:

MODERATOR: *If you were going to walk into a science classroom, what are the things you would expect the teacher to be doing?*

STUDENT 7: Explaining to us a lot of things we don't understand.

MODERATOR: *So, what kind of things do you do when [the resident engineer] comes that help you understand?*

STUDENT 7: Well, [the resident engineer] has a lot of hands-on projects that we do. Experiments. And lately we have been doing a lot of labs too.

MODERATOR: *What makes science interesting to you?*

STUDENT 4: Well [the resident engineer], well sometime he makes it interesting with experiments. It was fun ... and he helps put you into groups so you learn what you don't learn.

- STUDENT 1: [the resident engineer] makes it easier to learn.
- STUDENT 3: [the resident engineer] makes it fun and like you get to experiment with all these different things.
- STUDENT 5: I learn a lot!
- MODERATOR: *[Student 1] talk to me a little more about what you said.*
- STUDENT 1: Well, like he makes it easier for us to understand. Like last year, and the year before I did not understand science and now it is way easier and I get straight As.
- MODERATOR: *When you think about [the resident engineer] and [the teacher] working together, what stands out?*
- STUDENT 5: But sometimes [the teacher] explains it in a way I don't understand and [the resident engineer] speaks it in a way that I understand.
- STUDENT 6: It is like English!
- MODERATOR: *What does [the resident engineer] say and does he do?*
- STUDENT 1: [the resident engineer] would draw a picture for us on the board and like explain it more.
- STUDENT 3: [the resident engineer] will demonstrate it.
- STUDENT 2: Yeah [the resident engineer] demonstrates it.
- STUDENT 4: [the teacher] would give like the definition and everything but it's a little harder to understand. But [the resident engineer] would come in on Fridays and draw pictures and show us [examples].
- STUDENT 3: For motion, [the teacher] was like momentum is ..... and I did not even understand her. Then [the resident engineer] come in and okay momentum is ..... And then he demonstrated it.
- STUDENT 1: And it was easier to understand.

While being asked about how science class is unique on the days the resident engineer comes to the classroom, many students began excitedly sharing specific examples of what they really enjoyed learning and experimenting with in the classroom. This is readily evident in the focus groups seen here:

- MODERATOR: *Tell me what makes science more fun than others?*
- STUDENT 5: Like on Fridays, [the resident engineer] sets up crock pots and stuff around testing like we did to see how many watts each thing had like a curling iron, drill, fan, ...
- STUDENT 3: Yeah, and remember the experiment where we had to figure out the tire tracks?



STUDENT 1: Yeah, the car wreck that you had to figure out. That was fun.

MODERATOR: *Are there any other examples that you really remember?*

STUDENT 7: We just did a paper about finding the facts about a car crash. ... And I remember the minute to win it games. I had a lot of fun with that.

MODERATOR: *And [the resident engineer] specific expertise like as an engineer and those kinds of things. Do you think you would get that otherwise if [the resident engineer] wasn't in the middle school classroom? Do you think topics like that would come up?*

STUDENT 7: Not really. A lot of times I talk to him about my questions. He comes around and asks us questions.

Finally, the focus group highlighted the way in which students are becoming more aware of the science around them, not only in the classroom but at home as well. Specifically, students were taking concepts they were learning about in school when the resident engineer was there and finding ways to apply it at home. This can be seen in the students' responses below:

MODERATOR: *Can you think of how do you use what you learn in school outside of school?*

STUDENT 7: Yeah, like um, my science fair project the energies [the resident engineer] talked to us about I could figure out voltage and everything I needed to make a light, light up.

MODERATOR: *So, science fair was done outside of school. Good. What about at home or anything?*

STUDENT 7: Yeah, we were talking about electrical and everything and thought about the electrical when the power went out.

MODERATOR: *Do you think having [the resident engineer] in the classroom makes you think about science more?*

STUDENT 7: Yeah, cause it give me more. [The teacher] knows a lot but having someone who really knows about stuff helps a lot.

MODERATOR: *How have you used the concepts you learned in science outside of school?*

STUDENT 3: Well, I was actually in the car and like saw a car crash and they said one of them was drunk and I probably could have told that by how the car had skid.

STUDENT 6: Since we have learned like the 7 types of energy, I have been going around and looking at how much different type of energy at home.

MODERATOR: *So, having [the resident engineer] in the classroom, would you say has helped you think about science?*

All STUDENTS: Yes. A lot.

## **Discussion**

The focus of STEM in middle school classrooms is often limited to only science and mathematics<sup>8</sup>. However, the study of engineering is an excellent way to incorporate science, mathematical and technological principles into examples of real world phenomena<sup>9</sup>. Engineering provides the link between scientific understanding and application. Students are always interested in why they need to know the information and teachers are always struggling to present valid reasons for the applications. Hands-on activities provide problem-solving, designing, testing, and enhancement which helps students in the middle school classroom integrate multiple subjects into one activity. For all demonstrations or experiments presented in the classroom, time was given to apply the concepts to everyday life. Whether it was dental shape memory wire, making electrical generators, melting plastics, using electrical appliances, or “playing” detective in a crime scene accident, applying scientific topics to concrete technology and activities solidifies the concepts in students’ minds. Students can strengthen their knowledge of the scientific concepts and the relevance to their lives by being introduced to engineering concepts at an early age, especially through hands-on activities<sup>9,10</sup>.

Several students have expressed in class that they would be more interested in pursuing a career in science after their 8<sup>th</sup> grade experience because they can see how applicable science class can be on a daily basis. Most were not aware of how prevalent scientific technology is around them and the opportunities for careers in science. Often times middle school students find science uninteresting simply because they do not see a relevance to their live experiences<sup>11</sup>. By having an influential and encouraging teacher presenting the significance of science in their lives, a positive effect has been shown in students<sup>12</sup>. By providing engineering concepts student show an increased interest in science especially in the students generally disengaged in science and therefore focusing on a group of students often forgotten<sup>10,13</sup>.

Despite materials and engineering being vital to our current society, few school curriculum plans provide students a chance to explore concepts about materials and engineering. This case study outlines an interactive way where students learn broader concepts and at times are directed specifically to materials science engineering where they can freely explore, question, and investigate. In fact, students were so interested in the classroom activities that after almost every day the resident engineer was in the classroom, students remain behind to ask questions and share ideas.

The classroom specifically profited from a resident engineer by providing a fun and interactive environment where students learned through multiple learning styles. Furthermore, students were presented with activities that were engaging and at the end of the semester they were able to identify those

activities. As a result, several students shared in the focus groups that they are thinking about science class. One student specifically shared a story of when he witnessed a car accident and one of his first thoughts was born out of the car accident detective activity—thinking he could determine how the accident happened.

Science becomes more fun when you can not only experiment and demonstrate concepts but when you can also correlate it to everyday life. By connecting to real world application, students became more engaged and felt science class was fun. These connections come through the demonstrations the students were recalling as well as the discussion during and after each class. When the resident engineer first came to the class, several students readily interjected “who cares” after tackling a scientific topic. Yet after a few weeks, students were more willing to listen because they could see how often these topics are used. For instance, a few students were quite interested in how a generator works when the temperature drops well below room temperature. Additionally, the resident scientist exhibits the tangible career opportunity in science. Students seem more interested in science careers after he was in the classroom. In fact, one student admitted in a focus group that 6<sup>th</sup> and 7<sup>th</sup> grade science had not made sense and he was failing. Now that the resident scientist has been in the classroom 8<sup>th</sup> grade science seems simpler and now this student is excelling in the class.

These types of responses are not unique for this classroom. Data collected from the first year of *Symbi* Fellows and collected by the university’s Research Institute for Studies in Education shows a significant increase in 241 eighth grade students’ perception of science after being introduced to a resident engineer or scientist. Eighth graders showed an increase in problem-solving and engineering concepts once they were introduced to them. Furthermore, the data showed a decrease in wanting the answer given to them by teachers. Coupling this with the increase in problem-solving, the data shows independence in seeking out the truth in science class. This can easily be seen in the car accident detective project when the students wanted to figure out and think through who was actually at fault in the accident.

## **Conclusions**

The results of this study show that 1.) science can be fun and students will engage the topics, 2.) a resident engineer can provide additional explanation through demonstrations and illustrations that helps students learn better, and 3.) the resident engineer’s effective classroom activities stay with students and effect their thoughts about science outside of the classroom — specifically thinking about science and questioning in general.

In middle school when the mind is developing, introducing engineering concepts and critical thinking benefits cognitive development by forcing the utilization of several disciplines simultaneously. As a result, not only science becomes a stronger topic for them but so do math, reasoning, and communication skills. In the acronym STEM, the E stands for engineering and yet few classrooms focus their curriculum on engineering aspects, specifically by applying the classroom content to real world application. So, it is not surprising when students are presented with hands-on experiences, their interest significantly improves. From the focus groups alone, all the students confessed that when the resident engineer brought in activities, those activities caused the students to think more critically about science and the world around them not only in the classroom but also away from school. The disinterest from most students is

not from animosity but simply out of a place of indifference when they see no relevance to the curriculum being taught to their own life. Once students were offered explanations for why science is so relevant, many students were eager to learn. By fostering this interest in students through showing how applicable science is to everyday life, students are three times more likely to pursue STEM careers if engaged in science early<sup>14</sup>.

Having a resident engineer in the classroom provides eighth grade students a mentor who can design learning activities from an engineering perspective — offering not only the content but also an application for the students to connect. This results in a better appreciation for why their science class is so important for them and simultaneously, having an engineer offers a tangible figure to associate with the scientific career. The focus groups show that students are benefitting greatly from the resident engineer in the classroom. One of the most exciting results of this case study is the extracurricular scientific thought being developed in students. If scientific thought can be cultivated in a way where the middle school students are actively thinking about science without being prompted, then the next generation of scientific professionals has real potential.

## Limitations

This case study was limited to a single resident engineer's experiences in the fall semester of one public middle school classroom. While the case study shows significant promise in encouraging scientific thought in eighth grade students, the scalability and sustainability of the program would be in question. However, *Symbi* is actively seeking ways in which to assimilate and disseminate these lesson plans for use by others. This would involve providing teachers the materials to confidently present these topics to students in ways that students will respond in similar fashion. Placing a resident engineer/scientist in the classroom is not always practical. And although the classroom would no longer benefit from the resident engineer/scientist as a mentor to the classroom for which students obtain a better appreciation for the profession, it is the authors' feeling that when a teacher is confident in offering the engineering concepts to the classroom, the classroom as a whole can gain substantial academic improvements and individual interest in the classroom. In this example, the resident engineer's work provided the support for the teacher to confidently present the material to the classroom in a way that emphasized engineering concepts.

## References

- [1] U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics. Nation's report card 2009.
- [2] U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2009 Science Assessment
- [3] N. Tran, and M. Nathan. *Pre-College Engineering Studies: An Investigation of the Relationship between Pre-College Engineering Studies and Student Achievement in Science and Mathematics*. Journal of Engineering Education. 2010. 143-157.
- [4] Business Roundtable. *Tapping America's Potential: The Education for Innovation Initiative*. Washington DC. Business Roundtable. 2005.
- [5] Steve Spangler Science. *Twist in Time – Laminar Flow*. Retrieved from <http://www.stevespanglerscience.com/science-video/twist-in-time> 2013.

- [6] Iowa Department of Education, Basic Educational Data Survey, Bureau of Information and Analysis Services, Fall 2011.
- [7] U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, State Education Data Profiles, 2009-2010.
- [8] R. Bybee. *What is STEM Education?* Science. Vol. 329. 2010. 996.
- [9] C. Rogers, M. Portsmore. *Bringing Engineering to Elementary School*. Journal of STEM Education. Vol 5. Iss. 3 and 4. P. 17-28. 2004.
- [10] H. Kim. *Inquiry-Based Science and Technology Enrichment Program: Green Earth Enhanced with Inquiry and Technology*. Journal of Science Education Technology. 2011. 20:803-814.
- [11] Talton, E. L., and Simpson, R. D. (1986). *Relationships of attitude towards self, family, and school with attitude toward science among adolescents*. Science Education 70: 365–374.
- [12] Keeves, J. P. *The home, the school, and achievement in mathematics and science*. Science Education 1975. 59: 439–460.
- [13] P. Cantrell, G. Pekcan, A. Itani, and N. Velasquez-Bryant. *The Effects of Engineering Modules on Student Learning in Middle School Science Classrooms*. Journal of Engineering Education. 2006. 301-309.
- [14] G. Nicholls, H. Wolfe, M. Besterfield-Sacre, and L. Shuman. *Predicting STEM Degree Outcomes Based on Eighth Grade Data and Standard Test Scores*. Journal of Engineering Education. 2010. 209-222.