Embedding Assessment in School-Based Making

Preliminary Exploration of Principles for Embedded Assessment in Maker Learning

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ABSTRACT

Although maker-centered learning in schools has grown rapidly in recent years, the existing assessment approaches often do not meet the needs in assessing the multifaceted learning and development that occur in making processes. This short research paper reports on the design principles of embedded assessment and shares insights gained from working with middle school teachers developing, testing, and examining an embedded assessment toolkit consisting of seven assessment tools and activities.

CCS CONCEPTS

• Applied computing~Interactive learning environments

KEYWORDS

Maker education, Embedded assessment, Assessment tools

1 Introduction

Maker-centered learning has grown rapidly in recent years, first in out-of-school environments such as museums and after-school spaces, and increasingly in formal classroom environments. Making is a powerful method to engage learners in STEM ideas through projects, but also offers a unique opportunity to support valuable competencies beyond STEM such as problem solving and collaboration [1]. Traditional assessment approaches, however, often fall short in meeting the needs of assessing learning and development in maker classrooms for the following reasons.

First, while traditional instruction often leads students to one clear answer or set path, maker projects often do not have one right answer, and rather are open-ended with multiple possible trajectories toward solutions [2]. To assess such diverse trajectories of learning, assessment needs to be oriented toward the process rather than the product of an activity. With limited time and hands, it's not always practical for a single teacher to collect information in the process. Second, maker activities often involve abundant peer learning in the form of collaboration, mentorship, and feedback exchange, or the sharing and remixing of ideas [3]. Thus assessment in making needs to carefully consider the dynamic nature of social learning, not just individual learning. Third, since maker learning processes are exploratory and often without any clear steps or stages, traditional assessment can be disruptive to the learning processes. The skills and dispositions that are present in maker-centered learning must be tracked in the context of the project itself, thereby embedding the assessments into the work.

Some maker educators utilize certain assessment practices to document student learning in open-ended projects, such as portfolios and rubrics [4]. While these provide some structure for teachers to assess student work, they are insufficient to collect the rich data generated in the process of making while simultaneously supporting intentional interactions and meaningful outcomes. Inspired by embedded assessment commonly employed in digital learning environments [5], we have explored the idea of embedded assessment in maker classroom environments through the design of an assessment toolkit. This short research paper shares preliminary insights from interviews, workshops, and online discussions with middle school teachers as well as coaches.

2 Embedded Assessment in Making

Embedded assessment refers to a form of assessment that is directly woven into the learning environment and activities, so student

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learning can be monitored and supported in real-time without interrupting the flow of learning [5, 6]. Embedded assessment has been widely adopted in digital learning environments such as simulations and video games to design tasks within a system that can elicit evidence of desired outcomes, and to automatically and rapidly capture and process rich data generated in the process of performance [7]. With well-designed embedded assessments in place, students' actions within a learning environment provide robust evidence for underlying competencies while the distinction between assessment and learning is blurred. Based on the existing literature of embedded assessment in digital and non-digital environments, we have established four design principles of embedded assessment to guide our initial conception of embedded assessment tools for making:

1: Embedded assessment should seamlessly integrate assessment within the learning environment or activities. That means that the assessment process of collecting evidence, reflecting and analyzing, and giving feedback is directly and seamlessly woven into activity, the task itself, or the environment, instead of being a separate event that happens after learning occurs. As a result, embedded assessment should occur at any point throughout the learning process and is often ongoing and continuous. Although the hands-on nature of activities in classrooms limits the extent to which seamless evidence can be collected, we aim to create assessment tools that invite learners to be immersed in an integrated process of assessment and making.

2: Embedded assessment should be construct-driven, and start by clarifying target outcomes that an activity intends to foster. Embedded assessment can measure not just knowledge and skills, but also attitudes, beliefs, interests, and practices, instances often referred to as constructs. While this is a principle for any good assessment, this principle is particularly relevant for maker environments where each student's learning process can take various forms and trajectories, and where anticipated learning outcomes tend to be ambiguous. Therefore, embedded assessment in making should include a clear understanding of a possible outcome space and how specific actions within the learning environment could be connected to these constructs. In our work, we designed our assessment tools targeting seven constructs (i.e., agency, design process, social scaffolding, productive risk-taking, troubleshooting, bridging knowledge, and content knowledge) that we call Maker Elements. These seven constructs are selected based on review of literature [8, 9] and discussion with educators. They are not meant to be a comprehensive list, but a list of skills and dispositions that maker educators commonly thrive to foster.

3: Embedded assessment should be evidence-centered, generating visible, tangible, and varied forms of evidence for the underlying constructs. Although it is valuable to monitor and support students' learning by capturing visible and tangible evidence for all assessment practices, it is particularly crucial for maker education classrooms. In a maker education setting, where learning can be projected in various forms and can appear at various points throughout the process, teachers cannot capture evidence and provide immediate feedback to every student. Visible and tangible evidence collected in the moment allows students to see and monitor the evidence of their own progress in the moment it is collected, giving form to the abstract constructs. In addition, visible and tangible forms of evidence can persist beyond the moment of making and can be shared with stakeholders who want to see students' progress. Our tools aim to capture multiple types of evidence that can be used to make inferences about learners in relation to the constructs.

4: Embedded assessment should involve students as active participants in the assessment process. Because maker activities involve many exploratory and complex interactions involving students, a less structured environment, and tasks with varied outcomes, assessment might be more feasible if students participate in their assessment. Therefore, embedded assessment should invite and motivate learners to be participants in collecting evidence of their process, and gaining immediate feedback for themselves and one another. To truly engage students in the assessment processes, it is important that embedded assessment is interactive, social, playful, captivating, or enjoyable for students. In our work, we aimed to make assessment tools participatory and accessible to engage students in the process of collecting and organizing evidence.

These principles draw heavily from the application of embedded assessment in digital learning environments, while also considering the essential differences between digital environments and non-digital maker learning environments: Maker-centered learning does not have the same data affordances of digital environments, and there are limits to capturing rich, process-oriented data with minimum interruption to making. The following section discusses how these principles guided the design of embedded assessment tool prototypes for maker-centered learning, and for examining the usefulness of these principles.

3 Tool Development

We have developed an assessment toolkit that teachers can use to conduct embedded assessment in their classrooms. The toolkit includes seven tools and activities that teachers can customize and integrate into their maker projects. Each tool is designed to support teachers in conducting one of the three steps of embedded assessment: context setting, evidence collection, and meaning making.

In an embedded assessment for maker classrooms, performance data cannot be collected automatically as it can in digital learning environments. Given this constraint, our tools took different approaches to make the assessment woven into the process of learning (but not hidden). For example, one tool, *Sparkle Sleuth*, is designed to guide teachers to use paper slips to document moments when students demonstrate a Maker Element and share the slips with students in a way that supports them without disturbing their activity. Another tool, *Maker Moments*, involves a bingo-like diagram where students quickly and easily capture quantitative evidence of their making process by making marks each time they demonstrate a particular Maker Element.

All of the tools are designed to capture, organize, and understand performances of at least one defined construct. For example, with *Maker Moments* students record how many times they demonstrate

three constructs that they or their teachers have chosen. *Sparkle Sleuth* slips are also labeled with one construct chosen by the teacher. *Field Guide*, a tool designed to make meaning from the accumulated evidence collected by other tools, is a customizable binder where students curate evidence to show their achievements and progress in demonstrating any one Maker Element. By explicitly focusing on few constructs, these tools help teachers and students pay attention to specific constructs that might otherwise be overlooked.

Evidence of learning in maker activities might already exist as visible artifacts (such as photographs, post-it notes, or sketches), but other evidence of learning might not have any visible artifact (such as feelings, thoughts, ideas, questions). Our data collection tools are designed to help students and teachers collect both types of evidence and create visible artifacts when there are none, while also supporting them in making meaning from that evidence. For example, *Maker Moments* and *Sparkle Sleuth* help students and teachers to quantitatively document the moment of learning as it occurs. Whereas two other data collection tools, *Stuck Station* and *Stereocraft*, both support students' qualitative reflections on their moments of learning. *Stuck Station* is a standalone video recording station that students can visit to record a video describing the moment and explore strategies to get "unstuck". *Stereocraft* is a multi-dimensional paper shape that allows students to capture evidence of Maker Elements in writing and images on the shape's faces. These tools aim to help students and teachers articulate and document learning during the learning process, yielding rich, multifaceted evidence of their learning.

We recognized that, in order to involve students in the assessment process, it is important for the assessment process to have qualities that make assessment captivating and comfortable for students. *Stereocraft*, for example, allows students to use any medium of their choice (such as any writing utensil, colors, illustrations, stickers) to decorate the shapes and represent their learning processes. In order to engage students in the assessment process, we recognized that it is also essential to first familiarize the students with the Maker Elements and assessment method by using tools that set the context. One context setting tool, a *Maker Element Poster*, shows graphic representations, descriptions, and I statements for each Maker Element and is displayed in classrooms for students and teachers to see throughout the process of making and assessment. Another context setting tool, *Superpower Hour*, is an activity for classes to gain a shared understanding of what selected Maker Elements mean and look like in practice. Students work together to identify and represent Maker Elements (framed as superpowers) that supported real live designers and innovators as capes that the individuals might wear. These tools aim to help students and teachers fully understand and become fluent at noticing, documenting, and reflecting on the constructs. (see http://bit.ly/2Bkkjlj for a more detailed overview).

4 Methods

In this study, the first phase of a design-based research project, we conducted five one or two-day workshops with nine teachers and four coaches in two middle schools in Portola Valley, CA, and Charlottesville, VA to collaboratively design a toolkit and implementations of embedded assessment in their classrooms.

During the first two workshops at each partner school, we focused on collecting information about teachers' teaching and assessment practices while also brainstorming how embedded assessment could be integrated into their maker-centered classrooms. The latter three workshops focused on collecting feedback from teachers and coaches on early prototypes of tools by testing the tools in our small groups and designing ways for the teacher to implement them during activities planned for the upcoming school year. Throughout this phase of collaboratively designing the tools and their implementations with teachers, we recorded interviews, phone calls, and observation notes that would inform future iterations of each tool and assist our examination of embedded assessment principles.

5 Findings

The initial examination of recordings and observation notes yielded insights about each design principle of embedded assessment for maker learning contexts.

As expected, we encountered limits related to how seamlessly the assessment could be embedded in maker-centered learning activities. Rather than a seamless integration of learning and assessment, we approached embedded assessment as a process of braiding assessment into the process of learning. This not only was a necessity due to the manual nature of our tools, but also presented an opportunity to draw students' attention to their own assessment and learning. Although our partner teachers and coaches were interested in assessments that would not interrupt students in the process of making, they put more emphasis on minimizing the time spent on the assessment. Teachers also reported that they had been struggling to incorporate reflection at any point in students' making practices (during and after an activity) and they expressed the need to improve their noticing practices to give just-in-time feedback on students' making. These findings suggested that embedded assessment tools could focus less on seamless integration and more on supporting teachers and students at the moments when it is helpful to exchange feedback or identify learning in an activity, while being mindful of time constraints.

The construct-driven approach was generally received well by teachers and coaches as an appropriate and potentially useful way to address assessment needs in maker activities. During the workshops teachers expressed their hope that the tools would improve students' understanding of the Maker Elements and other constructs that are abstract and less familiar compared to content acquisition. Workshops and interactions with teachers also revealed the importance of focusing on only a few constructs during a maker activity in order to meaningfully engage students in the assessment process. Feedback from the teachers indicated that all seven constructs we identified as Maker Elements were highly valued and can be (or should be) observed in maker classrooms. However, it is challenging to observe several constructs at a time. Some teachers and coaches suggested during one workshop that two constructs might be the maximum number to be meaningfully introduced.

Our interaction with teachers highlighted the importance of an evidence-centered approach anchored by visible and tangible evidence. The teachers repeatedly mentioned that one of the struggles they have with assessment is capturing tangible evidence of learning that is rapidly generated in the process of maker activities. Thus the teachers seemed to have confirmed the value of tools that would allow them to make the internal state of a learner (such as ideas, questions, struggles, feelings, or inspirations) visible and tangible to others, both as they occur and as students talk about those aspects of learning with others. We also learned that teachers value visible and tangible evidence that can persist across time and space in order to describe students' learning with other stakeholders such as parents and school administrations. One teacher described that he usually notices and takes mental notes on how students are learning and developing their skills, but those insights are only apparent to him. Such an approach might work in a classroom that is relatively small sized and with an experienced teacher, but it might not work at scale or for teachers who are still developing the capacity to notice and remember each student's performance. Teachers and coaches spoke readily about the challenge of organizing and making meaning out of the evidence collected with our tools. The tools capture visible and tangible evidence in the form of writing, illustrations, colors, shapes, photos, or videos - and some tools capture a mixture of forms - which teachers felt would require training or practice to interpret. Teachers were interested in *Field Guide* as an attempt to help students and teachers organize and understand various types of evidence collected during maker activities, but the challenge of making sense of evidence requires further exploration.

Although we are still in the process of testing the tools with students in classroom settings, the participatory nature of embedded assessment was positively received among partner teachers. Teachers pointed out that having students participate in the process of assessment would enable them to identify learning of students with various learning styles in the moment and provide immediate support for them. For example, one teacher mentioned that a very quiet student in his class could take advantage of being a participant of the assessment process by generating documentation herself using various media. Other teacher mentioned that by letting students articulate their own goal and talk about how they are trying to approach it, he as a teacher can support each student better. Letting students decide what evidence to collect and how to collect and display them support students agency and support them to self-regulate their learning better. However, we also learned that it is extremely important to build a shared understanding of learning goals with students in order to engage them meaningfully in the assessment process. One teacher decided to dedicate a good amount of time to discuss what each construct means using the Maker Elements Poster and Superpower Hour activity. Other teachers also hanged the Maker Elements Poster in the classroom and encouraged their students to talk about those skills in daily lives. Without having a good understanding of the constructs, it is difficult for students to start capturing their own and peers' learning in the classroom. This is crucial process to seamlessly integrate assessment process in learning activities. Setting the Context phase needs to be emphasized in order for the whole embedded assessment to yield valuable learning outcomes.

6 Conclusion

This short paper introduced the design principles of embedded assessment in maker classrooms and insights we have been gaining from the ongoing project. The interaction with teachers and coaches testing our embedded assessment toolkit that addresses the design principles highlighted several elements that require further considerations. Our findings here are limited to the insights from teachers and coaches outside the classrooms and the insights from their future implementation in their classrooms would provide more practical insights. Our design principles and related insights are largely focused on how to introduce embedded assessment in maker classrooms, but as a future research, it may be interesting to explore what values and challenges may emerge once the fluency of embedded assessment has been achieved among both students and teachers.

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