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Engagement and knowledge building in an afterschool STEM Club: analyzing youth and facilitator posting behavior on a social networking site

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Social networking sites (SNSs) are popular technologies used frequently among youth for recreational purposes. Increasing attention has been paid to the use of SNSs in educational settings as a way to engage youth interest and encourage academically productive discussion. Potential affordances of using SNSs for education include knowledge building, collaborative communities, and the ability to document and share processes and designs. In this study, the SNS, *Edmodo*, is examined as an educational tool used with Studio STEM. Results indicated that youth appropriated *Edmodo* to exhibit engagement and articulate knowledge through reciting facts, acknowledging learning, and documenting progress with the guidance of instructors and facilitators. Based on results, we suggest that efforts to include SNSs in integrative science, technology, engineering, and mathematics programming for youth prioritize consistent monitoring and guidance by supportive and more knowledgeable others as this serves to develop community and encourage youth engagement.

Keywords: engagement; integrative STEM education; knowledge building; out-of-school time; social networking sites

1. Introduction

In the USA, integrative science, technology, engineering, and mathematics (STEM) education has taken center stage as an area of interest for teacher educators, learning scientists, and curriculum developers. While integrative STEM education in the classroom is of great importance, greater attention is being devoted to opportunities to engage youth, and particularly marginalized youth, in STEM-related activities and programs outside of the classroom (Adams and Gupta 2013; Jaramillo and Britcher 2013). These informal learning

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settings may encourage youth to learn STEM concepts in different ways through problem-solving, collaboration, and design-based learning activities.

Informal STEM educators working with youth increasingly appropriate social networking sites (SNSs) as a way to extend the learning environment beyond the formal classroom setting and into other less formal environments, such as afterschool programming and even the home (Clegg et al. 2013; Nacu et al. 2014). The term, 'social media' has been defined by Dabbagh and Kitsantas (2011) as a diverse group of networked technological tools allowing for social interaction, communication, and collaboration. SNSs, a subset of this broader term, are defined as online forums or platforms that enable the creation of personal profiles, communication among users, the production of comments, posts, and other networking residues, and the development of a hierarchy of access in which some users can participate in more varied ways than others (Grimes and Fields 2012). Specifically, the focus of SNSs, when compared to other forms of social media, is on relationship building rather than on the content that is produced. These factors distinguish SNSs from other forms of social media. Tess (2013) also distinguishes SNSs from other forms of social media, including blogging, wikis, video game communities, etc., and explains that it is common to use examples of specific social media to distinguish social media formats (for example, *Facebook* as an example to represent SNSs or *WordPress* to represent blogging communities).

While a primary appeal of SNSs resides in their current popularity within youth culture, the collaborative potential of SNSs may be desirable for use in informal or non-traditional settings that strive for academic achievement (Ito et al. 2013). SNSs are predominantly used by youth as a way to maintain friendships and engage in recreation. Research suggests that youth aged 12–18 years access SNSs to connect with individuals that they are similar to, with whom they are emotionally close, and who live nearby (Ünlüsoy, de Haan, and Leander 2012). In addition, information discovery has been strongly linked to SNS activities such as sharing resources or links, giving feedback to others, and working on artifacts collaboratively online. The significance of being able to document experiences and ask questions at any time has been emphasized by Ahn et al. (2014) in their investigation of *ScienceKit*, an SNS developed for use with an out-of-school summer program centered on cooking. Ahn et al. (2014) specifically made reference to the idea that the use of SNSs by youth allows facilitators to adjust their focus based on what is posted online. For example, facilitators may discover misconceptions based on questions that youth may ask, or see who might be struggling based on posts expressing frustration. In essence, SNSs provide a rich set of material conditions for learning, with strong potential for encouraging youth to explore STEM concepts through familiar and appealing technologies.

The affordances presented might also be beneficial when considering the critical role of supportive communication between learners and instructors as well as among peers in the same classroom (Hamm et al. 2013; Mills 2011).

The use of SNSs could therefore provide an opportunity for youth to connect with one another and instructors within a less formal environment allowing for casual conversation intertwined with academic exploration (Nacu et al. 2014). The potential to engage youth through the appropriation of technologies that are familiar and integrated into youth culture may give SNSs an edge in the ongoing search for innovative learning strategies and technologies.

Though SNSs are familiar among youth, there are still discrepancies when considering access to SNS technologies (Barbour 2013). This is particularly true of rural, low-income areas in the USA, and specifically the population of youth participating in the current study. In locations such as the study area, schools might not have the financial means necessary to appropriate SNSs due to a lack of computers in school buildings (Chen and Liu 2013; Roberts and Green 2013). Youth who may not have consistent access to the internet still know about SNSs as part of their youth culture. For example, interactions with peers having more consistent access can increase youth interest in using SNSs. However, access may be further complicated by a lack of youth access to computers and SNSs from the home environment. These challenges can make it difficult for instructors to take advantage of the potential benefits associated with newer technologies, including SNSs. They may also complicate the ability of youth to access a preferred SNS for recreational purposes.

Thus, the purpose of this study was to explore youth engagement and knowledge building through the integration of the education-specific SNS, *Edmodo*, into an afterschool integrative STEM program, Studio STEM. Through focusing on the rural youth population, the study also explores potential challenges associated with using SNSs with underserved populations. Since students in the target population do not have many opportunities to engage in integrative STEM-related activities, Studio STEM provides a way for youth to learn content using the design process in an after school setting with technology. Understanding the interactions that youth have with one another and facilitators through the *Edmodo* site could illuminate the benefits of including SNSs in similar youth programming. In the sections to follow, a review of the literature will be conducted, focusing on youth and facilitator interactions through SNSs youth engagement through SNSs, the affordances of SNSs for youth knowledge-building, and challenges associated with adopting SNSs for education. An explanation of the methodology will then be given, followed by results to conclude with a final summation of significance and implications for future research and implementation.

2. Literature review

2.1. *Youth engagement through SNSs*

According to Jones (2009), engagement consists of interest in a subject and concentration or focus toward that subject. Interest and focus can be identified using a variety of indicators. For example, youth may display their engagement through indicating a preference for certain topics. They may also indicate their interest and focus through asking questions to further their understanding. Mutual engagement by contrast is defined by Mills (2011) as joint participation in discussions and exchange related to the community, centered on common interests and goals. Mutual engagement is particularly important when considering the use of SNSs as educational tools for youth. Due to the popularity of SNSs within youth culture, it is possible to keep youth interested by blending the margin at which academic and personal lives intersect (Asselin and Moayeri 2011).

While much of the current literature focuses on youth that have consistent access to technology, the current study population has less consistent access to SNSs for recreational and educational use. For the purposes of this study, several categories of focus were chosen when exploring the role of youth engagement through SNSs. These included involvement in Studio STEM material, as indicated by the ways in which youth articulated concepts and recognized their learning process, interaction and discussion with other members of the SNS community, and the expression of emotions related to the program.

Mao (2013) has previously discussed the attitudes of high school-aged students toward the use of SNSs for educational purposes. Students indicated that they had positive attitudes toward using SNSs in the classroom, saying that they felt more creative and that they felt that they learned more when they had the opportunity to use it. They also indicated that they enjoyed using SNSs to complete assignments and for their own personal learning outside of school. These results indicate that there is a strong potential for the use of SNSs to engage students in and out of class, perhaps keeping them interested and making assignments more enjoyable. Ahn et al. (2013) have also reported the efficacy of SNSs as a way to engage students in scientific inquiry. The education-specific SNS, *Scientific INQuiry* (SINQ), provided a way for youth to learn about kitchen chemistry through asking exploratory questions, hypothesizing, and generating ideas for experiments to try. While results indicated that different youth preferred to participate in different ways and to different degrees, SINQ was found to be useful in encouraging youth to interact collaboratively and through scientific inquiry.

Works focusing on the benefits of education-specific SNSs vary in terms of which platform or site becomes the focus. For example, SINQ, investigated by Ahn et al. (2014), was an SNS originally designed to organize thoughts, questions, and ideas related to educational projects. Youth that interacted through SINQ identified it as an SNS that they would use for school, but that they might not access for fun in a home environment. It was only in later iterations of SINQ that researchers began to include features aimed at social engagement and personal expression. In contrast, general SNSs such as *Facebook* and *Twitter* allow for a great deal of personal expression through the customization of avatars and profiles, as well as the ability to upload photos and videos. While

SNSs in the current literature vary from study to study, it is important to note that the capacity for productive interaction between members should remain the focal point. The types of interactions that occur may affect the formation of communities for knowledge building and discussion.

2.2. *SNSs for youth knowledge-building*

SNSs have the potential to serve as a place for youth to discuss their ideas and collaborate. This may be enhanced through the collection of information, links, and other resources within SNSs over time. SNSs then become tools that youth may utilize for learning and sharing ideas as well as knowledge repositories for youth to refer to throughout the learning process. Bielaczyc and Ow (2014) have investigated this knowledge-building process in which players participating in a virtual community advance their ideas through taking specific actions, such as proposing ideas, improving upon the ideas of others, asking new questions, and adding relevant information to the community knowledge pool. The idea of knowledge building as a set of behavioral indicators was adopted as an area of investigation for the current study. The behaviors associated with the knowledge-building process as identified by Bielaczyc and Ow (2014) are observable in SNS environments, and may provide insight into the ways that youth interact and learn through their participation in discussion. In their study, Bielaczyc and Ow (2014) indicated that youth were encouraged to explore a specific problem using these actions in the form of notes that could be posted online to the community. Youth were able to view others' notes in relation to the core problem as well as to provide commentary and suggestions aimed at improving the notes. While the format for the learning community in this study does differ from the *Edmodo* SNS format used for Studio STEM, the idea of knowledge building through maintaining access to the ideas of others is still present and relevant.

The work of Chen et al. (2011) investigated the ways in which fifth and sixth-grade youth identify important ideas and opportunities for online discussion with their peers. Consistent with the previously discussed markers of knowledge building, Chen et al. (2011) observed that students identified statements of fact, and questions posed by other members as ideas of particular interest. These are particularly related to knowledge building since both types of interactions resulted in a discussion of content. For example, youth responded by proposing ideas and contributing knowledge to the forum. Friesen and Lowe (2012) recognize discussion, particularly debate and disagreement as an important part of learning. Although interaction through SNSs was not originally meant to have intentional impacts on education and learning, the opportunities that SNSs create for discussion of ideas and opinions may lead to learning experiences online. This is relevant to the knowledge-building identifiers discussed by Bielaczyc and Ow (2014), which can be integrated into a community knowledge pool.

Collaborative knowledge building through the use of online environments similar to SNSs has also been verified as a way to improve academic literacy (Zhao and Chan 2014). In their study, business students used an online forum to discuss and organize ideas related to quality management. Students had the opportunity to create notes. These notes were available to other students who could then respond, provide evidence, or give feedback. Throughout this process, concepts were expanded on and a learning community was formed. Oftentimes, the notes that business students created had to do with concepts that they struggled with in the course. Other students and instructors could then explain difficult concepts through discussion and scaffolding. The *Edmodo* SNS, integrated into Studio STEM, provides similar opportunities for knowledge building. Youth were encouraged to talk about the interesting things that they learned during each session as well as to update others on progress.

2.3. *Youth interactions and discourse with facilitators*

Facilitators prompt youth to persist with their experimentation and express themselves through a variety of media, including photographs, links to external resources, video, and text (Evans, Won, and Drape 2014). These media types provide outlets for youth to articulate their understanding of activities and concepts. These interactions take place through SNSs, and can vary in terms of strategy. For example, Darabi et al. (2011) discussed four different types of discussion strategies implemented through online learning environments: structured, scaffolded, debate, and role-play. When questioning and prompting were aimed at scaffolding students, Darabi et al. (2011) found that students were more likely to engage in the application of knowledge to new situations. By contrast, questioning and prompting meant to inspire debate and role-play encouraged exploration and hypothesizing. Studies such as this emphasize the importance of strategy on the part of facilitators and instructors in online learning environments. Choosing the appropriate strategy may result in different types of learning outcomes for youth. Previous literature also suggests that students at the college level have enjoyed using the *Edmodo* site specifically for group discussions with lecturers and other students in the course (Balasubramanian, Jaykumar, and Fukey 2014). Students found *Edmodo* to be useful for asking questions and receiving feedback, and indicated that communication through the site was quick.

Youth interactions through education-specific SNSs might be compared to interactions that they might engage in while present in a physical classroom. The manner in which instructors and facilitators manage and promote meaningful classroom discourse can have a productive influence on youth learning (Kim and Hannafin 2011). Smart and Marshall (2013), in a study of middle school youth and classroom discourse, reported that instructors have the opportunity to engage youth on a higher level through the use of questioning in the classroom. Asking questions of increasing complexity, or involving the application of new concepts to different situations can result in more complex processing by youth in the classroom. Questioning can also be used to scaffold students, steadily guiding them toward higher levels of understanding (Kim and Hannafin 2011). The questioning strategies used by instructors in the physical classroom are just as relevant through SNSs.

Both physical and SNS classroom discourse should also take into account the equity of youth responses. Shepherd (2014) discussed how classroom elicitation strategies might affect the equity (or even distribution) or participation by students. Ideally, all youth will choose to participate through offering contributions to class discussion. Nevertheless, it is oftentimes necessary for the facilitator or instructor to ensure that participation is distributed evenly. Shepherd (2014) identified three different strategies that teachers use to give students opportunities to respond in class. The first is an individual nomination (directed at a specific individual), the second is an invitation to reply (any individual can speak up at any time to respond), and the third is an invitation to bid (individuals identify themselves, for example, through raising hands, and the teacher selects one to respond). In an SNS setting, it is likely that the elicitation strategies used will be directed toward all youth participants with access to the page. As a result, questions and other prompts should give youth the opportunity to delve into content and to apply it in new ways. Understanding the ways in which youth display engagement by using *Edmodo* such as the manners in which they participate in discussion and articulate knowledge might provide valuable insight into how SNSs can be used effectively to engage youth in learning about STEM concepts.

2.4. *Challenges to social media adoption for learning*

Many of the concerns associated with informal learning environments, including education-specific SNSs, mimic the concerns that instructors have in more formalized classroom settings. For example, encouraging students to engage in academic material is an area of focus in all learning settings. Hamm et al. (2013) mentioned an emotional risk of academic participation in which youth may avoid working hard in school to prevent a negative social image with their peers. Nevertheless, with the promotion of an accepting environment in which peers show support for one another's academic efforts, students are much more willing to participate in school activities and remain engaged. Teachers might facilitate these types of supportive learning environments through encouraging productive behavior and facilitating interactions between students (Hamm et al. 2013).

The work of Kreijns, Kirscher, and Jochems (2002) discussed two major areas of concern when implementing computer-supported collaborative environments, such as SNSs. Social interaction is considered to be increasingly significant due to the potential lack of face-to-face opportunities. Nevertheless, Kreijns, Kirscher, and Jochems (2002) pointed out that social interaction can be taken for granted in online learning environments since it is easy to assume that students will be engaged enough to participate. The second pitfall mentioned is the tendency for instructors to forget about the non-task-oriented social interactions that must occur to maintain a sense of community. In the case of Studio STEM, facilitators and teachers have both face-to-face and online interactions with youth. The different types of interactions are meant to provide support to the learning community as well as to extend the learning environment beyond the time allotted for weekly sessions. In both settings, side conversations are admitted, but guidance provided by facilitators and teachers can serve to bring youth back to focusing on particular tasks.

2.5. *Research questions*

In this study, the following research questions were explored:

(1) How do rural youth, with limited access to SNSs, display engagement through the *Edmodo* SNS?
(2) How can knowledge building (in the form of contributions to the community knowledge base, asking questions, and proposing ideas) be identified in youth posts created through SNSs?
(3) How do facilitators guide youth interactions and knowledge building through SNSs?

3. Methods

3.1. *Participants*

Participants in [*The STEM Club*] were located at two separate study sites in a single school district in rural southwest Virginia. A total of 30 youth between the ages of 10 and 12 years participated in the curriculum (14 from site A and 16 from site B). The gender distribution was 14 male participants to 16 female. Youth were recruited via teacher recommendation as well as through word-of-mouth. While some youth were first-time participants in Studio STEM, others had been involved in previous versions of the program focusing on different STEM content areas. At each study site, multiple facilitators were also involved, including one primary site leader (a middle school teacher), three to four undergraduate facilitators, and a supervising faculty member from the university.

3.2. Studio STEM *afterschool program*

Studio STEM is an afterschool program in which rural middle school-aged youth from low-income communities are encouraged to collaboratively specify and construct a final product (e.g., model of a power grid) using knowledge of scientific concepts and the engineering design process (Evans, Won, and Drape 2014). The objectives for Studio STEM unit were to teach youth about electricity storing in capacitors and batteries, and to familiarize them with the design process used by engineers. This design process involved formulating a plan for construction based on STEM concept knowledge, construction of prototypes, and testing of new iterations.

Studio STEM was conducted in eight sessions over eight weeks. Sessions were centered on teaching new concepts related to circuits, capacitors, and computer-aided design. Over the course of the program, youth worked in teams of three or four toward designing and constructing a model of a village power grid moving from computer-driven design to design in the physical space. Youth conducted experiments designed to reinforce lesson concepts and provide them with information necessary to construct their power grids. Examples of experiments included determining the difference between series and parallel circuits using small LED lights, building a homemade capacitor with aluminum foil and a plastic dialectric, and creating a battery using coins and vinegar-soaked paper. Youth were also encouraged to document their progress each day in storyboard format using posterboard and markers. The concept of village power grids was linked to the environmental issue of declining black-footed ferret habitat. The inclusion of the animal context provided youth with the additional motivation of designing a power grid that was environmentally friendly and that could save the ferrets.

Youth were encouraged to converse and share resources through the freely available SNS, *Edmodo*. The process was guided by the presence of middle school mathematics and science teachers as well as project facilitators who provide support and prompting for youth discussion. For example, the middle school teacher in charge might ask students questions about capacitors to assess what they have learned during a Studio STEM session. Project facilitators, oftentimes undergraduate students in STEM degree programs from a local research university, might encourage students to persist or suggest ideas when they appear to be frustrated with their project. While these forms of encouragement and prompting may also be present in the physical space, the use of *Edmodo* allows for documentation of youth responses and encouraging words that can act as a reference inside and outside of the actual Studio STEM sessions, usually held in the school library.

3.3. *Data collection*

Data consisted of posts to the SNS *Edmodo* created throughout the duration of Studio STEM. During each session, youth were provided time to access *Edmodo*. Facilitators often prompted students to discuss or post about different things related to the day's activities. For example, if youth learned about circuits during a session, prompts might ask youth to talk about what they learned about circuits. Youth were encouraged to use *Edmodo* to interact with peers and facilitators involved with Studio STEM during the sessions and outside of the allotted time. These interactions could take the form of text-only postings as well as shared links to resources on the internet, and pictures and videos taken during Studio STEM activities.

3.4. *Data analysis*

The data analysis was conducted using the work of Geisler (2004) as a guide. The process of coding is described as a cyclical process during which the researcher analyzes data through the use of labeling. As the researcher becomes immersed in the data-set and revisits ideas over time, the codes are linked and become a way to conceptualize main ideas emerging from raw data. This process of constant comparison is useful, as it allows the researcher to continuously compare data to data for the further development of ideas. Codes are defined here as short labels that are used to describe and highlight interesting blocks of data (Corbin and Strauss 2008). Codes can then be organized into categories, which provide a way of conceptualizing similar codes and how they may contribute to overall themes.

The codebook used for the study was developed based on observations within the current data-set. Special attention was paid to instances in which youth discussed their knowledge and how youth displayed engagement with Studio STEM materials and activities. Preliminary codes were organized into a codebook and tested on a first pass through the data-set. The coding for the first 70 data entries was then compared with the coding of a second researcher to establish reliability for the codes. Simple agreement reliabilities (i.e., the number of agreed items is divided by the total items coded) were greater than or close to 80% (articulation of knowledge = 90.67%, engagement = 88%, community interaction = 77.33%, and facilitator input = 100%). Two Kappa values were greater than 0.80: (articulation of knowledge, $\kappa = 0.839$, the strength of agreement is very good; engagement, $\kappa = 0.776$, the strength of agreement is good; community interaction, $\kappa = 0.575$, the strength of agreement is good; facilitator input, $\kappa = 1.0$, the strength of agreement is perfect).

Four main categories were used to organize the emerging codes. The first three categories, articulation of knowledge, engagement, and community interaction build upon the ideas of Bielaczyc and Ow (2014) in their discussion of knowledge building, and were developed through emergent ideas found in the data-set. A complete listing of categories and codes organized into a coding dictionary can be found in Appendix 1:

(1) *Articulation of knowledge:* This category included three codes (1) direct fact recitation, (2) acknowledges learning, and (3) documentation of progress. Codes in this category described instances in which youth discussed what they had learned through participating in Studio STEM. For example, one participant posted, ‘I learned that thicker wires conduct more ELECTRICITY.’

(2) *Engagement:* The engagement category included three codes (1) expression of enjoyment, (2) expression of frustration, and (3) Enquires about STEM Club material. These codes were aimed at capturing ways in which youth expressed involvement or investment in Studio STEM content or activities. For example, one participant posted, 'It was time consuming but AWESOME!!!!!'
(3) *Community interaction:* The community interaction category included four codes (1) providing advice to community, (2) encouragement of others, (3) related commentary, and (4) casual socialization. These codes described ways that youth interacted with one another via the *Edmodo* SNS. For example, one participant posted, 'we should really use a parallel cicuit [sic] so if one goes out they all don't go out'.
(4) *Facilitator input:* The three facilitator-input codes were (1) facilitator provides encouragement, (2) facilitator prompts discussion of concepts, and (3) facilitator socializes. These three codes described ways that the facilitator contributed to the learning community and interacted with youth. For example, one facilitator posted, 'I was very impressed with the BFF towns you created and the results of lighting them using your capacitors!'

4. Results

4.1. *How do rural youth, with limited access to SNSs, display engagement through the* Edmodo *SNS?*

Youth participating in Studio STEM displayed engagement through articulating their knowledge and expressing feelings related to their experiences. From the current study, it was determined that youth articulated their knowledge in three major ways: direct statements of fact, acknowledging that they had learned something from Studio STEM, and documenting progress with their group projects and activities. These results were consistent with previous work with youth in non-rural environments indicating that rural youth are not necessarily at a disadvantage when given the opportunity to interact through SNSs in educational environments. When youth chose to express their feelings about activities related to Studio STEM, these feelings were identified as feelings of inquiry, feelings of enjoyment, and feelings of frustration.

Out of the three ways that youth were seen to articulate knowledge, direct statements of fact were the most common. These facts were most often associated with the program curriculum, and were commonly created in response to prompting by facilitators. The following excerpt is an example of an instance in which youth articulate their knowledge via direct statements:

Youth 1: One of the black footed ferret's favorite snacks is a prairie dog.
Youth 2: The electrons traveled up to the light because the electrons were moving so fast

When youth articulated knowledge, it was identified as engagement with the material that was presented through Studio STEM as well as engagement through the SNS environment. These direct statements of fact were often created in response to a question (similar to a test or quiz answer). Youth also acknowledged that they had learned things from participating in Studio STEM. When youth acknowledged that they had learned something, it was identified as engagement with the material since youth were aware of not having known things prior to Studio STEM. The following excerpts include examples of instances in which youth acknowledged their learning:

Youth 1: I learned that a thicker wire conducts more electricity, which is why machines that require more electricity have thick wires.

Youth 2: Today in STEM we are learning about capacitors!! Capacitors are much simplier than a battery. A capacitor is a device that stores electrons, where a battery produces electrons in one terminal and absorbs them in the other. A capacitor lookd something like this,-{ }-

Youth also articulated their knowledge through documenting their progress. As youth progressed through Studio STEM and became more involved in experimentation and testing, they were more likely to document their experiences on the SNS feed. Since posts were available for all to see, they became a running log of experimental results. This log illustrated not only findings, but the challenges and successes that youth experienced. The following excerpts are examples of several instances in which youth document their progress:

Youth 1: For the Generator we got 16 mins and cranked for 2 mins and that means for our ferret town is 16 hours. For the wind we got 13.20 mins and turned it on for 2 mins and that means 13 hours and 20 seconds for the ferret towns. For solar power we got 8.13 mins and turned it on for 2 mins which means we have 8 hours and and 13 seconds for the ferret towns. The generator worked best for us.

Youth 2: We did 2 minutes charging each energy source. Wind we got 13 minutes, Solar 8 minutes, Generator 16 minutes. Our best GENERATOR!!!!!! Energy SWAG …

The number of all instances in which students articulated their knowledge over the course of Studio STEM can be seen in Figure 1.

While knowledge articulation was seen as an important way that youth showed their engagement with material on an intellectual level, they also displayed engagement through more affective means. These instances were not always separate from instances in which youth articulated knowledge. Oftentimes, youth would state a fact or document results alongside their feelings about those facts of results. In one example, a facilitator asked students a variety of questions related to the day's activities. The responses provided by the youth contain a mix of articulations of knowledge and expressions of affect, both indicative of engagement in Studio STEM:

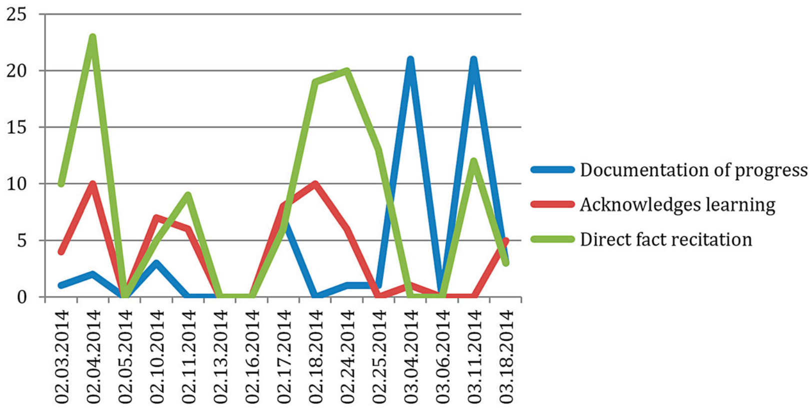

Figure 1. Number of posts by category throughout Studio STEM.

Facilitator: Hello BFF Eastern STEM friends! What did you learn about series and parallel circuits today? We know that the electrical grid in the U.S. is not made of playdough, but what is it made of? What would be a better option to wiring a self-sufficient town, series or parallel? Why???

Youth 1: I like using play-doh as a conductor. I never knew that playdough would do that.

Youth 2: I like playdoh and i cant spell playdoh hehe lol :} hehe

Youth 3: I have learned a lot today at stem ! I learned that parallel is better than series and that when you make a series that it is all connected in a chain and a parallel is not connected in a chain but when you put in the light it all connects. I had a lot of fun with all the play dough today!

Youth 1: Ok [Facilitator] my answers are I learned that parallel circuits are much better circuits than series. The U.S. grid is made of copper wires. Parallel, b/c if one light goes out all the rest stay on.

Youth 4: I learn, electric circuits + parallel are much beater to use, and series are in a chain shape.

In this example, youth express their engagement through discussing specific things that they learned in Studio STEM as well as their feelings of enjoyment. Youth talk about the similarities and differences between types of circuits, and show enthusiasm for working with play-doh. While this example illustrates an instance of positive engagement, it was observed that youth were not always positively engaged with Studio STEM material. At times, they became frustrated with the experimental process. For example, one participant begins to construct a model and exclaims:

Youth 1: OURS WAS A BIG FAIL! BROKEN LIGHTS, BROKEN CAPACITORS! GAAAHHH!!!!!!!

Instances of frustration were common throughout the model construction phases of Studio STEM, but were often met with encouragement from

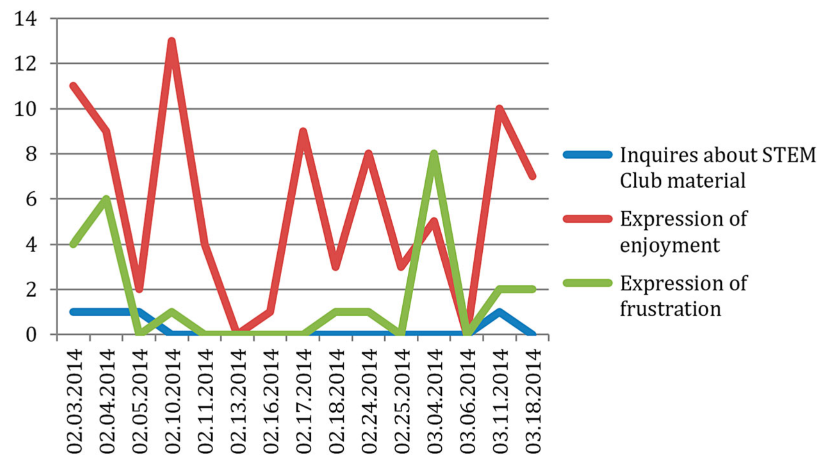

Figure 2. Number of posts within the engagement category throughout Studio STEM.

facilitators and other students. Figure 2 shows patterns in the ways that youth expressed engagement over time.

From the incident count in Figure 2, it was observed that youth expressed feelings of enjoyment throughout the study period. These were much more common than expressions of frustration, especially in the earlier sessions. For example, youth were more likely to express that they 'liked' something or had 'fun' than they were to express that they were 'sad' about ferret habitats were being destroyed or upset about difficulties with their experiments. Less positive emotions such as frustration were expressed more commonly toward the later sessions in which youth were engaged in testing and redesigning. Specific questions posted about material covered during Studio STEM were relatively uncommon throughout the study period.

4.2. *How can knowledge building (in the form of contributions to the community knowledge base, asking questions, and proposing ideas) be identified in youth posts created through SNSs?*

Knowledge building was identified among youth in the form of knowledge articulation and community actions. The previous section has made mention of knowledge articulation, and the idea that stating facts, acknowledging the learning process, and documenting progress throughout Studio STEM indicated engagement with the materials and activities. This engagement was viewed as important to knowledge building, where youth interacted and collaborated in the SNS community. The interactions between youth as well as between youth and facilitators resulted in discussions of concepts available for the rest of the community to see and refer to.

Community interaction was common among youth and also between youth and facilitators. Facilitators played a strong role in initiating the discussion of topics specifically related to Studio STEM. However, youth were also observed to initiate discussion and contribute to conversations occurring on the *Edmodo* feed. While community interactions were most often centered on activities or concepts, youth were also observed to encourage one another and engage in more casual socialization:

Youth 1:	we [me and Youth 2] got our lights on every time on bike for 5 mins and 54 sec. solar for 3 mims and wind for 3 mins i think the bikes would work better!!!!!!!!!!!!!Had fun today! :)
Youth 2:	We had 4 minutes for wind …
Youth 3:	Ya!!!!! [Youth 1] gosh get it right?!?!
Youth 2:	That's right [Youth 3]
Youth 1:	Hahah
Youth 3:	I am always right. lol

In this example, a participant informs the community of the progress that their group has made. Specifically, the participant talks about the different amounts of energy that their group was able to store to power their model. Youth 3, who was not originally involved in the group, then appears to congratulate Youth 1 on the results of the experiment. The two then go on to engage in some playful banter. While at first glance, it may not seem that casual posts and encouragement have much to do with knowledge building, and youth appeared to enjoy creating these posts, perhaps contributing to feelings of community and developing peer relationships.

Engagement in discussion and collaboration also took the form of providing advice to the rest of the community. These posts were not specifically addressed to a particular person, and were instead left as more general commentary to further community knowledge. For example, one participant posts:

Youth 1:	today we learned that if you do the pipe and wool thing enough times that it will make the light light up. But BE CARFUL!!! IF YO: TOUCH THE PLATE OR THE ALUMINUM FOIL IT WILL TAKE ALL OF THE ELECTRONS OUT AND YOIU WILL HAVE TO START OVER!! The light will blink briefly not stay lit for a time.
Youth 2:	I will not make that same mistake again! :)
Youth 1:	Okay!! Thanks! :~)

Youth 1 cautions other members of the community about making a particular mistake as they complete an experiment. The post addresses 'you', directing the advice to anyone who cares to read the post. Youth 2 finds the advice helpful, acknowledging that they had made the aforementioned mistake and that they will not make the mistake again. Figure 3 shows the different types of community interactions that youth engaged in throughout the study period.

From the incident counts included in Figure 3, it was observed that youth provided a great deal of commentary to peers during the earlier sessions, which leveled off for the remainder of the program. Casual socialization was observed sporadically throughout the sessions, and was particularly frequent

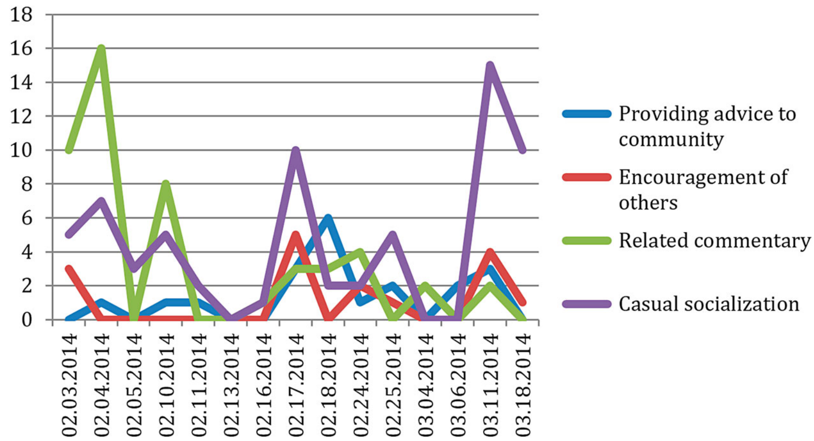

Figure 3. Number of posts within the engagement category throughout Studio STEM.

toward the later sessions. Encouragement of other participants and providing advice to the community as a whole were relatively uncommon, but increased in frequency from the middle to later study sessions, perhaps due to the testing and experimentation going on at that time.

4.3. *How do facilitators guide youth interactions and knowledge building through SNSs?*

Facilitator interaction and prompting remained steady throughout the study period. Facilitators were observed to guide youth interactions in several ways: providing encouragement, prompting the discussion of concepts, and socializing with participants. Figure 4 shows the instances in which facilitators interacted with youth through the SNS environment throughout the study period.

Facilitators provided encouragement throughout the study period. However, there was an increase in encouragement-type posts toward the end of the study period, consistent with the increase in frustration-type posts among youth. Facilitators maintained awareness for the frustrations that youth expressed, encouraging them to continue working on the projects and providing some guidance. The following example is an illustration of one of these instances:

Youth 1: We tried to get ours to work but it was a big fail. Our capacitor was bad. Or maybe the lights. We don't know. So we didn't get to try ours at all.

Facilitator: Don't give up! Try it again! I'll keep my fingers crossed you can succeed!

Youth 1: Okay!! We got ours to work this week!!!

Facilitators were also observed to prompt discussion of concepts learned during Studio STEM. These posts often took the form of questioning youth about

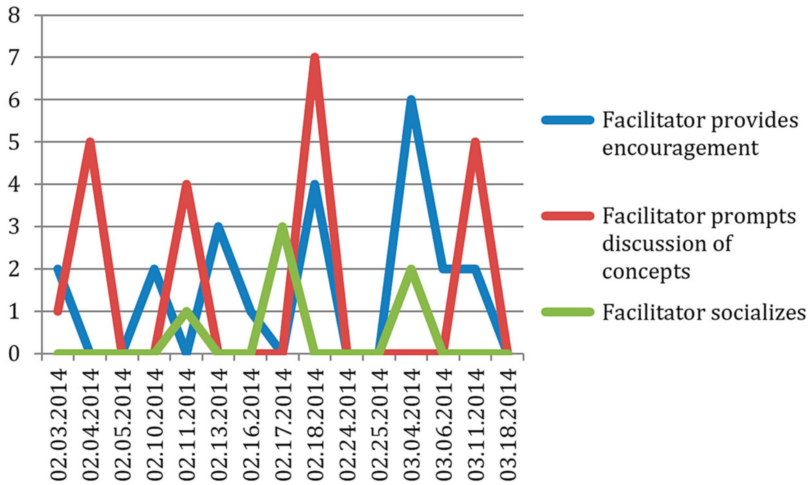

Figure 4. Number of posts within the facilitator interaction category throughout Studio STEM.

concepts to assess what they had learned, or what they had remembered from the sessions. Youth frequently responded to these posts, indicating that they were willing to interact with facilitators and show their knowledge. The following excerpt is an example in which youth discuss concepts via facilitator prompting:

> Facilitator: Okay, [school] BFF's, what did you learn today??? What is a capacitor made of? What does it do? Why would we want to use capacitors instead of batteries to light our town? What is the purpose of the resistor? By the way, you did an amazing job today!!!:)
>
> Youth 1: I found out that when we put the light up to the alluminum, before the light even touched the alluminum, the light turned on for a second, but when the light touched the alluminum it, the light turned off
>
> Facilitator: Ok … question: Why do you think the LED light lit up for a second BEFORE it actually touched the foil? What do you think happened?
>
> Youth 1: The electrons traveled up to the light because the electrons were moving so fast

Socialization on the part of facilitators was much less common than posts that were designed to encourage and prompt youth through Studio STEM curriculum. However, these posts may have played a role in maintaining feelings of community similar to the casual socialization among youth. The following is an example in which a facilitator socializes with a youth:

> Facilitator: I love your profile picture! You are beautiful! Reminds me of when my girls were dancing!
>
> Youth 1: Thanks, how nice

From this, it can be observed that facilitators did not always remain distant from youth participating in Studio STEM. Rather, while most interactions were focused on providing educational opportunities and encouraging persistence, facilitators also worked to develop community through the SNS environment.

5. Conclusions and implications

Through the analysis of the current data-set, the authors suggest that youth display engagement through knowledge building and posts signifying emotion when interacting through the SNS, *Edmodo*. Based upon previous work with youth and interactions through SNSs, it does not appear that rural youth are at a noticeable disadvantage when it comes to using an SNS for educational purposes. Rural youth also appeared to be engaged through the *Edmodo* SNS as evidenced by their documentation of facts and emotions associated with Studio STEM. Jones (2009) has previously defined engagement as consisting of two parts: interest and focus. When youth create posts for the purpose of stating facts, acknowledging the learning process, and documenting progress, they show that they are engaged with the material through focusing on the materials. These posts are then available for the community to view and refer to at other points during Studio STEM. When youth ask questions about material, or express their enjoyment or frustration, this is also indicative of engagement. Posts such as these indicate interest and investment in Studio STEM, and a desire to succeed in the group projects.

The eMpowerment, Usefulness, Success, Interest, and Caring (MUSIC) model of engagement may provide an interesting framework for viewing youth interactions through SNSs in Studio STEM (Jones 2009). The MUSIC model identifies five main factors that contribute to engagement in students. Thoughtful attention to these factors in similar programs to Studio STEM could increase student engagement and the probability of learning. For example, youth familiarity with SNS technology may lead to feelings of eMpowerment (Asselin and Moayeri 2011) and Success. The recognizable presence of SNSs in youth culture may also inspire Interest (Mills 2011) while the virtual presence of the instructor and classmates on the SNS may enhance feelings of Caring (Kreijns, Kirscher, and Jochems 2002).

Engagement in online learning environments has been discussed in terms of teaching presence, social presence, and cognitive presence (McKerlich et al. 2011). The idea of presence was seen as particularly important when observing the interactions taking place during Studio STEM. Facilitators were observed to have high levels of teaching presence, using periodic prompts to draw youth attention to program content and assess knowledge. Social presence, involving feelings of comfort with other members of the community was evident through the high levels of knowledge articulation and discussion that occurred. In addition to this, the casual conversations that took place also contributed to social presence, keeping the environment friendly and open among youth. Zhuang, Chen, and Zhang (2014) have previously reported on the importance of social presence in encouraging members of online communities to remain involved. This appears to be consistent with the findings presented. Finally, cognitive presence was observed to be high. Cognitive presence is the ability of the learner to make connections and form ideas through the online environment. Youth in the study were observed to frequently articulate and discuss their knowledge, and to express the feelings associated with their experiences. With these ideas in mind, further research on youth education integrating SNSs would do well to pay close attention to the interactions taking place between youth as well as between youth and facilitators.

Interactions occurring through the SNS environment resulted in the development of a community. This brought rural youth together in ways that may not have been possible previously due to lack of resources. This community was composed of youth participants in Studio STEM and undergraduate facilitators who acted as more knowledgeable others and supporters. Knowledge building throughout the program was accomplished through the posts created and viewed by members of the community. For example, encouragement was common, especially toward the later program sessions where experimentation was high. The development of a supportive community in which youth were willing to share their knowledge, document their progress, and provide advice to others was seen as particularly important for knowledge building. The presence of facilitators, who kept youth on task and provided extra encouragement to persist in the face of challenges, was also seen as beneficial. Ahn et al. (2014) have also described this phenomenon. Specifically, the ability to observe youth posts through SNSs provides instructors with opportunities to notice and track the progress of individual learners. This helps instructors to better respond to learners in ways that may not have been as obvious in a physical classroom environment. These results provide further evidence that SNSs can effectively be used as educational tools that maintain youth interest and encourage collaboration (Ahn et al. 2013; Kim and Hannafin 2011).

One of the methodological limitations of the current study was that the sole data source was *Edmodo* posts. Further work in the future should explore how posts through SNSs may be linked to actions in the physical learning environment. While SNSs have strong potential as educational technologies, they present several limitations and challenges. It is important to reemphasize that the location of the school may affect the ability for instructors and youth to access computers on a consistent basis (Barbour 2013; Chen and Liu 2013). While all youth participants in Studio STEM had access to computers for all of the program sessions, many youth were not able to access *Edmodo* from the home. Thus, their interaction was limited to the time that they were physically in the school building attending a session. The second factor to consider is the amount of time that youth spend socializing casually through the *Edmodo* SNS. While at first glance casual conversations may seem indicative of a lack of engagement with Studio STEM content specifically, allowing these conversations to occur may lead to more active engagement in learning as time progresses. Communicating with other participants about outside interests may have the potential to strengthen the sense of community necessary for collaboration at an academic level.

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Appendix 1

Category	Code	Definition	Example
Articulation of knowledge	Direct fact recitation	Participant delivers a specific fact or list of facts as a statement	'The black footed farrets are now becoming endangerd if we don't do somthig there will be none' 'They're trying to bring them back by mating them and giving them new homes'
	Acknowledges learning	Participant talks about the things that they learned in Studio STEM, for example, using 'I/we learned … '	'I learned that thicker wires conduct more ELECTRICITY' 'I learned that a Leyden jar was the first capacitor, or was credited as'
	Documentation of progress	Participant talks about the activities that they completed, results of experiments, or overall progress	'For solar power we got 8.13 mins and turned it on for 2 mins which means we have 8 hours and and 13 seconds for the ferret towns' 'Our houses were wired correctly and nothing happend with both the wind and the kinetic energy'
	Other	Post does not fit under any of the other articulation of knowledge codes	

Table 1. (*Continued*).

Category	Code	Definition	Example
Engagement	Enquires about Studio STEM material	Participant asks questions about material or activities within the Studio STEM	‘but answerer me a question do they have thick coats on the prarie?’ ‘generator = 6 min. windmill = 4 min. solar = 3 min we put them all on for 2 minutes the generator was the best for us. Which was your best?’
	Expression of enjoyment	Participant expresses that they are excited about Studio STEM activities or that they like things associated with the Studio STEM using words such as ‘awesome’ or ‘cool.’ Happy emoticons may be used	‘Black footed ferrets (BFF) are really cool.’ ‘It was time consuming but AWESOME!!!!!’ ‘I like playdoh and i cant spell playdoh hehe lol :} hehe’
	Expression of frustration	Participant expresses that an activity or concept is, for example, ‘hard,’ ‘sad,’ or that it ‘failed.’ Sad emoticons may be used - ☹	‘OURS WAS A BIG FAIL!’ “parallel circuits are hard’
	Other	Post does not fit under any of the other engagement codes	

Table 1. (*Continued*).

Category	Code	Definition	Example
Community interaction	Providing advice to community	Participant provides advice to the rest of the Studio STEM participants, sometimes addressed as 'you' or 'we.'	'we should really use a parallel cicuit so if one goes out they all don't go out.' 'IF YOU TOUCH THE PLATE OR THE ALUMINUM FOIL IT WILL TAKE ALL OF THE ELECTRONS OUT AND YOIU WILL HAVE TO START OVER!!'
	Encouragement of others	Participant encourages others to persist or shows support for something that they say or do in a response	'Just wonderful!!!!' 'cool I think that is cool'
	Related commentary	Commentary/reactions in response to the original post that do not fit into the other community categories. Related commentary must always be used to code a reply post (not an original post).	'Thanks, how nice' 'The electrons traveled up to the light because the electrons were moving so fast'
	Casual socialization	Participant socializes in a friendly way with other participants such as through joking or teasing. Conversation is not related to STEM curriculum	'SORRY i missed last week' 'I am always right'
	Other	Post does not fit under any of the other community interaction codes	

Table 1. (*Continued*).

Category	Code	Definition	Example
Facilitator input	Facilitator provides encouragement	Facilitator encourages participants to persist or tells them that they are doing a good job	'I was very impressed with the BFF towns you created and the results of lighting them using your capacitors!'
	Facilitator prompts discussion of concepts	Facilitator asks questions or makes comments meant to inspire participant response	'Do you think it would make a difference how fast you pedal (crank generator)?'
	Facilitator socializes	Facilitator socializes with participants about things outside of Studio STEM	'I love your profile picture!'
	Other	Post does not fit under any of the other facilitator-input codes	