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Looking for Learning in After-School Spaces

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Looking for Learning in After School Spaces

Abstract

The structured after-school space has long demonstrated educational benefits (Gerber, Cavallo, & Marek, 2001; Tamir, 1990). After-school settings typically provide homework support, helping youth build self-confidence (Beck, 1999). They are safe places for socializing and forming relationships with caring adults (Payton et al., 2008). While there is sufficient evidence that youth may learn science through non-school science programs (Cantrell, Pekcan, Itani, & Velasquez-Bryant, 2006; NRC, 2009; Sadler, Coyle, & Schwartz, 2000), there is a lack of research on determining what academics youth might learn in engineering design-based after-school settings. When the after-school curriculum encompasses engineering design, the challenge is great due to the difficulty in assessing intangibles such as design and deep conceptual knowledge. Additionally, ideal learning outcome measures differ between formal school settings and informal, after-school ones, as traditional academic measures do not capture the range of ways youth demonstrate learning in informal settings (NRC, 2009). In this study we designed an after-school experience in a studio setting, using research-validated engineering design-based curriculum (Schnittka, 2009; Schnittka, Bell, & Richards, 2010; Schnittka & Bell, 2011; Schnittka, Brandt, Jones, & Evans, 2012) and gave the youth different opportunities and methods to demonstrate what they learned through the process. In this study we examined three after-school settings for 8 weeks focusing on storyboarding, chatting on a social network site, videotaped conversations with volunteer facilitators, presentations the youth made at the end of the program, and structured interviews with researchers to look for evidence of learning in after-school spaces.

Introduction

The purpose of this study was to better understand how middle school youth learned science as they participated in an engineering design curriculum in an after-school studio setting (called STEM Club), guided by undergraduate facilitators within a collaborative Information and Communications Technology (ICT)-embedded environment. The research questions guiding the investigation were:

1. How does social media influence youth's understandings of science in this informal, engineering design-based afterschool studio setting?
2. What are ways to successfully determine changes in understanding?
3. How do the actions of site leaders and facilitators impact learning?

Using a discursive psychology framework (Davies & Harré, 2000) we identify ways in which the teachers' and facilitators' words and actions helped youth problem-solving abilities and conceptual understanding. Findings suggest that the different kinds of elicitation strategies adopted by teachers and facilitators had a significant influence on the ways that the youth were able to engage in the design process and to construct new conceptual knowledge.

Overview of the curriculum

The curriculum used in this study was *Save the Penguins*, developed by Schnittka (2009) and discussed in detail in several other publications (Schnittka, Bell, & Richards, 2010; Schnittka, Brandt, Jones, & Evans, 2012)

In brief, the *Save the Penguins* curriculum helps youth recognize how their behaviors at home might affect penguins in the southern hemisphere. The fossil fuel energy we use at home has been linked to increased levels of carbon dioxide in the atmosphere, which in turn has widespread effects on life on Earth, penguins included (Gross, 2005; Jenouvrier et al., 2009). When engineers design better building materials to conserve energy, it has a positive impact on the environment. This is the problem presented to youth - how to create better dwellings at home that conserve energy and spare the environment from pollution.

The site leaders in this study, math and science teachers from the host schools, introduced the science of conduction, convection, and radiation to engage the youth in activities illustrating all three methods of heat transfer. These discrepant event activities were designed to challenge youth's misconceptions and naïve conceptions about heat transfer. Youth were then given the design challenge: to design, build and test a small structure that would keep a penguin-shaped ice cube from melting in a heated oven. Youth worked in teams, and were given a small budget from which to purchase a choice of available materials. Facilitators guided youth through experiments to test each material's ability to reduce heat transfer. Material choices were: bubble wrap, aluminum foil, colored construction paper, colored foam sheets, metallic Mylar film, wooden sticks, cotton balls, and small paper cups. Youth used the Edmodo social networking site to communicate with each other (within site and between sites) and the teachers and facilitators as they worked on the project. The online interactions ranged from hanging out (discussing favorite foods and pop icons) to geeking out (engaging in sophisticated discussions on science and engineering problems and solutions).

Design studio model

The STEM Club is designed to increase middle school youth's understanding of science, technology, and engineering through issues related to energy. Youth are introduced to background information about an energy issue and its affect on an animal or ecosystem. Information is presented through the use of foundational, yet brief, lecture presentation technology with embedded video clips, audio, and images. The presentation challenges youth to contemplate the impact of humans and human-made technologies on the planet. This treatment was meant to relate the material more strongly to the student on a personal level, which could influence their engagement with the project. Science concepts are presented in the form of hands-on experiments, meant to physically demonstrate what has been presented in the previous lecture format. Youth are then given the challenge of designing and constructing an artifact of some sort, depending on the curriculum. Groups are given a limited amount of play money that they may use to purchase materials to use for construction. Through a design and redesign process, youth are given the opportunity to correct errors and improve upon earlier iterations of their designs.

The studio model places emphasis on: (a) a content-rich curriculum that links youth to their environment, (b) support and scaffolded discussions with mentors (site leaders and facilitators), and (c) an online network that supports the creation and maintenance of relationships among program participants. The informal character of this program allows youth the freedom to explore and self-identify with STEM topics.

Method

Participants

Youth in three after-school programs at middle schools in a rural, impoverished, mountainous region of a mid-Atlantic state were asked to participate in the project. The site leaders explained the project to the youth and provided them with information and parental consent forms to take home to their parents. All parents completed the consent forms, and all youth completed the assent forms.

At East Middle School (all school names are pseudonyms), there were 24 participants (11 boys and 13 girls) All of the youth were White/Caucasian. Their ages ranged from 10 to 13. Individual interviews were conducted with 14 randomly selected participants (7 boys and 7 girls) at the end of the unit. Twenty of the youth completed both the pre and post tests. East Middle School has 44.7% of its students qualifying for free or reduced lunch prices. At North Middle School, there were 30 participants (19 boys and 11 girls) with one female student being African American and the rest Caucasian. All youth participated in group interviews at the end of the unit. Twenty-five of the youth completed both pre and post tests. North Middle School has 46.6% of its students qualifying for free or reduced lunch prices. At South Middle School there were 11 participants (5 boys and 6 girls) with one male student being African American and the rest Caucasian. Only four boys participated in group interviews at the end of the unit and only three youth completed both the pre and the post tests. South Middle School has 57.49% of its students qualifying for free or reduced lunch prices.

East Middle School students were selected to participate in the STEM Club based on their engagement and performance in school. The site leader chose students using a low, medium, and highly engaged gauge of her own design and also looked at how the students each performed in their respective courses at school. The teacher worked to choose a mix of all three levels of engagement and grouped those students heterogeneously and among genders. Students met two afternoons each week for one hour over the course of 10 weeks. The site leader worked with the guidance counselor to make sure the students and parents understood the design base for the program and to ensure that students could commit to participating for the 10 week period. The administration at East Middle School was supportive of the program and the principal would often stop to say hello, talk with students, and joked with the students about building his own penguin house for the competition.

The site leader began each session by reviewing material from the previous session, asking questions to help the students recall information, and would use technology aides such as a computer and projector to help her teaching. She would then give the students their tasks for the day and follow with a demonstration or the students would begin their work. The facilitators mingled among the groups, asking more questions, helping students figure out their task, or observing. The site leader would check in with the students by giving time prompts or asking if there were any questions. Sessions usually finished with storyboarding, answering questions on Edmodo, and cleaning up the space.

North Middle School students were selected in a first come, first serve basis. The site leader sent the promotional materials home with students that she taught in her classes and worked with the principal and other teachers to distribute the materials. The first 30 students to return the signed IRB forms were chosen. The site leader wanted to see what level of interest the students in her school would have so she chose to purposely not limit it but instead to cap it at 30 students. The principal at North Middle School was very supportive of the program and would often stop by, engage with the students by asking them questions, and provided snacks at each of the sessions. The principal worked closely with the site leader and the project associate to overcome any challenges and made other spaces available within the school for the open house at the end of the program. Parents expressed their support and acceptance of the program during any interactions when they came to the school to pick up their children and were excited about the program.

The site leader began each session by encouraging students to get a snack and would often display a question on the SmartBoard to help students recall what they had done the previous session. While the students were eating, the site leader would review the previous session and begin by asking the studetns what their existing knowledge was on the upcoming content. Students would break into their groups and get instruction on the tasks for the day from the site leader and any demonstrations that needed to be delivered. Students would work for the majority of the session and finish the session by storyboarding, going on Edmodo, and cleaning up the library.

Students at East and North Middle School had a consistent attendance record and students would often tell the site leader in advance if they were going to have to miss on a given day. The site leader stressed to the students that this was a special opportunity and that they should take it seriously and be respectful of the special program being offered. East and North Middle School ran STEM Club two days per week for 10 weeks. The site leaders at East and North worked closely with the Information Technology Resource Teacher (ITRT) to set up the students' Edmodo accounts, teach the students how to use Edmodo, and also attended as many session as possible to help the site leader with the technology aspects of the program. The ITRT was the same person for both East and North, so her time was split on days the program ran on the same days.

The STEM Club for all three sites was delivered in the school library. Each library offered open space with large tables that could be moved around to meet the needs of the students. Students sat in their groups and were free to move about the room to get comfortable, spread out their supplies, and use the space in its entirety. Students set up their own stations for the project and were prompted for tasks like clean up and told to leave the space as they had found it to alleviate extra work for the site leader or librarian. East and North Middle Schools had access to computer labs for students to access Edmodo and the Internet that were in a different room. South Middle School had enough computer workstations in the library for students to access.

The students at South Middle School worked in conjunction with the local Boys and Girls Club that already performed after school interventions within the school during the school year. Students were selected on a first come, first serve basis. The site leader and cooperating administrator for the Boys and Girls Club did not outline the time commitment, leading to attrition, low attendance, and students failing to complete the program. Students would often attend STEM Club one week but not the next or comment that they had "forgot about it" altogether. Due to low and sporadic attendance, it was difficult for the site leader to deliver the content and difficult for the facilitators since students were at varying places in the curriculum each week. This site met once per week for 90 minutes for seven weeks. The site leader began the sessions by tracking down students and would send another student in attendance to find missing students. She would begin with an extensive review of the previous week to help students get on track and catch up students who had missed the previous week and demonstrations for the group. Students worked in pairs with a facilitator to complete the tasks and demonstrations. Students finished each session with storyboarding and time to answer questions on Edmodo. Students would leave early, sometimes asking for permission.

Information flyers, promotional materials, and IRB required forms were sent home to potential students' families for them to read with links to a website and Facebook page for more information. Contact information was provided in case any parent or guardian had lingering questions that could not be answered by the site leader. This was done for all three school sites for consistency in IRB protocol at the sponsoring institution. Each school site distributed the materials and kept track of the materials initially. Completed forms were given to the university to store securely.

At the end of the STEM Club, parents, administrators, and community members were invited to East and North Middle Schools for an open house. Students presented their penguin houses, described the design process and answered questions from their audience. The open house served as a way to bring closure to the program but also to highlight the students' work during the previous weeks. The Superintendent of Schools, local business and industry people, and other interested community members were in attendance.

The studio instructors were three females. The instructor at East MS was a 29 year old elementary teacher with 8 years of experience teaching 4^{th} grade math. The instructor at North MS was a 55 year old 5^{th} grade science teacher with 33 years of teaching experience. The instructor at South MS was a 29 year old middle school science teacher with 7 years of teaching experience. All three instructors received training so that they could implement the curriculum with the assistance of volunteer facilitator/mentors who worked directly with small groups of youth throughout the intervention. This full day of training (9am – 3pm) took place the month before the afterschool clubs began with all of the materials that the youth would be using. The professional development was led by the first author, and the instructors engaged in the curriculum as students would with plenty of time for discussion and metacognition. They worked in small groups, participated in the demonstrations, tested materials, designed and constructed penguin dwellings, tested these dwellings, and engaged in a re-design after discussion.

Additionally, they had the curriculum printed out for reference, and a detailed reading on heat, temperature, and thermal energy was provided. The entire day of training was videotaped. Many of the volunteer facilitators attended the day's training, and those who could not attend watched the video. All of the volunteer facilitators were undergraduate students at a nearby university.

Data Collection

Data were collected at each of the three sites through videotaped observations, pre and post tests on science concepts, Edmodo chat exchange logs, hand-drawn storyboards, and transcripts of interviews conducted by studio site leaders and the research team. The studio sessions were videotaped with two cameras. One camera was stationary and captured the action of the entire studio. A second hand held camera focused on selective close-up action at tables as youth were designing, or when youth were presenting, or at computers as youth worked on the Edmodo site.

Observations/ video analysis

Whole class studio sessions were videotaped at each location each week. Transcription took place in chunks. The videos were watched by two researchers, and every five minutes they were stopped and summarized in writing. After completed, the transcripts were open coded by both a researcher and a graduate student, and themes were noted. This observation procedure was used to pick up fine details about the teachers' implementation of the curriculum, the environmental differences between the three sites, the behaviors of the youth and the general level of engagement by the participants.

Pre and post tests

The pre and post test, *Heat Transfer Evaluation*, was administered on the first and last days of the unit. This 12-item multiple choice instrument from Schnittka & Bell (2010) has demonstrated validity and reliability with the middle school aged population. It was designed to target common alternative conceptions that youth have about heat transfer. This instrument was used to not only determine concept attainment, but to compare how youth in an informal, after-school environment perform on the assessment compared to middle school youth in formal school settings. The pre and post tests were analyzed using paired t-tests and a one-way ANOVA to look for differences between groups.

Edmodo

Throughout the STEM Club program, facilitators and youth were encouraged to interact through the social media site Edmodo. The purpose of including access to Edmodo was to expand upon the idea of informal learning settings, and to provide youth with the opportunity to continue interacting with one another and STEM Club materials outside of the scheduled program time. Transcripts of facilitator and student discourse on the Edmodo site were analyzed throughout the program. Special attention was given to the type of discourse relative to the HOMAGO model of media engagement, which describes three distinct levels of youth engagement: *hanging out* (HO), *messing around* (MA), and *geeking out* (GO) (Ito et al., 2010). The *hanging out* portion of the model describes interactions with technology that are geared towards developing social relationships with peers. In the chat logs, this form of participation would be identified by discussion about topics of interest not directly related to school or the program, e.g., "What's who's your favorite pop singer?" *Messing around* is the term used to describe interactions with technology for the purpose of informally seeking information of interest to the individual. In the chat logs, this was represented by quotes such as "What do you know about penguins?" Finally, *geeking out* describes interactions with technology that are specifically directed towards increasing individual expertise and knowledge of a particular subject area of interest. This would be reflected in the chat logs by quotes such as "Our penguin (-shaped ice cube) did better when we used cotton balls to insulate." The HOMAGO framework is descriptive in nature; thus, its use was analytical in nature as we looked for learning as driven by the appropriation of technology and increasing levels of interest that demonstrated knowledge related to the Save the Penguins program.

Youth were given time during the STEM Club sessions to sign in to Edmodo to engage with the concepts expressed through the program as well as peers. While on Edmodo, facilitators would encourage discussion related to STEM Club through posting related questions. Nevertheless, time spent on the site was dependent on the time required to complete the project activity for each day. At the end of each Edmodo session, a graduate research assistant was responsible for collecting chat logs, which lasted over the course of the following week. All postings were read thoroughly, and quotes relevant to the project were analyzed.

Storyboards

As the youth proceeded week by week through the curriculum, they kept track of their activities and findings, ideas, and designs on storyboards. A storyboard is simply a poster board divided up into sections like a comic strip. Approximately 16 squares result, and each group of students creates their own unique storyboard. These were used in analysis in order to look for written evidence of learning, perhaps evidence left by quieter members of the groups.

Interviews

Exit interviews were conducted with a subset of participants, videotaped, and transcribed for analysis. Analysis was directed at looking for evidence of learning science, evidence of misconceptions about science, and attitudes toward science and engineering. Coding was done by one researcher and a graduate student until agreement was met.

Results and discussion

Video Analysis

East Middle School

Based on whole-class video, it was evident that this was a teacher-centered environment during some of the time each week, and the teacher used a question and fill-in-the-blank answer format during whole class discussion. For example, she would ask, "Which means it rises to the…. ______ and the cold stuff sinks to the bottom…. And that is _______". She was not overly focused on definitions and gave the students ample time to freely discuss concepts amongst themselves, and asked probing questions to determine why students were choosing certain materials or placing materials in a specific location. She had students present their designs and findings each week once the design and testing phase begun. She regularly interjected questions during these presentations, and stressed that they were all trying to learn together. She offered additional funds for purchasing supplies based on the quality of the storyboard, so this was an incentive to document experimental and design details.

Based on interviews conducted with youth at the conclusion of the unit, the following broad assumptions can be made:

1. Most of the youth understood that the design of the house should have less surface area in order to reduce heat transfer into the house, but they did not always articulate why. One student said it kept down costs. "A rounded surface has less surface area so we could use the materials more thickly with it costing less. (male, J.N.)"
2. Most of the youth identified that Mylar and aluminum foil reflect light, thereby reducing radiation. However, some said it reflected heat. While it is true that reflective surfaces reflect infrared radiation (heat), this was not taught and may be a prior concept. "We used the Mylar and foam and aluminum to reflect the radiation… (male, L.L)"
3. Most of the youth recognized cotton, paper, and felt as insulators. "We used insulation so none of the heat could get in. We used foam, bubble wrap, and a cotton ball (female, N.H)."
4. A few of the youth used glue or paper to block holes to reduce heat getting into the house, but they did not articulate that they were preventing convection. "We used glue to make it air tight so none of the heat would seep in (female, C.H.)."
5. Most of the youth struggled with clearly identifying the mechanisms of heat transfer (i.e. radiation, conduction, and convection) underlying the construction of their penguin houses. Most of the youth used Popsicle sticks to hold (or position) the house, which is not a wise use of limited funds since other, less expensive materials can be modified for structural purposes.
6. There were some lingering misconceptions, such as the one that air is not a good insulator. "We minimized the amount of air because air isn't a good insulator (male, J.N)." or that black materials are conductors. "We used two black sheets to conduct heat (male, C.M.)."

North Middle School

Based on whole-class video, it was evident that the teacher focused on definitions and diverted from the curriculum to add in her own activities that may have added confusion and taken away interest. On the first day of the unit she was teaching the definitions of heat and temperature. She stressed the correct transcription of the definitions onto the storyboards, and corrected youth when they were wrong even on the second day of the unit. She was still stressing the definitions of heat and temperature on the third day of the unit even though these definitions are not explicitly in the curriculum to be taught. The learning (or lack thereof) is much more evident in the small group interviews than it is in the whole class video record.

Based on exit interviews with groups of youth, there was a clear lack of some key understandings at the end of the unit even though definitions were stressed throughout the unit.

1. Some youth could not easily associate the materials used in building their penguin houses with the kind of heat transfer they prevent. “We had a lot of stuff like foam, bubble wrap, and felt on top sandwiched to keep radiation, and Mylar on top to help with that (AAAs).”
2. There was an emphasis on structure instead of heat transfer. “We used the materials for the penguin house so that the house is steady and don’t break (The Penguins Group).” Some youth did not speak loud, and some youth did not pay considerable attention to the project.
3. There were examples where youth clearly did not understand the objective. For example, “The roof shades the floor. It keeps the radiation from hitting the black floor (The Classifieds).”
4. However, virtually all the youth thought about the cost of materials used to build the penguin house. They reduced cost by building smaller penguin houses. The budget may have played too large a role in the design. For example, “Money is really important because we were almost out (The Sparkquins).” “We made the house smaller and put an umbrella on top (Brainiacs).”

South Middle School

Based on the whole class video, youth and teachers at South Middle School had a very relaxed, informal attitude about the curriculum. The atmosphere was playful and the discussion frequently got off task. There were few examples of direct instruction, and few examples of interpretive discussions. In general, there was a lack of focus. For example, on the fourth day of the unit 5 minutes into the session, one young man was standing next to his table throwing pieces of paper in the air and spinning a piece of paper and a straw on his head. His group mate was using the flip cam, but it was unclear what her focus might have been. Then, 10 minutes into the session, all adults could be found seated at the back center table talking about school issues (politics). A male student in a football jersey was wandering around the room. He stopped in front of the camera to make gestures and dance as if he were a chicken. He then sat down at the computer and began to talk to his peers.

It comes as no surprise that youth at South Middle School demonstrated a significant lack of deep understanding while describing the design decisions they made in interviews about the penguin houses.

1. The three methods of heat transfer were not understood separately. “Well, we figure out Mylar and cotton works the best to keep the house cool (male, T.)” “The felt is to keep heat from getting to the penguin (male, B.).” “We put white felt so that it could protect the penguin (female, A.)”
2. The rationale for design decisions was not tied to scientific evidence. “We put cotton balls inside because it worked best (male, Folsom shirt).” “White foam will not conduct the penguin so it won’t burn it (male, T.).”

Pre and Post Test Analysis

The 12 item multiple choice instrument, Heat Transfer Evaluation, was used to assess conceptions about heat transfer before and after the unit. This instrument was found to be valid and reliable with 8th grade students in prior studies (Schnittka, 2009; Schnittka, Bell, & Richards, 2010) with students typically scoring 4 points on the pretest and 8 points on the posttest when instructed per the curriculum in a school setting. The topics tested were: Directionality of heat transfer (items 1,2, and 5), Insulators (items 3 and 9), Radiation (items 6 and 12), What generates heat? (item 4), Material properties (item 11), Conduction (items 7 and 10), and Convection (item 8).

At East Middle School, 20 out of 24 youth took both tests. The pretest average was 4.75 out of 12, and the posttest average was 7.3 out of 12, with a gain of 2.55 points. Paired t-tests demonstrated a statistically significant gain from pre- to posttest ($p < 0.001$). There were positive changes seen in items representing directionality, insulators, and material properties. There was no change seen in the concepts of conduction, convection, or radiation.

At North Middle School, 25 out of 30 youth took both tests. The pretest average was 4.64 points out of 12, and the posttest average was 6.88 points out of 12, with a gain of 2.24 points. This represented a statistically significant change ($p < 0.001$). There was moderate positive change in understandings about directionality and insulators, and little to no change in concepts of conduction, convection, radiation, and material properties.

At South Middle School, 3 out of 11 took both tests. The pretest average was 4.33 points out of 12, while the posttest average was 4.66 points out of 12, with a gain of .33 points. This was not a statistically significant change ($p = 0.667$). All three youth scored correctly on the posttest on one item about conduction and one item about radiation. Otherwise, there was no change in any other concepts.

Eliminating South Middle School from the analysis due to small sample size, an ANOVA demonstrated no significant difference overall between outcomes at East and North Middle Schools with statistically equivalent pretest scores ($p = 0.84$) and statistically equivalent posttest scores ($p = 0.56$).

However, there was an interesting gender difference. With females from both North and East Middle schools combined, and males from both schools combined (since both schools were statistically equivalent), results indicate that gender influenced the pretest scores because female youth performed significantly poorer ($p = 0.0012$) compared to the male youth. However, the implementation of the "Save the Penguin" curriculum seemed to improve the comprehension of the intended scientific concepts by female youth because their posttest scores were statistically equivalent to those of the male youth ($p = 0.29$). See Table 1.

Gender	Pretest	Posttest
Male (N=24)	5.46	7.42
Female (N=22)	3.81	6.67
P-values	**0.0012**	0.2885

Table 1. Gender effect

Edmodo Chat Analysis

Analysis of Edmodo discourse was performed using a codebook developed by the research team. The codebook was derived from the HOMAGO model to categorize student and facilitator discourse for further analysis, and the third iteration of the codebook became the working version. Development of the codebook emphasized the action-oriented nature of language (Roth, 2007) in which discourse is undertaken to serve a particular purpose. Here, analysis of language through Edmodo was based off of understanding the purpose behind youth posting as it related to STEM Club. For example, youth may post for the purpose of increasing social interaction with peers involved in the program. They may also post for the purpose of asking questions or clarifying concepts discussed in the STEM curriculum. The analytical posture compels one *not* to assume the talk is merely the reproduction of a priori constructs in the head. Meaning is made through active engagement with peers through social media.

There was a natural progression observed in student postings at East Middle School. For example, the first day of the program was dedicated to setting up Edmodo accounts and completing a pre-test to assess prior knowledge of heat transfer concepts. Youth were not given instruction on any of the materials related to the course, and as a result, the vast majority of posts were coded into the *hanging out* category. An example would be a post such as, “is anyone having a good time..... anyone?” also coded into the *virtual co-presence* subcode on the first day of the program. In contrast, on the first penguin house construction day, youth were prompted with a question and were able to respond with more posts that were coded into the *geeking out* category. An example here would be a post such as, “Ours bc we put an insulator inside,” which was also a *STEM talk* coded post in response to the question, “Who thinks their house is going to be the best at ‘saving the penguin?’ Why???” The participant uses the word “insulator” in order to provide a reason for the potential success of their design. This is most likely a result of youth possessing more background knowledge (provided through the PowerPoint lecture and hands on experiments) at this point in the curriculum.

A lack of Edmodo posts from outside of the after-school environment does not necessarily mean that there was a lack of understanding or engagement with science concepts. While youth may not have been engaged with Edmodo outside of the learning environment, they appeared actively engaged with the technology when they were given time to do so. An example can be found in the following discourse. All responses were completed on the same day as the first prompting question:

East M.S. Teacher to Save the Penguins: Why do you think your penguin ice cube melted the way it did under the lights? What will you do differently in the re-build?
B.F. - we are going to put white felt around it and some cotton balls
S.S. - um......probably put more Myler or more light colored material or alum. foil
B.R. - The Arctic Power Pengiuns are going i think we have not talk about it but i think that we are going to more bubble wrap in side of the house and out side
S.S. - good idea B.R.
B.R. - I agree with your group S.S., our group is going to put myler and some more bubble wrap

When facilitators asked questions directly related to the material ("What materials will you use to re-design your house?"), youth were much more likely to respond with postings that could be categorized as *messing around* or *geeking out*. This was again dependent on whether the facilitation posts were created during the scheduled Edmodo time, or whether they were created after the STEM Club session had ended. This is not to say that youth did not engage in STEM talk without facilitation, but just that the frequency of STEM talk, whether accurate or indicative of misconception, was much higher with prompting. A good example would be this particular collection of posts:

East M.S. Teacher to Save the Penguins: Which material was a better insulator and why?
G.D. – Wool, because it keeps the warm air out!
H.L. – wool,it was very thick to keep the cold in and the heat out.
F.F. – Wool i cant rember why
B.H. - it was the wool sock because it was filled in air and the heat couln't move inside to make the soda cold
A.S - it was the wool sock because it was the best isalator and kept the cool in better
S.S. - wool because it had a good amount of air in the sock for it to be a good insulator

From this example it is apparent that facilitation results in responses by participants. Though this sample was taken from earlier on in the STEM Club curriculum (misconceptions such as the ability of coldness to transfer are still common), youth are seen to begin to understand and articulate concepts such as insulation and the ability of heat to transfer.

Storyboards

East

Storyboard analysis from East Middle School revealed that students were given permission to draw freely and express themselves and the ideas discussed from the curriculum in multiple formats. Students were encouraged to draw what they thought were examples of convection, conduction, heat transfer, and radiation. All groups at East had unique drawings mixed with text or longer explanations of science concepts. Storyboards contained a plethora of information, from drawings, to results of materials testing. Based on the volume of data recorded on the storyboards, students were using them to record data throughout each session and not just when prompted. Students drew pictures of penguins and other artifacts that related to the project as well as stapling other data they had collected, such as their grant applications for funds to purchase extra materials. Students recorded their design ideas from phase one to phase two of the design process of their penguin house.

North

Students at North M.S. had text heavy storyboards with numerous pages of results and other data taped or stapled to them to depict testing and handouts from the curriculum. The site leader included a picture of the team members to help identify students in each group. Students shared pictures with written descriptions of convection, conduction, heat transfer, and radiation. Students used the storyboards extensively, recording data at each phase of the curriculum and included drawings of their first and second penguin house designs. Based on the volume of data, the storyboard appeared to serve as a living journal and was being used throughout each session.

East and North were consistent in their heavy use and journaling of the storyboard (using it as a living thing at each session) since the recorded data indicated that students had ready access and were encouraged to use the storyboards regularly. Students appeared to use a mix of drawings and text to help communicate the information being conveyed they would need to save their penguin. Students at both of these sites utilized drawings to show their creative agency and thought in designing their penguin houses. Both sites also had data after the testing phase of house design. Students recorded how much mass their ice cube penguin lost on their storyboards. Students tried to use identifying symbols or color-coded their storyboards to signify when something was 'cold' by using a specific color marker or 'hot' by using another. Students were creative and tried to use waves or squiggly lines to depict heat moving from one place to another (cookie monsters, big ocelot, smarties, triple A's, classifieds, penguins).

South

Storyboards at South M.S. were less consistently utilized with gaps in students' recorded data. Initially, students used the storyboards to communicate the main ideas of the curriculum, but use slowed steadily. Some groups stopped using the storyboard at the materials testing stage and did not record any other data (the penguins) while other groups (magical blue penguins & angry birds) used the storyboard to record drawings of what the penguin house looked like in the testing phase under the lights. Only one group had any data on the results of their penguin house testing (angry birds) and color coded their storyboard to make the marker color, blue, depict that something was cold.

Research Questions Revisited

The questions guiding this investigation were:

1. How does social media influence youth's understandings of science in this informal, engineering design-based afterschool studio setting?
2. What are ways to successfully determine changes in understanding?
3. How do the actions of site leaders and facilitators impact learning?

Through a thorough analysis of all the data sources available, we can tentatively surmise that social media played a positive role in giving the youth "voice" to express themselves to each other and to the teachers and facilitators outside of the classroom environment. The teachers made a point to allow youth weekly access to the Edmodo chat site, and the students used the site to not only talk with each other and the teacher, but to post websites and videos they had located relevant to the topic.

While the pre and post tests were valuable in determining changes in understanding over time, the whole class observations did not shed much light on the youths' learning progress, primarily due to the inability of the camera to be everywhere at once, and the inability of the camera's microphone to pick up all the small group discussions. The small group and one-on-one interviews were the best source of determining what students were thinking, learning, and how they were making sense of the science and engineering at hand.

The actions of the site leaders and facilitators seemed to be key in impacting youth learning. While teachers tended toward a school-like teacher-centric didactic style of teaching, they did incorporate elements of Socratic questioning, probing for reasoning, and allowed for ample free time to explore, design, test, and re-design. Even when the teachers focused on definitions and facts, and used a call-and-response style, the freedom allowed youth in the STEM Club space seemed to positively impact overall understanding. This conclusion leads us to the ultimate question-

Do youth come to change understandings of science through STEM Club?

Results indicate that STEM Club did have an effect on student understanding of heat transfer concepts at sites where attendance was regular. This is consistent with previous literature highlighting the effectiveness of informal extracurricular science programs in promoting science understanding among middle school aged youth (Sadler, Coyle, & Schwartz, 2000; Cantrell, Pekcan, Itani, & Velasquez-Bryant, 2006). Responses by youth often included scientific terminology introduced through the STEM curriculum, and were often accurate. There were also a larger number of posts and comments related directly to STEM material once participants had undergone the lesson on heat transfer and engineering. Posts and discussions prior to the more interactive program sessions were unrelated to the curriculum, and were for the purpose of socialization. This suggests that involvement with STEM Club increases student knowledge and interest in heat transfer concepts and application resulting in more STEM related discussion. Previous research has shown that the presence of well-defined goals help to engage student interest and interaction with science challenges (Sadler, Coyle, & Schwartz, 2000). STEM Club also provides a well-defined goal (to save the penguins through constructing an enclosure), and appears to have a positive impact upon participant knowledge and interest in science. While misconceptions were still evident at points throughout the program, this was probably a result of individual participant variation, and not of the way in which the program was implemented. Student engagement with the material was strong throughout the program as indicated through positive posts to the Edmodo website and video analysis. Pre and post tests of science content demonstrated significant gains for youth at North and East Middle schools, especially for the female youth.

Conclusion

Findings indicate that the relaxed freedom youth experienced in a setting after the school day was over was conducive to learning. When mediated by the support of adult volunteer facilitators who bounce ideas, focus excess energy, and challenge the youth to think deeply, this impact was even greater. Youth in the studio settings were able to apply the new knowledge they gained to engineering design activities, and demonstrated that knowledge through discourse, chatting online, drawing, and presenting in ways not normally accomplished in the school-day classroom.

However, an atmosphere that was too relaxed and not focused enough on productive scientific discourse (South Middle School) yielded much less impressive outcomes. The students at South Middle School lacked structure in the program with low expectations. This made it difficult for the site leader to deliver a consistent program since she was always working to catch students up on the material they had missed the previous week. There was little support from the Boys and Girls Club administrator to help ensure students were in attendance and the students were resistant to attend consistently for unknown reasons. Students who would veer off-task during the sessions were more concerned with outside concerns than the STEM Club.

This study has implications for how STEM programs can be integrated after school to reinforce school curriculum while providing safe, secure, social outlets for developing youth. It also has implications for how learning can be assessed in an informal setting through interviews, documented online chatting, storyboarding, and whole setting video analysis.

References

Beck, E. L. (1999). Prevention and intervention programming: Lessons from an after-school program. *Urban Review, 31*(1), 107–124. Gerber, B.L., Cavallo, A.M.L., & Marek, E.A. (2001). Relationships among informal learning environments, teaching procedure and scientific reasoning. International Journal of Science Education, 23(5), 535-549.

Cantrell, P., Peckan, G., Itani, A., & Velasquez-Bryant, N. (2006). The effects of engineering modules on student learning in middle school science classrooms. *Journal of Engineering Education,* 95(4), 301-309.

Davies, B., and Harré, R. (2000). Positioning: The discursive production of selves. In *A body of writing 1990-1999*, B. Davies (Ed.), 87-106. Walnut Creek, CA: Altamira Press.

Gross, L. (2005). As the Antarctic ice pack recedes, a fragile ecosystem hangs in the balance. *PLoS Biology 3*(4), 557-561. Downloaded from http://www.plosbiology.org/article/info%3Adoi%2F10.1371%2Fjournal.pbio.0030127

Ito, M., Baumer, S., Bittanti, M., Boyd, D., Cody, R., Herr-Stephenson, B., Horst, H. A., Lange, P. G., Mahendran, D., Martinez, K. Z., Pascoe, C. J., Perkel, D., Robinson, L., Sims, C., & Tripp, L. (2010). *Hanging out, messing around, and geeking out*. Cambridge, MA: The MIT Press.

Jenouvrier, S., Caswell, H., Barbraud, C., Holland, M., Stroeve, J., & Weimerskirch, H. (2009). Demographic models and IPCC climate projections predict the decline of an emperor penguin population. *Proceedings of the National Academy of Sciences, 106* (6), 1844-1847. Downloaded from http://www.pnas.org/content/106/6/1844.full.pdf+html

National Research Council [NRC] (2009). *Learning science in informal settings: People, places, and pursuits*. Washington, DC: The National Academies Press.

Payton, J. et al. (2008). *The positive impact of social and emotional learning for kindergarten to eighth-grade students: Findings from three scientific reviews*. Chicago, IL: Collaborative for Academic, Social, and Emotional Learning.

Roth, W. M. (2007). The nature of scientific conceptions: A discursive psychological perspective. *Educational Research Review, 3*, 30-25.

Schnittka, C.G., Brandt, C., Jones, B., & Evans, M.A (2012). Informal engineering education after school: A studio model for middle school girls and boys. *Advances in Engineering Education, 3*(2). Retrieved from http://advances.asee.org/vol03/issue02/papers/aee-vol03-issue02-p04.pdf

Schnittka, C.G., & Bell, R.L. (2011). Engineering design and conceptual change in the middle school science classroom. *International Journal of Science Education, 33*, 1861-1887.

Schnittka, C.G., Bell, R.L., & Richards, L.G. (2010). Save the penguins: Teaching the science of heat transfer through engineering design. *Science Scope, 34*(3), 82-91.

Schnittka, C.G. (2009). *Save the Penguins Engineering Teaching Kit: An Introduction to Thermodynamics and Heat Transfer*. http://www.auburn.edu/~cgs0013/ETK/SaveThePenguinsETK.pdf

Sadler, P. M., Coyle, H. P., & Schwartz, M. (2000). Engineering competitions in the middle school classroom: Key elements in developing effective design challenges. *The Journal of the Learning Sciences,* 9(3), 299-327.

Tamir, P. (1990). Factors associated with the relationship between formal, informal, and nonformal science learning. Journal of Environmental Education, 22, 34-42.