STEM Integration

Through 3D Printing and Modeling

by Leah R. Cheek
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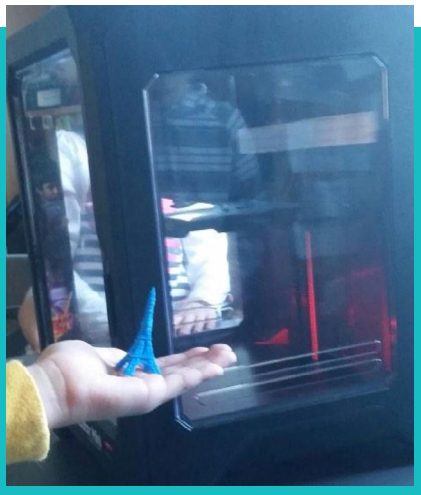
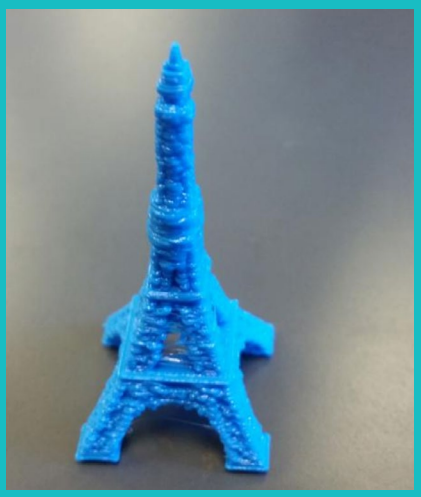




Three-dimensional modeling and 3D printing are increasingly becoming more accessible across the K-12 education spectrum. Martin, Bowden, and Merrill (2014) noted that "students may be enticed to pursue STEM-based careers by just having a 3D printer in the classroom... (p. 33)." Typically, inspiring statements like this describe older students using the 3D printer in the junior high Makerspace or technology and engineering classroom but adding a 3D printer can also have great value in an elementary classroom. As indicated by Daugherty, Carter, and Swagerty (2014) "... research suggests that elementary school is the most appropriate time to engage students in integrated STEM education and spark the interest of elementary-aged students–particularly in science, technology, engineering, and mathematics" (pp. 46-47).

3D printing experiences in the classroom characteristically evolve from a student developed design drawing completed in a 3D modeling program, then saved as a stereolithographic (STL) file type, and finally imported into a slicing program such as Cura to then be sent to a 3D printer as a computer numerical controlled (G-code) file type. However, a 3D printer in the classroom may have other potential applications for integrated STEM learning.

The following account is an example of how 3D printing might be used to introduce students to the abundant possibilities of STEM integration through 3D printing in the elementary classroom.

Mrs. Rojas is a firm believer in the integration of STEM components throughout the curriculum. The second graders in her classroom are using the 3D printer in an atypical, intriguing manner by printing a replica of the Eiffel Tower. Twenty-four seven- and eight-year-olds are huddled around a 3D printer, atop a child-sized table in the center of the classroom. Mrs. Rojas borrowed the printer from the Makerspace at the neighboring junior high. The students peer intently as the 3D printer makes purring, whirling, and humming sounds. Jonah, a student in the class, questions, "So the extruder is so hot, like almost 400 Fahrenheit?" In response to his question, Natalie, a classmate, answers the question, "So, yes. Almost 400 Fahrenheit. We estimated. That is like double boiling, Jonah. That is so hot." Seven-year-old Eli adds, "Yeah. That's the only way the extruder can melt the filament. We're not touching it..." As surprising as it may seem to observe a second grader even using the vocabulary, "extruder" to question, label, and identify temperature, it is just as surprising for his classmates to answer and extend his understanding. Mrs. Rojas, although present, is not needed in this discussion.

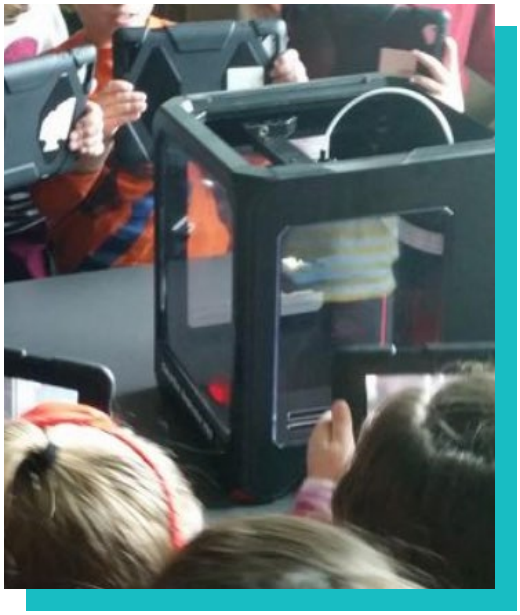
Instead of focusing on teaching STEM at a specific time block in the schedule, Mrs. Rojas is driven by integrating STEM with all curricula throughout the school day. During her class's time at the school library, Mrs. Rojas noticed Natalie endlessly borrowed books from the classic *Madeline* series by Ludwig Bemelmans. Normally, it might be difficult to make a connection with, "...the old house in Paris that was covered with vine..." to science, technology, engineering, and mathematics, but Mrs. Rojas saw the opportunity to use the interests of her students to guide her instruction and integrate STEM.

When questioned about the connection and integration between literacy and STEM, Mrs. Rojas deferred to seven-year-old Natalie. Natalie explained, "I love *Madeline*. I love Paris. I love the Eiffel Tower. I REALLY love the Eiffel tower. Mrs. Rojas said we should go to the Eiffel Tower, but that's really hard. It's in Europe. So... we are printing it. We had to know a lot to print."

On the wall adjacent to the printer is an anchor chart, typical in many elementary classrooms, but this one is not typical. Entitled, "3D Printer Vocabulary," the anchor chart contains bold faced words like EXTRUDER, FILAMENT, BUILD PLATE, CAD, ALGORITHM, STL, SD CARD, USB, EXTRUDER NOZZLE, FLOW..." Each word appeared to be added at different times because the handwriting differed. Next to each word was a child-centered definition, along with an obviously student-drawn sketch to show the meaning. Finally following the sketch was a student-written sentence including the vocabulary designed to show meaning. For example, the word EXTRUDER was followed by this definition: "The rectangular prism part that gets really hot and heats the filament so we can print. It pushes the filament out of the hot end. That means extrude."

Next there was a child-drawn picture of a rectangular prism with a pointed end at the bottom (extruder nozzle) and something that resembled a string of spaghetti (filament) entering the rectangular prism from the top end. Following the picture was this sentence. "The EXTRUDER will heat up so we can print the Eiffel Tower."

Mrs. Rojas clarified, "When STEM integration occurs naturally in an elementary classroom it is powerful. As a teacher/facilitator I just started with my students. Natalie was obsessed with Paris...don't ask me why. She has no personal connections and she, like most of my students, has never traveled beyond our state. I saw this as a

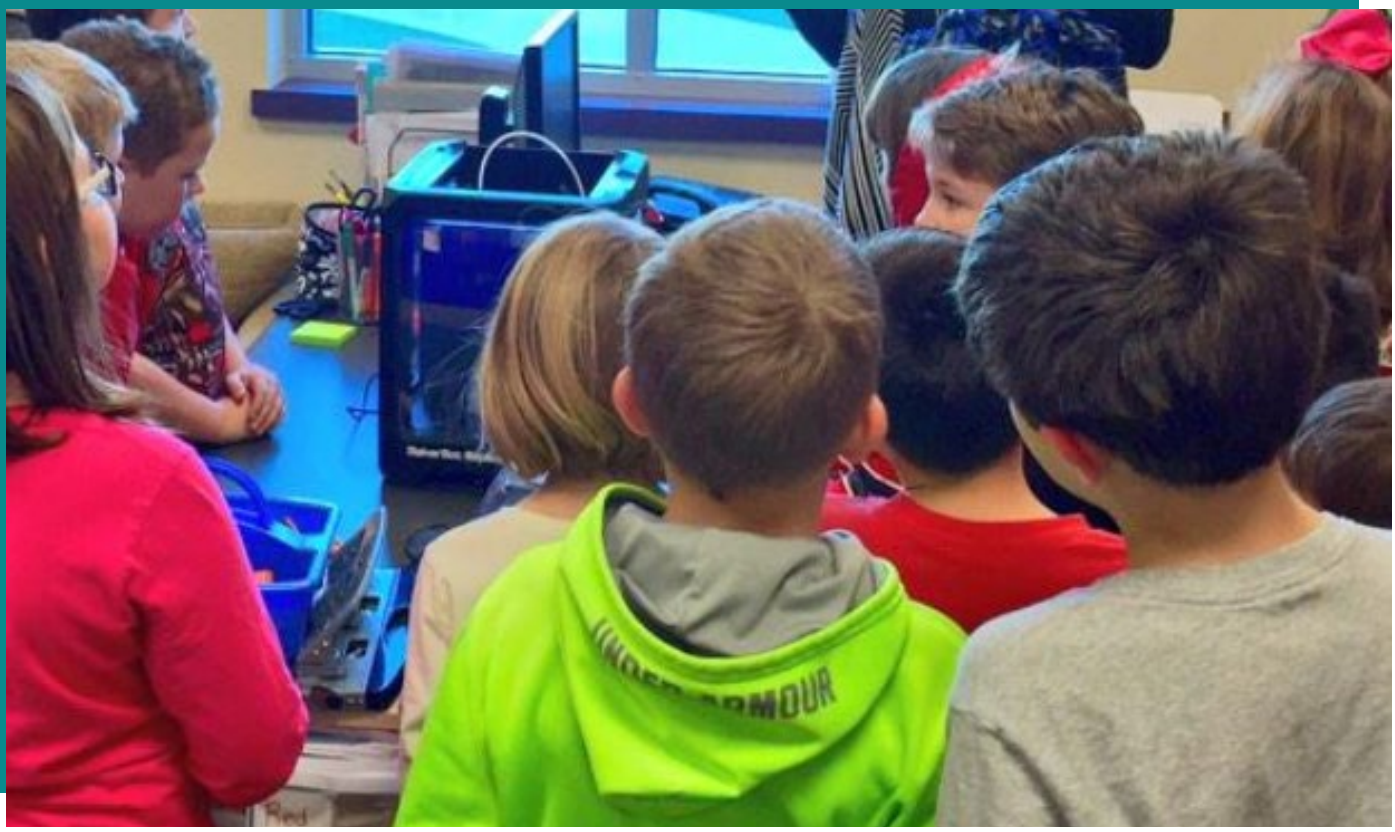


perfect time to use her enthusiasm and make it contagious. It started as a *Madeline* read aloud at group time…she couldn't keep quiet when she heard the word, 'Paris.' I knew that would happen. We put down the book and the class started writing down what we knew about Paris and what we wanted to know using a familiar K-W-L chart. The Eiffel Tower was of big interest. I knew this would be a perfect time to bring in a 3D printer and work towards actually printing an Eiffel Tower."

When Mrs. Rojas said, "work towards," she meant it. She explained the many standards that she integrated with the *Madeline* series of books. For mathematics there is measurement (the height of the tower) and estimation. In science she can discuss temperature and properties of matter. There are multiple ELA possibilities such as making connections, retelling, and building vocabulary.

Taking the time to consider the value of the STEM integration transformed a potential side-show 3D printing experience into an experience of informed students aware that there are engineering and scientific principles involved in 3D printing. Mrs. Rojas cannot predict if these students will seek out a STEM-related career, but she does feel confident stating these early experiences with technology and STEM-based integration are setting a deeper foundation for that potential outcome.

3D printing is often seen as an intimidating and cost-prohibitive type of learning. The cost of 3D printers as well as the emergence of 3D modeling software such as Autodesk TinkerCAD, Onshape, Autodesk Fusion 360, as well as others have made it easier than ever for students and teachers to integrate this type of technology in the classroom, especially in elementary schools. As noted by Katsioloudis and Jones (2015), it is important to understand that "3D printers are only a tool that can enhance learning experience and not something that can replace it" (p. 18). Mrs. Rojas understands the importance of integration as opposed to isolation of STEM throughout the school day. Many elementary classrooms are exceptionally structed to provide opportunities for meaningful curriculum integration (Carter, Kindall & Elsass, 2016), providing more depth and increased student engagement.



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