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Youth appropriation of social media for collaborative and facilitated design-based learning ☆

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ABSTRACT

The purpose of this paper is to report on the ways that middle school age youth in the US appropriated a social networking forum (SNF) during an afterschool integrative STEM program, Studio STEM. SNFs are a form of social media created predominantly for social interaction and maintenance of relationships. In design-based learning environments, SNFs have the potential to facilitate the documentation of the design process from collaborative idea generation through testing and refinement. These records can be accessed from anytime and anywhere with Internet access, providing opportunities for youth to draw connections between classroom and afterschool environments. Studio STEM was designed intentionally to expose youth to scientific concepts related to electrical generation and energy transformations through collaborative design of lights powered through motion. Concurrently, facilitators encouraged youth to post to the SNF, Edmodo. All posts were analyzed using the theoretical framework of connected learning in which peer and instructor interactions mediated through SNFs might enhance learning. Results indicate that youth appropriated Edmodo to connect with others, articulate knowledge, and exchange design ideas. Facilitators played a strong role in encouraging youth to persist with design refinement through the use of Edmodo. Results suggest that youth are open to using SNFs to collaborate and provide updates on design processes, which is encouraging in terms of blending formal and informal STEM learning environments with social media.

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1. Introduction

While the emphasis on integrative science, technology, engineering, and mathematics (STEM) education in the United States has focused predominantly on classroom instruction, it is increasingly common to see research centered on alternative venues for teaching STEM concepts to youth (Bell, Lewenstein, Shouse, & Feder, 2009; Hmelo, Holton, & Kolodner, 2000). Whereas there tends to be a distinct separation between formal and informal learning environments in the current literature, more attention is being given to studies that make attempts to bridge the boundaries between the two. Studio STEM, the focal site of the current study, is one program that seeks to establish connections between classroom concepts and design-based projects conducted in an informal afterschool setting. Multiple iterations of Studio STEM have been implemented, with each program focusing on a different set of STEM related concepts and providing youth with a problem centered on saving a different animal species (Evans, Won, & Drape, 2014). The current study was centered on saving snails, salamanders, and other slimy creatures, and integrated concepts such as the generation and transformation of electricity through the design of lights powered through motion.

Social media technologies are a variety of networked tools that allow for and encourage collaboration, communication, and productivity among users (Dabbagh & Kitsantas, 2012). Under this

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broad definition, examples include social networking forums (SNFs) such as Facebook, Edmodo, and Twitter, blogging sites such as WordPress and Xanga, and video sharing sites such as Youtube and Vimeo among others. SNFs, investigated via the current study, are a subset of social media technologies that are focused primarily on the capacity for social interaction and the maintenance of relationships (Boyd & Ellison, 2008). This can be compared with other formats such as blogs and video sharing websites that allow for social interaction, but focus primarily on the ability to publish and comment on works. Despite their increasing popularity and use in educational settings, there is scant empirical evidence centered on the specific affordances and limitations of SNF integration into intentional learning settings (Tess, 2013). In this study, Edmodo, was integrated into the existing [STEM Club] routine to provide youth with opportunities to interact with learning materials, one another, and facilitators in an extension and expansion of the informal learning environment.

The use of SNFs has been recognized as familiar and well integrated into the peer culture of youth today making it an attractive area of research in the context of bridging formal and informal learning experiences. Vollum (2014) has discussed the relevance of SNF integration into K-12 health and physical fitness education through the encouragement of positive social interactions. Mao (2014) has also reported that SNFs provide opportunities for high school students to interact more effectively with peers and instructors via the online learning environment. Mao (2014) also notes that guidance may be necessary for students to truly take advantage of SNFs for learning rather than using it predominantly for leisure and recreational activities.

The theoretical framework adopted for the current study is the connected learning theory of Ito et al. (2013). Connected learning is described as the intersection among the personal interest, academics, and peer culture. Specifically, learning takes place when the individual is able to explore areas of interest in a peer supported environment. The social interactions available to learners are important in providing opportunities for sharing ideas, asking questions, and collaboration. This provides opportunities for learners to draw connections between concepts learned in the classroom and ideas that they have explored out of interest. Connected learning is particularly appropriate as a framework to view Studio STEM due to its focus on the blending of formal and informal learning. For example, peer culture can incorporate not only members of the same age group, but also more knowledgeable others such as parents, teachers, and members of online communities that might support the development of the learner. The appropriation of Edmodo into Studio STEM experience was intended to provide a way to extend the learning environment beyond the afterschool sessions, providing additional opportunities for interaction.

Studio STEM aims to engage youth and spark interest through the presentation of a global problem involving different animal species. This challenge sparks interest in youth, who are encouraged to solve the problem through the designs that they create collaboratively. As youth interact, explore their resources, and iteratively design and redesign their motion-powered lights, they are encouraged to make use of Edmodo, to log their progress, communicate with others, and share resources. Youth have been found to display varying depths of engagement while using Edmodo in previous iterations of Studio STEM (Evans et al., 2014). While some interactions are more casual, such as joking around with friends, others are more strongly related to Studio STEM curriculum, with the use of new vocabulary and understandings.

The various factors that play into youth interactions with Edmodo as a result of Studio STEM make connected learning theory with its blending of interest, academics, and peer culture an appropriate theoretical framework for further study. For example the integration of SNFs provides the opportunity for youth to use technologies common and enjoyable within their peer culture for the purpose of engaging in design-based learning and the articulation of academic concepts. While the concepts introduced in Studio STEM may be initially challenging for youth to understand, the presence of supportive facilitators might play an important role in guiding youth through their design creation, construction, and testing. The integration of SNFs may play an interesting role in providing avenues for youth to interact with one another and facilitators, promoting idea generation and experimentation.

1.1. Research questions

Based upon the current literature, this study seeks to answer the following research questions:

1. How do youth leverage SNFs as a part of the iterative design process in an informal learning environment?
2. How do youth utilize SNFs for the purpose of collaborative design?
3. How does facilitator interaction through Edmodo aid in progression of the design process?

1.2. Informal, design-based learning and social networking forums

Informal learning has been described as learning that happens in environments that invoke minimal amounts of structure in terms of instructor, content, and resources (Heo, Jo, Lim, Lee, & Suh, 2013). Informal learning happens willingly, and is customizable to the individual learner's interests and motivations. Nevertheless, while informal learning could be interest driven and highly engaging, it is also unstructured making it difficult to determine whether informal learning experiences are meaningful to youth. Perhaps as a result, bridging the gap between what is learned in formal classroom settings and informal learning experiences presents an attractive area of research (Greene, Lee, Constance, & Hynes, 2013; Shernoff & Vandell, 2007).

Activities centered on design-based learning are one method intended to bridge the gap between formal and informal learning. Design-based learning is composed of two features: (1) the conceptual aspect of learning that requires knowledge seeking and idea formation, and (2) the material aspect of learning that involves the creation of prototypes, models, and end products (Seitamaa-Hakkarainen, 2011). The incorporation of authentic learning contexts in which learners are encouraged to solve loosely defined, but relevant problems encourages the development of reasoning skills and domain knowledge. Integrating learning technologies such as SNFs into design-based learning activities could encourage youth to connect formal and informal learning experiences.

Vartiainen, Liljestrom, and Enkenberg (2012) have proposed an instructional model for design-oriented pedagogy that is meant to bridge the boundaries between formal and informal learning. The model aligns well with many aspects of Studio STEM, proposing that learning through design is a process comprised of four main steps. Step one involves articulation of the learning phenomenon in which learners are presented with a specific problem that they must solve through the design process. Step two is the design of the learning object, in this case, the motion-powered lights. Designing the learning object involves exploration of the resources that need to be included, as well as planning out the design and structure of the object. Step three is the data collection for the learning object, which equates to testing and experimentation with the design elements. Finally, step four is the actual construction of the learning object. Youth at Studio STEM are encouraged to engage in a fifth step: redesign. After constructing and evaluating the learning object, changes are made to improve the object. In the case of the motion-powered light, one improvement could be to increase the amount of time the light is on, and another improvement could be to vary the ways motion can be harnessed.

1.3. Social networking forums to support collaborative design

Design based learning is a highly collaborative experience that offers many outlets and opportunities for innovation. As such, design based learning relies heavily on communication among group or team members. The process of design has undergone change over time, signifying different strategies that might be implemented during design-based learning experiences. One of the core ideas that Studio STEM stresses is *collaboration* by orchestrating the learning setting with groups, facilitators, and teachers. By encouraging the provision of appropriate feedback and idea generation, groups might construct more efficient designs than any individual could alone. This offers a broader understanding of concepts and the creation of social interdependence that could also encourage more active participation. In the current iteration of Studio STEM, Edmodo provided the means for allowing youth to voice their opinions, questions, and ideas for designs and future iterations.

The role of the facilitator within SNFs is intended to have substantive implications for learning. The virtual presence of more knowledgeable others could play an integral role in determining the degree of guidance a learner receives. In some instances, youth might perceive new concepts as ingrained or previously learned. By failing to recognize a novel idea, one can interrupt the full progression and understanding of certain topics (Eraut, 2010). To encourage youth learning within Studio STEM, undergraduate facilitators were present. The idea of having a facilitator for youth is a strategy that could be advantageous in many ways. Previous research shows that without some sort of facilitation present a learner might rely only on observation and their peers for information and learning. The lack of facilitation available might lead to a shallower understanding of certain concepts. With a facilitator present, a youth might be more likely to seek advice and understanding from observation and from their facilitator. Thus, having a facilitator present plays an instrumental role in understanding content and realizing the importance of competency (Ostroff & Kozlowski, 1993). Effective facilitation could help youth to more effectively organize their knowledge, skills and processes. This allows for more effective learning and might have further benefits in encouraging youth to pursue higher education in the future (Colomo-Palacios, Casado-Lumbreras, Soto-Acosta, & Misra, 2014).

Within Studio STEM, facilitator responsibilities were restricted to youth in the physical and virtual learning environments. During each session, facilitators were responsible for interacting with youth, connecting ideas and finding relevance in a participant's line of reasoning, monitoring interactions within groups and observing group dynamics, and helping youth stay on track toward the given weeks' goal (Fulton & Britton, 2011). These responsibilities were performed in a number of ways including the provision of facts, ideas, or resources to troubleshoot youth designs, encouragement when youth expressed frustrations through the Edmodo feed, and discussion prompts to engage youth with the material.

2. Materials and methods

2.1. Participants and facilitators

A total of 44 middle school aged youth participated in Studio STEM during the study period. Three separate study sites were active. Two sites implemented the current [Save the Animals] curriculum and the third site implemented an older version of [Save the Animals]. All three sites were located in rural southwest Virginia in contiguous school districts in the US. While all 44 participants contributed survey data on Internet and SNF usage, the Edmodo SNF data was analyzed for participants in the updated [Save the Animals] curriculum only due to the difference in curriculum content. These youth were assigned to an Edmodo site specific to their [Save the Animals] program curriculum, separate from the site for the curriculum from an earlier version. Facilitators involved at each site included three undergraduate student researchers, undergraduate facilitators, a middle school teacher, and a supervising faculty member from the university. An off-site graduate student researcher was responsible for monitoring interactions on Edmodo. To fully implement the hands on activities associated with the curriculum the undergraduate student facilitators were particularly important.

2.2. Survey instrument

The first iteration of the Social Media and Internet Use by Youth Survey (Appendix A) was designed by the research team to assess the technologies used to access the Internet from home and school, how frequently youth accessed the Internet, and the reasons why youth participants used, or would use SNFs. All 44 participants completed the survey across the three study sites prior to the implementation of Studio STEM curriculum to collect preliminary data about how and why participants used the Internet and SNFs in formal and informal learning environments. Data from the survey were analyzed to determine the most frequent ways that youth used the Internet and SNFs in school and home environments. Frequencies were calculated as percentages of the total responses.

2.3. Implementation and data collection

Studio STEM curriculum was aimed at connecting personally meaningful ideas with more advanced STEM concepts in an after-school-learning environment. Each week, science concepts were introduced in order to provide a foundation for the design process. After the completion of surveys at the start of the program, youth were introduced to the potential negative effects of coal mining for electrical power generation on the global climate. Youth were asked to brainstorm alternative ways to generate electricity so as to limit fossil fuel consumption. Youth participated in hands-on activities such as handling and making observations about coal, and observing devices that make electricity without utilizing coal.

As the curriculum progressed, various demonstrative tools were used to emphasize specific concepts influential to youth designs. For example, the concept of electrical induction was introduced as youth moved a magnet in and out of a coil of wire. This activity resulted in measurable amounts of electricity, leading to a discussion about how electricity and magnetism are connected. As youth experimented with magnets, wires to make electricity, and measuring electricity with a multimeter, they modified variables, used trial and error, and posed a variety of questions and ideas.

Text-based data were collected over the course of Studio STEM through Edmodo. Edmodo has a similar design layout and structure to the popular SNF, Facebook, but is designed to be appropriate for youth within the K-8 age range. Youth using Edmodo can customize personal profiles with avatars that can be seen by other members. New posts and comments appear chronologically at the top of the feed, with older posts toward the bottom. The posts that youth create may be entirely text-based or inclusive of photographs, links to external resources, or videos. The text and content included in all posts were part of the final data set for analysis. Time was devoted specifically to Edmodo during Studio STEM sessions, but youth were encouraged to continue logging on outside of the scheduled time periods. Participants were encouraged to use the Edmodo site to interact with their peers across study sites, within their design teams, and with facilitators.

2.4. Data analysis

SNFs, as a knowledge repository, provide a substantial cache of text-based data that can be analyzed qualitatively. To analyze the posts created on the Edmodo page, thematic coding was implemented to identify major themes and categories emerging from the data set (Fereday & Muir-Cochrane, 2006). The process has multiple steps including (1) the development of a coding manual or codebook, (2) testing the reliability of codes, (3) summarizing data and identifying major themes, (4) applying the coding template and continuing coding of the data, (5) connecting codes and identification of themes, and (6) legitimating coding themes. Prior to the current round of data analysis, researchers had access to an existing codebook from related work, which was used as a starting point for the reported study. This codebook was created to capture ideas related to the *Hanging Out, Messing Around, Geeking Out* (HOMAGO) framework of Ito et al. (2010), and had been validated with past data sets. Due to the iterative nature of qualitative research, researchers carefully documented any codebook revisions based on the new data set. With thematic coding, codes are often revised with each pass through the data set making the process relatively flexible and adaptable to ensure accurate representation of major themes (Fonteyn, Vettese, Lancaster, & Bauer-Wu, 2008). These codes are then used to mark excerpts in the transcript that contribute to findings relevant to the research questions. Analysis was considered complete when no new themes emerged from the data set, resulting in theoretical saturation. The connections and relationships between codes were then analyzed and expanded to provide a rich description of the phenomenon of study (Bryman, 2012).

Previous work with Studio STEM has suggested that youth appropriate SNFs for the articulation of ideas and interaction with other participants or facilitators (Evans et al., 2014). This is consistent with the ideas of Lerman (2001) suggesting that youth might feel more comfortable to engage in discussion when they are placed in a less formal environment. Examining the ways that youth discuss science concepts, the design process, and other less related topics (for example, within casual conversations not necessarily related to Studio STEM) could therefore provide insights into the ways that youth appropriate SNFs for collaborative design purposes. Changes in language patterns that can be captured through thematic coding of Edmodo data might signify changes in thought, learning, and understanding (Lester, 2011).

Two researchers utilizing the established codebook separately analyzed transcripts of all Edmodo posts submitted during the study period. The researchers then consulted in person to compare coding results. Any disagreements encountered during the coding process were reviewed and discussed until agreement was reached. The codebook was organized into categories based on the above referenced HOMAGO model. For example the code "virtual play" was analyzed as a casual interaction and categorized into the *hanging out* category. A separate category was also available for facilitator posts, which kept analysis of facilitation strategies separate from the posts of youth. Following the first pass through the data, researchers discussed potential adjustments to existing codes, deletions of codes that did not represent major themes in this data set, and the addition of more relevant codes. This resulted in adjustments to the codebook and subsequent passes through the data set to apply the modified codebook. Major changes from the previous iterations included the addition of several codes corresponding to new themes emerging from the current data set. Codes added included:

- *Information sharing*: categorized as *messing around* and used to describe instances where youth made informational statements or shared resources about certain aspects of the STEM curriculum.
- *Discussion of greater impact*: categorized as *geeking out* and used to describe instances where youth recognized connections between what they learned in Studio STEM and their daily lives or global issues.
- *Facilitator guidance*: categorized as a *facilitation strategy* and used to describe instances where facilitators provided direct information or advice meant to assist youth.

A few codes were also modified. For example, the code **method comparison** was revised to **progress comparison** to better capture the phenomenon of youth comparing their progress during the design process. Another code labeled **excited about design** was changed to **excited about STEM Club** to capture the idea that youth were enthusiastic about participating in the program for a variety of reasons. Finally, the code titled **relation to others**, meant to capture the idea that youth commiserated with one another as part of *hanging out*, was omitted from the current iteration of the codebook due to lack of relevance. A full version of the codebook can be found in Appendix B.

3. Results and discussion

The Social Media and Internet Use by Youth Survey was implemented in order to collect general information on how youth accessed the internet and SNFs from the home and school environments. Results indicated that participants in the study accessed the Internet from home and school for the purpose of looking up information. Looking up information was the most common response for why youth accessed the Internet at home (23% of the responses) and at school (34% of the responses). At home, video games made up the second most common response (21%). At school, homework was the second most common response (18%), with email a very close third (17%). While SNFs were not a common reason why youth accessed the Internet from either home or school, 50% of participants indicated that they generally enjoyed using SNFs. 50% of participants also indicated that they would enjoy using SNFs for school purposes with 23% indicating that they would not enjoy using SNFs for school and 27% indicating that they were unsure whether they would enjoy using SNFs for school. Results from the survey can be found in Table 1.

3.1. How do youth leverage SNFs as part of the iterative design process?

Results from The Social Media and Internet Use by Youth Survey indicated that 50% of the youth participating in the study were open to using SNFs for educational purposes, which bodes well

Table 1
School and home social media usage by percentage of total responses.

Type of social media usage	School social media usage (%)	Home social media usage (%)
Email	17	17
Video games	14	21
Information search	34	23
Shopping	2	10
Homework	18	12
Social media	2	11
Other	14	7

for this informal STEM setting. This may have implications for the ways that youth appropriated Edmodo as part of their design process. Out of the 290 total codes, the most common code assigned during data analysis was the code entitled **experimentation**, (21% of the total codes assigned) indicating that youth were willing to articulate their thoughts on the Edmodo feed. Table 2 depicts the frequencies for **experimentation** as well as all other codes.

Experimentation was a code created within the category of *messing around* to capture instances in which youth discussed their design process. The following excerpts are examples of Edmodo chat data coded as such:

- C. E. to STEM Club: at station 2 when you pressed [sic] the handle the light on the flashlight lit up.
- F. G. to STEM Club: Darlene and I got to every station except one or two. I think the station with the bell and crank was the neatest one yet. We found that if you look inside a spark makes the metal bar vibrate and hit the bell which makes it ring. And if you smell it afterwards it smells like smoke.
- Q. S. to STEM Club: At station 1: You hook the alligator clips to the bottom of the machine then crank the handle which makes the bell ring.

These excerpts suggest how youth articulate what they are observing in person at stations set up within the classroom. Youth then share what they have learned using Edmodo as a log for their thoughts and observations. This goes along well with the second most common code assigned during the data analysis, **STEM talk**.

The second most common code was the code for STEM talk (16% of the total codes), which was categorized as *geeking out* and meant to capture instances where youth articulated concepts covered in Studio STEM curriculum through the use of vocabulary or detailed discussion of their understanding. Examples of instances of STEM talk are listed here:

- L. I. to STEM Club: we learned about a bell and if you turn attach clips to the correct thingy and turn a crank it will make the bell ring because the crank turns cogs and it generates power into the copper wires to the clips that make the bell ring.
- D. N. to STEM Club: Station 4: It looks like the mechanism of a wind mill. The blades spin a shaft in a generator and creates electricity for the light to come on.

Table 2
Incidences of codes assigned to posts created through Edmodo.

Category	Code	Counts	Percent of Total (%)
Hanging out	Shared interests	3	1.0
	Virtual co-presence	13	4.5
	Virtual play	14	4.8
Messing around	Collaboration	23	7.9
	Experimentation	60	20.7
	Information sharing	4	1.4
	Excited about STEM Club	19	6.6
Geeking out	Discussion of greater impact	19	6.6
	Method comparison	7	2.4
	STEM talk	45	15.5
	Sharing success	14	4.8
	Directed inquiry	20	6.9
Facilitation strategy	Casual facilitation	7	2.4
	Task orientation	4	1.4
	Encouragement	19	6.6
	Facilitator guidance	10	3.4
	Assessment	9	3.1

STEM talk is one way that youth incorporated Edmodo into the design process. The articulation of in depth understanding related to STEM concepts was again captured in a log format using the Edmodo chat feed. While initially, only half of youth participants indicated that they would like to use SNFs for educational purposes, these data indicate that youth frequently articulated their ideas. This was especially true in instances where youth had insights while interacting with resources placed at stations around the room.

Another code emerging from the data set, and relevant to the design process, was **direct inquiry** in which youth asked specific questions related to Studio STEM curriculum or their designs. Examples of direct inquiry included questions that were specific to a team's design such as "Why couldn't my team make a slightly decent amount of electricity with the copper wire and magnet? Basically what did we do wrong?" and questions that were more broad in scope such as, "Can turbines charge cell phones?" This process of asking questions could be important to not only the process of design, but also to the process of collaboration that was observed among team members, between teams, and across study sites.

3.2. How do youth utilize SNFs for the purpose of collaborative design?

Thematic coding provided evidence that youth appropriated SNFs for collaboration with others. Collaboration took place in a few different ways. Specifically, youth collaborated through the discussion of ideas, comparing methods, and posting questions to the Edmodo feed. A total of 23 excerpts (8% of the total codes) were coded as **collaboration**. The collaboration code was designed to describe instances of questioning and advice among youth. A representative example can be found in the following excerpt:

- T. K. to STEM Club: what can you do to make the multimeter go higher, what can we do with the weirs.
- D. I. to STEM Club: You might have not wrapped them tight enough.

In this example, a participant asks a question, posted to the Edmodo feed. Another participant responds with advice, suggesting an answer to the problem. Collaboration was a common occurrence among youth in Studio STEM. While much of the collaborative effort was captured in excerpts of conversation among multiple participants, there were also instances in which advice was posted in hopes of contributing to common group knowledge:

- F. G. to STEM Club: to all of those [Site] students here are some tips on the magnet and wire experiment: If you can wrap the wire around the plastic cylinder and connect it to the PK meter then you can shake it if possible it should make some numbers come up. Good Luck!
- D. Z. to STEM Club: At Station 4 You See A Windmill That Is Activated By Blowing On It. When You Blow Really Hard A Red Light Will Flash BUT BE SURE TO BLOW HARD!!! ~This Donald Z Reporting For Mary H And Harriet D XD.

While instances such as these did not result in any responses posted to the feed, the intent was to provide information to other participants using the Edmodo site. While the **collaboration** code was meant to describe more of a suggestion or advice style of interaction between youth, the **progress comparison** code was created to describe instances where youth compared their progress with their group designs. Progress comparison was not as common (seven instances were coded), but still constituted a way that youth appropriated SNFs for collaborative purposes. An example can be found in the following interaction:

- D. I. to STEM Club: we found out that the less gears you use the faster the gears go and the less friction it has
- M.: That is what worked with us.

In this example, a participant describes a discovery that their team has made through testing their design. A different participant from another team then acknowledges that they have made the same discovery.

3.3. How does facilitator interaction through Edmodo aid in the progression of the design process?

During the course of Studio STEM, facilitation was aimed at making direct impacts on youth and driving youth initiative. Results of the study showed that facilitators accomplished this through casual facilitation, encouragement, and assessment. Posts coded for casual facilitation involved instances in which facilitators discussed experiences outside of Studio STEM with youth. Encouragement posts were aimed at providing support to youth throughout the design process. Finally, assessment posts were meant to prompt youth to discuss things that they had learned from participating in Studio STEM. By using these types of prompting, youth exhibited comfort in asking questions and discussing ideas associated with the design process. From this, it is possible that having facilitators present may have encouraged learning through the provision of valuable feedback and encouragement.

Casual facilitation, which accounted for a total of seven excerpts, offered a way for the facilitator to introduce questions that were mildly related to the STEM Club curriculum:

- Facilitator to STEM Club: What questions do you have that you hope we'll answer during Save the Snails?
- Facilitator to STEM Club: What is your favorite food from this list?
- Facilitator to STEM Club: I loved playing the ''Power Up'' game on the ''A little more...'' tab on studiostem.weebly.com!! I learned a lot about all of the different types of power supply.

In these examples, the facilitators attempted to invoke youth interest to encourage participation. Following instances of casual facilitation, there would often be a small response rate from youth participating. Nevertheless, with more prompting, youth were seen to participate in a specific activity.

Direct inquiries were also seen as a result of facilitation. Examples of these inquiries, direct and indirect, can be cited from Edmodo:

- H.C. to STEM Club: What's up with the freaky glowing balls?
- W.O. to STEM Club: Can turbines charge cellphones?
- M.H. to STEM Club: Why couldn't my team make a slightly decent amount of electricity with the copper wire and magnet? Basically what did we do wrong?

These directed inquiries generally prompted quick responses from facilitators. Nevertheless, in instances where youth did not have an immediate response, trial and error became a common option. Codes within the *geeking out* category, accounting for 105 excerpts, were utilized most often directly following some form of facilitative prompt.

The presence of facilitators encouraged youth to engage in critical thinking, and was valuable as a way to assess what youth were absorbing throughout each session. Many times, youth became engaged in a process of trial and error for specific lesson plans. This sometimes resulted in frustration that youth would express through Edmodo posts. The use of encouraging posts such as ''great job,'' ''don't give up,'' or ''keep at it!'' would often encourage youth to persist in forming new ideas.

4. Conclusions

To conclude, the results of this study suggest that there are identifiable benefits to the appropriation of SNFs by youth as a part of the design process. Seitamaa-Hakkarainen (2011) has previously discussed conceptual and material parts of the design process, explaining how the conceptual involves ideas and knowledge formation and the material involves prototyping and testing. Throughout the study, youth used Edmodo to express ideas and track progress as part of their conceptual process. The material process of construction, testing, and retesting during Studio STEM sessions may have been enhanced through youth having the ability to document and share their design ideas through the informal learning environment. The presence of supportive others willing to answer questions and provide guidance may have also served as a benefit of using the Edmodo site consistent with the work of Mao (2014).

The use of social media, including SNFs as highlighted in this study, as educational tools aligns well with the connected learning theory of Ito et al. (2013) in that it provides a way of blending the peer culture of youth (which heavily incorporates the use of technology for social interaction), their personal interests in communication and science topics, and the more formal academics that they are involved with at school. Analysis of discourse occurring through the Edmodo chat feed provided a wealth of examples showing how youth share ideas, articulate new knowledge, and provide advice to others for collaborative purposes. The ability for youth to interact not only with one another, but also with encouraging facilitators can be mediated through the use of these popular technologies. In particular, encouragement may be particularly important when youth express their frustrations with the curriculum and activities, and could provide an attractive area of study for future research centered on Studio STEM.

The integration of SNFs into Studio STEM has purposefully been designed to serve as an extension of the informal learning environment, allowing youth to articulate their insights and collaborate with peers during and outside of Studio STEM sessions. The implementation strategies of Studio STEM provide guidance and support for youth as they explore new concepts and transfer their ideas to a virtual learning environment. Through Edmodo, youth are encouraged to share their thoughts, discuss concepts, and interact casually with one another and adult facilitators. This may potentially influence the formation and refinement of new ideas related to the integrative STEM curriculum. Clegg et al. (2013) have suggested that SNFs could be appropriated as a way to encourage the formation of learning communities in which youth could collaborate through the sharing of resources and ideas. Ahn, Gubbels, Yip, Bonsignore, and Clegg (2013) also report that SNFs could provide a virtual knowledge repository where youth might collect and expand on one another's knowledge as part of the design process. These ideas are consistent with work involving previous iterations of Studio STEM in which social networking forums were found to provide a virtual, learner-centered space for the articulation of knowledge and ideas (Evans et al., 2014). Studio STEM is meant to be collaborative and social in nature with small groups engaging in the design process, and the instructor acting as a facilitator and a member of the learning community. The integration of SNFs into the learning environment should therefore provide the ability for learners to, present their ideas, record their data, and engage in effective collaboration with peers and facilitators.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.chb.2015.04.017.

References

Ahn, J., Gubbels, M., Yip, J., Bonsignore, E., & Clegg, T. (2013). Using social media and learning analytics to understand how children engage in scientific inquiry. *INQuiry (SINQ), 1*, 9.

Bell, P., Lewenstein, B., Shouse, A. W., & Feder, M. A. (Eds.). (2009). *Learning science in informal environments: People, places, and pursuits*. Washington, DC: National Academies Press.

Boyd, D. M., & Ellison, N. B. (2008). Social network sites: Definition, history, and scholarship. *Journal of Computer-Mediated Communication, 13*, 210–230.

Bryman, A. (2012). *Social research methods*. Oxford University Press.

Clegg, T., Yip, J. C., Ahn, J., Bonsignore, E., Gubbels, M., Lewittes, B., & Rhodes, E. (2013). What face-to-face fails: Opportunities for social media to foster collaborative learning. In *Tenth international conference on computer supported collaborative learning*.

Colomo-Palacios, R., Casado-Lumbreras, C., Soto-Acosta, P., & Misra, S. (2014). Providing knowledge recommendations: An approach for informal electronic mentoring. *Interactive Learning Environments, 22*(2), 221–240.

Dabbagh, N., & Kitsantas, A. (2012). Personal learning environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning. *Internet and Higher Education, 15*, 3–8.

Eraut, M. (2010). Informal learning in the workplace. *Studies in Continuing Education, 26*(2), 249.

Evans, M. A., Won, S. G. L., & Drape, T. A. (2014). Interest-driven learning of STEM concepts among youth through a social networking site. *International Journal of Social Media and Interactive Learning Environments., 2*(1), 3–20.

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor through thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods, 5*(1), 80–92.

Fonteyn, M. E., Vettese, M., Lancaster, D. R., & Bauer-Wu, S. (2008). Developing a codebook to guide content analysis of expressive writing transcripts. *Applied Nursing Research, 21*, 165–168. http://dx.doi.org/10.1016/j.apnr.2006.08.005.

Fulton, K., & Britton, T. (2011). STEM teachers in professional learning communities: From good teachers to great teaching. *National Commission on Teaching and America's Future, 1*(1), 15–16.

Greene, K. M., Lee, B., Constance, N., & Hynes, K. (2013). Examining youth and program predictors of engagement in out-of-school time programs. *Journal of Youth and Adolescence, 42*(10), 1557–1572.

Heo, H., Jo, I., Lim, K. Y., Lee, H. W., & Suh, S. (2013). The convergence of informal learning and formal education in a ubiquitous environment. *Handbook of Design in Educational Technology*, 310.

Hmelo, C. E., Holton, D. L., & Kolodner, J. L. (2000). Designing to learn about complex systems. *The Journal of the Learning Sciences, 9*(3), 247–298.

Ito, M., Baumer, S., Bittanti, M., Boyd, D., Cody, R., Herr-Stephenson, B., et al. (2010). *Hanging out, messing around, and geeking out*. Cambridge: The MIT Press.

Ito, M., Gutierrez, K., Livingstone, S., Penuel, B., Rhodes, J., Salen, K., et al. (2013). *Connected learning: An agenda for research and design*. Irvine: The Digital Media and Learning Research Hub.

Lerman, S. (2001). Cultural, discursive psychology: A sociocultural approach to studying the teaching and learning of mathematics. *Educational Studies in Mathematics, 46*, 87–113.

Lester, J. N. (2011). Exploring the borders of cognitive and discursive psychology: A methodological reconception of cognition and discourse. *Journal of Cognitive Education and Psychology, 10*(3), 1–14.

Mao, J. (2014). Social media for learning: A mixed methods study on high school students' technology affordances and perspectives. *Computers in Human Behavior, 33*, 213–223.

Ostroff, C., & Kozlowski, S. (1993). The role of mentoring in the information gathering processes of newcomers during early organizational socialization. *Journal of Vocational Behavior, 42*(2), 170–174.

Seitamaa-Hakkarainen, P. (2011). Design based learning in crafts education: Authentic problems and materialization of design thinking. *Design Learning and Well-being, 4*, 3–14.

Shernoff, D. J., & Vandell, D. L. (2007). Engagement in after-school program activities: Quality of experience from the perspective of participants. *Journal of Youth and Adolescence, 36*(7), 891–903.

Tess, P. A. (2013). The role of social media in higher education classes (real and virtual) – A literature review. *Computers in Human Behavior, 29*, A60–A68. http://dx.doi.org/10.1016/j.chb.2012.12.032.

Vartiainen, H., Liljestrom, A., & Enkenberg, J. (2012). Design-oriented pedagogy for technology-enhanced learning to cross over the borders between formal and informal environments. *Journal of Universal Computer Science, 18*(15), 2097–2119.

Vollum, M. J. (2014). The potential for social media use in K-12 physical and health education. *Computers in Human Behavior, 35*, 560–564.