STEM Integration: Evidence of Student Learning in Design-Based Curricula

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Abstract—This study focuses on student learning of engineering design practices and the development of engineering thinking skills during participation in design-based curricular activities and will seek to answer the question: What evidence is present in students’ engineering design project work of engineering learning? Student teams working in a STEM integration curricular module implemented in a fifth grade science classroom were analyzed. This study employs case study methods as a means to deeply analyze each team’s work through content analysis of student classroom artifacts and video analysis. We use the Framework for Quality K-12 Engineering Education, with a particular focus on process of design, STEM content, engineering thinking, and communication, as a lens for analyzing the engineering thinking involved in student learning. This research aims to develop an initial understanding of how to identify these engineering learning outcomes in classrooms, with the overall goal of developing engineering assessment tools for classroom teachers. Evidence of student learning outcomes for these key engineering components was found throughout student work and student interactions, though varying levels of learning were shown by each group. This study demonstrates that it is possible to identify student learning of engineering processes within a design-based curriculum.

Keywords—STEM integration, engineering design, case study

I. INTRODUCTION

Engineering continues to gain increased attention at pre-college levels. In the United States, for example, the recently published Next Generation Science Standards [1] place engineering design on equal footing with scientific inquiry and include engineering content and practices throughout the K-12 standards. Although these standards are not national standards, they have already been adopted by many states and have the potential to influence the science standards of states even if they choose not to adopt them outright. At the same time, much work has and is being done in establishing principles of quality K-12 engineering [2]–[4], and researchers are beginning to investigate student learning of engineering content (see reference [5] for example).

The ramping up of engineering in K-12 classrooms, however, requires not only research into student learning and curriculum development, but also support for teachers being asked to teach this additional content. Professional development for inservice teachers, as well as the addition of engineering content and pedagogy to teacher training programs, will be essential in supporting teachers towards the successful inclusion of engineering at the K-12 level. One of the key components of these supports for teachers will be tools for formatively and summatively assessing student learning of engineering content. This paper is part of a larger study aimed at developing these assessment tools.

One of the first steps in developing these formative and summative assessment tools is identifying what counts as evidence of learning in engineering lessons. As students work through engineering design challenges in their classes, they engage in background research, develop plans, test their designs, and make final recommendations or build final products. Throughout this process, students are often encouraged to document their work in engineering notebooks or on handouts or worksheets. These student artifacts provide a record of the process, but it is not often clear how these documents provide evidence of learning. In this paper, we examine student work and classroom interactions in order to both characterize the learning of this group of students as well as to demonstrate the ways in which these student artifacts and classroom interactions can be used as evidence of learning. The artifacts were taken from one class of 5th grade science students as they engaged in an engineering design challenge from the Engineering is Elementary [6] curricula.

In order to characterize student learning of engineering, we used components of the Framework for Quality K-12 Engineering Education (FQEE-K12) [3]. Of the indicators in that framework, we focused on those identified by Kersten [7] as essential for successful implementation of engineering in K-12 science classrooms. Lessons that address these indicators provide students with the opportunity to (1) engage in a process of design, (2) apply their knowledge of science, engineering, and mathematics, (3) develop components of engineering thinking, (4) develop and practice communication skills necessary in engineering, and (5) work collaboratively on teams. Teamwork has been extensively studied elsewhere; so for the purpose of this study, we will consider the first four of these essential indicators. Using a case study design, we investigated the research question: What evidence is present in students’ engineering design project work of engineering (process of design, STEM content, engineering thinking, communication) learning?
II. BACKGROUND AND THEORETICAL FRAMEWORK

Engineering is a natural integrator. Engineering design-based integrated STEM learning environments have the potential to allow students to learn about STEM subjects in ways that more naturally mimic real-world problems and issues than typical siloed lessons from only one STEM discipline [8]. Our working definition of STEM integration includes that engineering helps students to address the problems of our increasingly technological society and provides students with opportunities to understand these problems through rich, engaging, and powerful experiences that integrate the disciplines of STEM [9].

With many states adding engineering to their academic science standards [10], and with the addition engineering within the Next Generation Science Standards [1], there are significant efforts being put into curriculum development for engineering within science classrooms [11]. However, there is limited knowledge about what students are learning within these engineering integration units. There is a need to understand, at the theoretical level, what type of evidence of student learning is present in engineering environments.

The report Knowing What Students Know [12] introduces the assessment triangle, which shows that there are three critical components of effective assessment: student cognition, observation, and interpretation. Fig. 1 shows our modified version of the assessment triangle. When assessing student learning in the classroom, the teacher is expected to use instruments, observations, or questioning strategies to collect information on student learning and interpret this information to make a judgment about student performance. While the assessment triangle has been mostly used as a framework for large-scale, external assessments, our long-term goal is to focus on the assessment practices of science teachers in engineering design learning settings. This paper is concerned with the student cognition and observation side of this triangle.

For this study, we consider only the key indicators identified by Kersten [7] as being essential for successful implementation in her work on science teachers implementing engineering in their classrooms. She classified the 12 indicators into the following categories: (1) indicators central to what elements of engineering learning provide evidence of how students learn and develop competence in engineering. Moore et al. [3] designed the Framework for Quality K-12 Engineering Education to address this need. This framework consists of 12 key indicators that mark the essential elements of a K-12 engineering education. The indicators and a brief explanation of each are included in Tab. 1. These indicators are meant to be addressed multiple times and at multiple levels throughout a student’s K-12 experience, so that a student whose education has been structured in such a way should be prepared to pursue further study in engineering or engineering related careers.

Fig. 1. A modified assessment triangle.

In order to recognize evidence of student cognition in engineering design-based environments, we must consider
engineering and engineering education (POD [POD-PB, POD-PI, POD-TE], SEM, and EThink), (2) indicators important to the development of students’ understanding of engineering (CEE and ETools), and (3) indicators that promote important professional skills used by engineers (ISI, Ethics, Team, and Comm-Engr). The results of her study indicated that in order for a curriculum module to be of adequate quality, it needed to include all of three of the indicators central to engineering (POD, SEM, and EThink). She found that when these were not present, “a project can merely become a craft or tinkering project, rather than an engineering design project” (p. 243). Her results also indicated that the Team and Comm-Engr indicators are required for the module to be considered of adequate quality. Her findings suggested that the indicators important to the development of students’ understanding of engineering (CEE and ETools) and the ISI and Ethics indicators are not required for a quality engineering unit, but that when they are added, the projects are more authentic. This paper will focus on the evidence of student learning within the essential elements of K-12 engineering education identified by Kersten [7]: process of design, STEM content, engineering thinking, and communication. Teamwork was purposely left for further study as this is a topic that has been widely studied (for examples see references [13]–[15]) and needs a very different treatment than the other four indicators above.

III. RESEARCH DESIGN

This paper uses a case study methodology, which is a qualitative research design. The case study methodology allows for in-depth exploration of a bounded entity. As stated by Creswell [16], “The cases are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time” (p. 15). The focus of this case study was one 5th grade science classroom’s implementation of the engineering design challenge portion of an Engineering is Elementary [6] curriculum. The class split into seven groups, each group containing three to four students. A closer look each group’s written work, as well as their interactions, allowed us to find evidence of student learning of engineering. When quoting students’ written work, minor spelling and grammar mistakes were corrected for readability.

The Engineering is Elementary (EiE) [6] curriculum used was A Stick in the Mud: Evaluating a Landscape, which has a science focus of landforms. After learning about soil properties and erosion in the curriculum, students applied their knowledge to an engineering design challenge. The challenge was to choose a new location for a TarPul cable bridge for the villagers, their clients, to use to cross a river. Student groups had to consider several factors in their design: how far the TarPul site was from the village, clinic, and school; the soil type at their selected site; the potential for erosion at their site, which depended on the curviness of the river; the amount and cost of compaction in order to make their TarPul sturdier, and the tested strength of their design. The curriculum provided detailed guidance for the students, taking them step-by-step through the EiE engineering design process. After initial brainstorming, students were prompted to define the problem and design considerations. Students then considered two design ideas, chose one to implement and test. The test includes a scoring rubric that the students use to evaluate their design. After initial testing, students redesigned and re-tested a new solution, trying to improve upon their initial design. Finally, the curriculum guided students through a final report process, prompting them to consider what to write in their persuasive report to the village elders. Because of this prompted guidance, certain aspects of the four key indicators were guaranteed to be found in our search for evidence of learning, though the extent of their elaboration varied from group to group.

IV. EVIDENCE OF LEARNING

After examining each group’s work for evidence of learning around the four essential components of an engineering lesson, we looked across groups to compare and contrast the evidence for each component. (Again, the fifth essential component, teamwork, was not within the scope of this paper.) In this section, we present examples, organized by the key indicator of engineering in question in order to provide a rich description of the types of evidence of student learning that are available to the teacher during classroom implementation of engineering design work.

A. Process of Design

Providing students with the opportunity to engage in design processes is a focal point of the FQEE-K12 as described above, and it is also a centerpiece of engineering. The A Stick in the Mud curriculum guides students through the EiE engineering design process, ensuring that they do in fact get the opportunity to experience it. By examining different aspects of their work, however, we can learn more about how these experiences are contributing to students’ understanding of engineering and engineering design. Again, following the model from the FQEE-K12, we examined three different aspects of the process of design: identifying the problem and background research; planning and implementing; and testing, evaluating and redesigning.

1) Problem and Background

Evidence of student learning with regard to identifying the problem and doing background research can be seen in how students describe the problem and the relevant science content. During the A Stick in the Mud challenge, all groups were able to correctly state the problem, with several groups giving answers similar to Group 2: “The problem that we need to solve is to find a site to put the tarpul.” Other groups, however, were already indicating their awareness of some of the design considerations of the problem. Group 4, for example, responded that “The problem that we need to solve is to find the best spot and a good soil spot.” By separating the location of the site from the soil type, this group reveals that they are considering location, or distance from the clinic, as a separate issue from the type of soil in which they will build. On the other hand, Group 7’s answer of “To put the tarpul in a good spot so it won’t fall or erode in the area” indicates that they are aware of the importance of a solid foundation for their TarPul. This group, however, does not address the issue of proximity, which may indicate that they don’t consider this as important an issue at this early stage.

In the pre-planning phase of a design cycle, students should also be gathering relevant background information. Typically,
in K-12 settings, this background research gives students a chance to develop their science, mathematics, or engineering content knowledge. The *A Stick in the Mud* activity provides direct prompts to elicit this background knowledge, such as “What do you already know about erosion along a riverbank?” and “What do you already know about how soil type and compaction affect the TarPul?” Student work for these prompts, however, will be discussed in the *Apply Science, Engineering, and Mathematics* section.

2) **Plan and Implement**

The planning and implementing phase of a design cycle involves considering the constraints, brainstorming ideas, and developing a plan, among other things. The *A Stick in the Mud* curriculum guides the students through several of these steps, with prompts to list several ideas, or create a plan, but an important part of this process that is not so easily scaffolded is considering multiple solutions and weighing the pros and cons of each. One way the curriculum addresses this is by explicitly asking students to list advantages and disadvantages for each of their choices. Each of the seven groups in this class was able to identify at least one advantage and one disadvantage for their choices, indicating at least a minimal awareness that possible solutions have pros and cons.

We can see evidence of students weighing the pros and cons of solutions when they are asked why a particular site would make a good choice. Group 7 answered: “[Site] A is close enough and sturdy, and it won’t erode because the water is going straight.” Site A was not the closest site, but this group had decided that soil type and potential for erosion were more important than proximity, thus Site A was “close enough.” Similarly, Group 7 said about their choice in their final letters, “it is far away, but it is safe.” These groups are weighing the structural features of the TarPul versus the practical or functional aspects as they develop their plans. Students also had to consider the cost of their design. Students learned that compacting the soil allows it to better support the foundation of the TarPul, but that process also costs money. Group 3, for example, explained why they chose to compact ½ inch rather than ½ inch saying, “We think this is the best amount of compaction because it is still strong, but it does not cost as much as ½ of an inch.” The design challenge itself places constraints on the student solutions, and we can see from their work that they do actively engage in weighing the importance of those constraints.

3) **Test and Evaluate**

After creating a plan and prototype, engineers test their solutions in order to identify areas of improvement. Using the information from these tests, the engineers make improvements to their design in the next iteration. One potential pitfall in the implementation of K-12 engineering curricula is to stop the design cycle after the first iteration, without giving students a chance to improve their designs. The *A Stick in the Mud* unit explicitly builds in two designs that are each tested to ensure that students go through the entire process at least twice. Going through the iterative process, although necessary for a complete experience, does not guarantee that students will grasp the value or importance of this phase of the design process.

Among the seven groups examined, we found evidence of various levels of understanding of the testing and evaluating phase. The first place that this shows up is when groups are asked in their packet how they will know if their design is successful. Group 4 responded directly saying, “we will test our design to see if it is successful.” Two groups interpreted the challenge very literally, imagining their design culminating in the building of an actual TarPul. This can be seen in Group 5’s response: “We will know if it will be successful if it is strong and can hold lots of people.” Some groups focused on the tests outlined in the lesson, e.g. Group 6 who said, “When you get a low score and lots of washers.” Other groups, like Group 1, focused squarely on the score saying, “The way we will know our design is successful is we will have a low score.” Group 3, on the other hand, demonstrated some confusion about what it means for their design to be successful saying, “we have been testing and we found out that rocky soil is the best.” The variety of responses seen here indicate that, although judging whether a design is successful or not may seem like a straightforward question, students may need support in focusing in on the important aspects of a successful design.

Evidence of students’ understanding of the testing and evaluating phase also showed up in their interpretation of the test results. After testing their first design, students were asked what they would change in their second design. All groups indicated something to change in order to try to improve their design, but Groups 1 and 6 did not follow through on what they wrote they should change. This indicates some sort of disconnect in interpreting the purpose and meaning of testing and evaluating their designs. Similarly, after testing two different plans, students were asked to make a final recommendation to the villagers. As we would expect for students who are correctly interpreting the results of their tests, all students recommended the plan that received the best score and not just their second design.

B. **Apply Science, Engineering, and Mathematics**

Another key component of the FQEE-K12 framework is the application of STEM content knowledge to an engineering project. For the *A Stick in the Mud* curriculum, students had focused on learning the science topics of erosion and soil compaction earlier in the unit. They studied maps of riverbanks to learn that erosion affects curves more than straight areas; they also conducted controlled experiments to determine that rocky soil is stronger than organic soil and that soil compaction improves a foundation’s strength. Evidence of this application of science knowledge was integrated into every group’s engineering design project, primarily in four locations.

The first location was at the end of the third lesson and prior to the start of the engineering design, where students made preliminary recommendations for TarPul placement and soil compaction. During this initial brainstorming, five of the seven groups explained that their initial site choice was good because it was on a straight part of the river. Two groups further justified this by referring to the science concept of erosion; for example, Group 7 explained their site choice with “it won’t erode because the water is going straight.” This indicates that most groups were using their science knowledge in the design context, though only a couple of them linked this.
knowledge to specific science vocabulary. Evidence of their science background knowledge of soil type and compaction was also evident. For example, most groups’ recommendations included a preference for rocky over organic soil. For groups that did choose a site with each soil type of each side, they tended to recommend compacting the organic side more. In Group 4’s compaction recommendation, they advised using “1/2 inch, because it is organic soil and it is less strong than rocky.” All groups advised some amount of compaction to make the foundations stronger; in Group 5’s words, “because it can hold more weight.”

As mentioned in the Problem and Background section above, students were also prompted to answer questions about erosion, soil type, and compaction in the pre-planning, problem-defining stage of the design cycle. In response to “What do you already know about erosion along a riverbank?”, five of the seven groups directly explained a connection between erosion and curves in a river. Group 3 was one of two groups to expand upon this further and mention the role of soil or sediment, stating “When the river meanders, you get erosion, and the soil will wash away.” Student groups also had to answer “What do you already know about soil type and compaction affect the TarPul?” Unlike the preliminary recommendations section where every group wrote about compaction, here only a few mentioned it. Instead, the groups focused on soil type, stating something along the lines of rocky soil being better than organic soil. Group 1’s answer, “compaction = sturdier, organic = loose soil,” was the rare case that addressed both soil type and compaction. An interesting aspect of student work shown in the problem-defining stage is that although many of the science references were similar to those in the earlier preliminary recommendations, emphases of their answers depended upon the wording and context of the questions asked.

The third location that provided evidence of applying science knowledge was found throughout the design process. Unlike the previous two locations, these bits of evidence were not answers to direct questions; rather, they were present in the design choices the students made, as well as their descriptions of advantages and disadvantages of these choices. While slightly more difficult to find, this evidence showed the best direct integration of science knowledge into an engineering context. For example, all groups used some soil compaction in at least one of their designs, and most groups compacted organic soil more than rocky soil. Exceptions to these rules seemed to be related to other design factors. For example, Group 6’s original design called for ½ inch compaction on the organic side and ¼ inch compaction on the rocky side. When their re-design used the same site but ¼ inch compaction for both sides, the group achieved the same strength score. Thus, their final design was the only one to use the same compaction for different soil types, since it had not affected the strength of their design. Other evidence of applying science knowledge appeared in groups’ lists of advantages and disadvantages, which were required for their initial designs. Every group that chose a site on a straight segment of river listed either “straight” or “it doesn’t erode” as an advantage of that design, and those designs that were on curved parts usually had a reference to “curves,” “bends,” and/or “erosion” in the disadvantages. Similarly, all but one group listed organic soil as a disadvantage and/or rocky soil as an advantage. The exception to this, Group 6, stated “not the same soil” in their disadvantages section, which has a questionable interpretation as evidence of science application. From their design choices, it is evident that students were applying their recently-learned knowledge about erosion, soil type, and compaction to their designs.

The last place displaying evidence of students’ application of science knowledge is in their final reports. The final report prompted students to not only state which site and compaction they chose, but also why they thought this was the best choice. In most of their responses, it was evident that groups applied their science knowledge to answer the latter portion of this prompt. Six of the groups justified their site choice with statements about the site being on a straight part of the river, experiencing less erosion, or both. While five of the groups stated their soil types, only three related them to strength or compaction. For example, after recommending 0 inches of compaction on the rocky side and ¼ inch compaction on the organic side, Group 4 explained that “We think that is enough because rocky soil is already strong, but the organic soil is weaker so it needs more compaction.” In the final reports, it was more common for student groups to justify their site choice with science knowledge than their compaction choice.

C. Engineering Thinking

Evidence of engineering thinking can be seen both in students’ plans and in their final recommendations. First, all of the constraints in an engineering design challenge cannot typically be met equally and thus, engineers must make trade-offs. As mentioned in the Plan and Implement section, students had to consider trade-offs between the strength of the actual TarPul, the location, and the cost. One important implication of these trade-offs is that there is not one right or best solution to an engineering design challenge. After the groups had shared their scores for the tests of their first designs, the teacher pointed out that the best score in the class was achieved by four of the groups using four different sites. During the discussion that followed the sharing of results, the teacher asked, “Is there one right answer to this challenge?” and the students quickly answered “no.”

Part of navigating trade-offs is the ability to make informed judgments regarding these trade-offs, and we see evidence of this in the students’ final letters to the villagers. As mentioned above, Group 3 chose to only compact the soil ¼ inch, even though they acknowledged that ½ inch would have been stronger. The tests of their designs and of the soil itself during their background research convinced them that ½ inch compacted soil was only marginally stronger than ¼ inch compaction and thus not worth the extra money. On the other hand, this group sacrificed somewhat on proximity when they chose a site that was slightly farther away saying, “it may be far away, but it is the strongest choice for your village.” This group was carefully navigating trade-offs as they tried to achieve the closest, cheapest, yet still sufficiently strong TarPul for the villagers.

Some groups, however, showed room for growth in their ability to deal with competing constraints. Group 5, for example, recommended not compacting the soil “because we
will have to pay more for more compaction,” despite the fact that when they did compact the soil more their TarPul supported about 40% more weight. Additionally, because several aspects of the testing process were combined into one ‘score’ for their design, some groups focused more on that score than on the actual design features of their plan. Group 1, for example, explained in their letter to the villagers that “it is our recommendation because it was a good score,” even though the score itself is not what is important to the villagers.

Another important aspect of engineering thinking that appeared in the student work is an awareness of the risks involved in engineering and the importance of reliability of the final product. In this project, students were planning a bridge for transporting people across a river, and some groups keyed into the need for safety in such a process. One example of this came from Group 2 who said, “We believe that this is the best amount to compact because it would be safest.” Group 7 also indicated that safety was an important feature of their plan. Although strength or ‘sturdiness’ of the TarPul was an important factor in the testing process, the prompts for testing their designs and communicating their final designs to the villagers did not specifically indicate safety as a goal. Yet, as these groups considered the context of the problem, they understood that safety would be important aspect should their designs actually be implemented.

Learning from failure is also an important aspect of engineering thinking. Although we did find evidence of this in the student work, it was not as easily identifiable as some of the other learning goals. Learning from failure was most visible in what choices the students made for their final designs. In several cases, the modifications they made to their first design resulted in a better score for their second design, so their choices resulted in improvements. Group 7, for example, attempted to improve their score by not compacting the soil. Their initial score was rather low to begin with, so they did not have much room for improvement in terms of the test score. This change, however, greatly reduced the strength of their design, and the second design ended up scoring worse than the first. Ultimately, however, they learned from this and ended up recommending that the villagers compact it ⅛ inch as they had originally planned saying, “it is more safe if is compacted at ¼.” Other groups were fortunate enough to actually improve their score with the changes they made, thus it is difficult to tell if they learned from failure.

D. Communication

Communication related to engineering should allow students to communicate their technical information through client reports, presentations, and explicit demonstrations. In this study, students used three primary means of engineering-related communication: each individual student’s science notebook, each groups’ engineering design packets (which included a simultaneous physical model of their design), and each groups’ final reports to the village elders.

The groups’ design packets consisted of student writings of this group eliminated some potential sites, while considering other sites as potential. Prompts were included so students could provide verbal justification for the choices they made for location and begin to brainstorm how much compaction they would need for their choices. A group that brainstormed that sites A and E were good possibilities said that they would recommend these sites because “they are on straight segments of the river where there would not be as much erosion”. They also recommended that they should perform the maximum amount of compaction “because it is stronger!”

The groups also had to communicate to the client through the “Geotechnical Engineers’ Final Report.” This consisted of two pages: the first page included a map and a series of short questions through which groups filled in their design choices (more pictorial and verbal representations of their design choices). The second page required students to write a persuasive report to their clients about which site and compaction they chose, as well as why they chose them (which they presented orally at a later time). These reports, both written and oral, provide evidence of students’ verbal representations of their engineering designs. Details of the contents of these reports have already been addressed in the Process of Design, Apply Science Engineering and Mathematics, and Engineering Thinking sections of this paper. However, a full example has not been given. Group 3’s final report was one of the better examples because it directly addressed underlying science and engineering trade-offs.

Dear village elders: We recommend site H because it is strong and on a straight part of a river so there would not be very much erosion. It may be far away, but it is the strongest choice for your village. We think both sides should be compacted ¼ of an inch. We think this is the best amount of compaction because it is still strong but it does not cost as much as ½ of an inch. It has rocky soil on both sides. From your friends at group 3.

When student groups presented these reports to the whole classroom on the last day of the project, they were all required to go to the front of the room. While a few groups split up the task of giving the reports, most of them had one person read
the whole paragraph, though the other members looked attentively at the elected speaker. When the teacher asked follow-up questions, almost all of the students answered, not just the designated speakers.

In general, these final reports included many elements of quality engineering communication: multiple representations, technical language, and justification of the designs. However, it should be noted that these elements were built into the instructions for the individual notebooks and the final report, prompting students to address them.

V. CONCLUSIONS AND IMPLICATIONS

The curriculum used in this class, A Stick in the Mud, took explicit steps to ensure that students had a chance to demonstrate their knowledge of science and engineering in a variety of ways, and this analysis shows that the student artifacts resulting from the engineering design challenge provides evidence of student learning in engineering. Furthermore, the student work generated as a result of this design challenge revealed stratification between the levels of learning of different groups for different key indicators. For example, some groups demonstrated a more sophisticated ability to apply their knowledge of erosion, and some groups were more adept at negotiating trade-offs. Thus, the student work generated in this design activity can provide valuable information for teachers in identifying both the achievement of learning goals as well as the strengths and weaknesses of groups of students.

As can be seen in the FQEE-K12, much of what students should learn about engineering at the K-12 level is focused more on processes than on content. While content knowledge is often measured through factual questions, knowledge or understanding of a process is typically more difficult to assess. This analysis shows that when units or activities are structured to encourage students to document their work and prompt them to articulate their thinking, the resulting artifacts do indeed provide evidence of such learning. That is not to claim, however, that all aspects of the FQEE-K12 indicators were exemplified in the student work. For example, reflective thinking, creativity, and the ability to seek out new knowledge on their own are important aspects of engineering thinking and problem and background, but this analysis found only limited evidence of these. Student artifacts and classroom interactions do in fact provide evidence of learning of engineering, but as we continue to develop K-12 engineering curricula and the assessments that go along with them, educators and researchers will need to carefully consider how the activities and student work align with the goals of K-12 engineering education.

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