Implementing Making Experiences for Struggling Learners

Abstract

Given the proliferation of makerspace experiences in K-12 education, there is growing attention on ensuring accessibility for all learners, including those with disabilities. However, there is limited research on the participation of students with disabilities as well as other struggling learners in makerspace activities. Therefore, it is essential to examine how these learners participate in K-12 makerspace activities, any barriers that they face, and how to address those barriers. Project MAPLE: MAkerspaces Promoting Learning and Engagement examines the pedagogical and curriculum approaches by middle school teachers to include students with disabilities in maker learning activities. The aims were to answer preliminary questions related to (1) what learning barriers are present during the design-redesign and problem/project process common to makerspace and early engineering experiences, especially for struggling learners and (2) how can instruction that supports metacognitive strategies be integrated within typical K-12 classroom makerspace activities to address those barriers.

Project MAPLE employed a cross-case qualitative methodology including four middle school teachers who taught makerspace activities within their inclusive STEM or science classrooms. Data was collected and triangulated across three sources (i.e., classroom observations, teacher interviews, and instructional materials). Across four schools, teachers reported that students with disabilities meaningfully participated in making activities. However, they also reported both student-level barriers and structural barriers. Recommendations and implications for future research and practices are discussed from an ecological model perspective that account for the interconnectedness between student-level and systems-level challenges.

This work was supported by the National Science Foundation under Grant DRL #1721236.

Makerspaces in K-12 Learning

While K-12 formal education has a history of including applied, hands-on learning in instructional areas such as inquiry-based science (Salmon, Rossman, & Dipinto, 2012), agriculture, industrial arts (Barba, 2015), and art and design (Bequette & Bequette, 2012), makerspaces are at the beginning stages of implementation in the K-12 educational landscape (Meyer, 2017). The maker movement emerged in the early 2000s as informal learning environments that emphasize opportunities for open exploration, collaboration, and failure as a source of iterative feedback (Peppler & Bender, 2013; 2016). The core of this movement is comprised of three critical tenets: "*Making* as learning activities, *makerspaces* as communities of practice and designed learning environments, and *makers* as identities of participation that afford new forms of interaction between self and learning" (Halverson & Sheridan, 2014, p.502). This focus on creative problem solving and learner-centered engaged learning has drawn the attention of the formal K-12 education community. For example, K-12 leaders interested in bringing making into schools have focused on the "maker mindset," hoping to create opportunities that promote student empowerment and problem-solving (Meyer, 2017). These attributes -- empowerment, problem-solving, and authentic learning -- help to foster the 21st Century skills of communication, collaboration, creativity, and critical thinking (Blackley, et al., 2018; Peppler & Bender, 2016). Therefore, intentional educational makerspaces often aim to "harness the same intellectual playground concept for the purpose of inspiring deeper learning through deeper questioning" (Kurti, Kurti, & Fleming, 2014, p. 8).

At the same time, there is a need to understand the extent that formal classroom implementation of making aligns with the pedagogical theories of constructivism and constructionism, which are fundamental to the maker movement (Willett, 2017). These theories call for hands-on experiences driven by the learner and, as such, may conflict with many of the traditional structures of formal education (Willet, 2017). In many places, however, K-12 education is experiencing a shift toward more flexible implementations of standards and assessment that emphasize a more inquiry-based approach to learning, which is more aligned with authentic, engaging, and personalized making. (Meyer, 2017).

Students with Disabilities or At-risk in Makerspace Learning

Given the increasing acceptance of the maker movement in K-12 learning, it is imperative to consider how making experiences can be designed to be inclusive of all learners, including those with disabilities and other struggling learners (Barton & Tan, 2018; Seymour, 2018; Taylor, Hurley & Connolly, 2016). However, there is a scarcity of research exploring students with disabilities or who are at-risk for academic failure in the context of makerspace learning. Among the few studies, researchers reported that students with disabilities can succeed in makerspace learning if given the appropriate supports. For example, Seymour (2018) reported that students with disabilities and English language learners showed positive outcomes in makerspace learning with greater hands-on activities and opportunities for collaborative learning. However, Klipper (2014) noted that students with disabilities were often overlooked in makerspace learning. Further, there is limited research about how teachers meet the needs of students with disabilities in project-based makerspace activities. Thus, it is critical to understand how teachers can better promote participation for students with disabilities and those at risk for academic failure during makerspace instruction.

Project MAPLE: MAkerspaces Promoting Learning and Engagement

Given the limited research about the experiences of students with disabilities and those at risk for academic failure, this study focused on examining the makerspace experiences in which these learners participated from a qualitative perspective. Instead of beginning with an intervention, the research team decided to first examine existing makerspace opportunities, with the goal of understanding challenges inherent in current school-based makerspace settings for these populations of students. Consequently, this study employed a cross-case qualitative approach (Stake, 2006) to understand the challenges and successes that four general education teachers faced in meeting the needs of students with disabilities and at-risk in middle school makerspace instruction. Each case was initially examined independently as a unique instrumental case study. Then, the cases studies were grouped into a multi-case analysis, and these individual cases were compared for similarities and differences. The complete research methodology is described in Lee, et al. (2020). It is important to note that this study was intended to be exploratory rather than conclusive. The findings related to barriers are consistent with existing literature, but the recommendations for addressing those barriers are preliminary based on individual case observations and interviews. Further study is needed to verify whether these interventions are successful in developing the necessary metacognitive practices among students with learning disabilities or at risk of academic failure.

Barriers to Engaging in Maker Activities

Project MAPLE identified a number of barriers, categorized into three sections: (1) students, (2) teachers, and (3) current practices in school.

Student – All teachers experienced performance avoidance and limited persistence among the students with disabilities as well as those receiving Tier 2 support in the making activities. The students rarely tried these activities on their own. One teacher explained that her struggling learners, especially those with disabilities, often exhibited learned helplessness, wherein they would not initiate or persist in learning activities independently. Another teacher, similarly, stated that students with disabilities feared failure in his class and exhibited limited persistence. The students' fear of failure often meant that he had to work one-on-one with them to help them maintain effort and persistence. A third teacher reported similar lack of persistence and explained that she prompted her students and gave directions, but continued to set the expectation for the students to complete tasks as independently as possible. Classroom observations also showcased task avoidance. The students with disabilities were often observed exhibiting off-task behaviors (i.e., making noise, using phone, chasing one another) as compared to their peers who were also talking with their peers, but were doing so while also working on their projects. Teachers usually attempted to re-engage the students by verbally or physically intervening to redirect them. However, given the teacher and student ratio, it is challenging for teachers to re-engage all the students.

Teacher – The classroom observation shows that it was too challenging for teachers to implement instructional strategies (e.g., explicit instruction, modeling, prompting) to meet the needs of students with disabilities or at-risk in maker activities. One teacher prepared directions for every class including the agenda on the smartboard, worksheets, and verbal directions. However, she was not seen providing any form of cues to the students to look at those directions, which often resulted in students asking the same question repeatedly. Similarly, during this class' dream home project (February 28, 2018), field note reflections indicated "[l]ots of further instruction is needed to perform merger (instruction seemed to have been given too quickly for students to grasp the necessary steps)." Most interactions appear to be depositing of information to the student instead of prompting techniques to determine how to figure out the answer. Classroom observations also indicated limited implementation of instructional strategies to support students with disabilities. Another teacher, for example, had a student with a learning disability whose IEP accommodations included reduced reading load and additional time to complete assignments. Despite these mandated accommodations, observers noted that the teacher has not given any relevant accommodations or instructions. Observers reported

> "[i]t seems like everyone receives the same format of worksheets. Also, it is not clear whether a student with a learning disability understands the directions. It might be better to provide both oral and written directions for her. She seemed [she was] just sitting in the chair, and not doing any work until the teacher check-ins with her (February 10, 2018)."

<u>Current practices in School</u>

Limited Access to STEM for Students with LD – The number of students with disabilities was fewer than expected in all four classes observed. Although some students with disabilities were included, there were no students with intellectual disabilities, behavior disorders, or other more moderate to severe disabilities. Except for the science class, the three schools ran on an 8-week, quarter-based schedule for STEM Lab and other non-core classes. These non-core classes included band/orchestra, foreign language, drama, and STEM Lab classes. One teacher noted that most students with intellectual and developmental disabilities were "pulled out" of the STEM course to receive reading instruction (or other specialized interventions) and did not have an opportunity to participate in the STEM class. Thus, although there were a few students with disabilities in the STEM classes, the teachers did not have many experiences teaching students with disabilities in their classrooms. Indeed, researchers only observed a few ESL students or students with learning or behavior issues in two of the three STEM lab classrooms. The third STEM teacher, however, had an opposite experience in which she had more struggling learners in her class because most high-achieving students enrolled in courses such as foreign language or band. However, her class also did not include students with more significant needs.

Technology Failure – Across observations and interviews, teachers experienced technology challenges during maker activities. These challenges fell into four categories: (1) Technology failure, (2) lengthy bootup time, (3) internet stability issues, and (4) challenges associated with logging into systems such as Google classroom. For example, one teacher has a 3D printer in her classroom but the 3D printer did not always work reliably. Furthermore, some schools have used Chromebooks or PCs that have some internet connection issues and students constantly struggle to log-in, often mistyping or forgetting their login or password. As instructional time was limited (classes are only 40 minutes long), the technology challenges were viewed by teachers as problematic for implementation of the making activities.

Limited Professional Development – Three teachers from the same school district mentioned that there were limited opportunities for PD on either maker activities or inclusive instructional strategies. All four teachers were interested in learning different kinds of hands-on maker activities, but at the time of this study, they had not had opportunities to participate in any maker-related PD. During the interviews, researchers asked the teachers about their background and any PD that they received. Two teachers confided that they struggled executing new maker activities. Ms. Morgan reported that PD was not always presented in ways that teachers could easily apply new content into their classrooms. Similar to PD on maker activities, teachers did not report having opportunities to attend PD related to culturally responsive instructional strategies or inclusive instructional strategies.

Limited Instructional Time – Across four schools, a project usually took a week and each session lasted approximately 40 minutes. Setting up and wrapping up activities often took at least 10 minutes which left only 30 minutes for the activities themselves. Due to this limited time, there was not always time for student exploration and iteration. One teacher, for example, reported difficulty in facilitating tinkering due to time constraints. Furthermore, researchers observed that learners who needed additional support only received this instruction when they asked for one-on-one help as teachers dealt with 20 or more students per class. For instance, on teacher explained that he was trying to provide accommodations for students with disabilities, but it took a lot of time to revise materials and instructions.

Strategies for Meeting Needs of Struggling Learners

These recommendations stem from researchers' observations in the classroom and interviews with students and teachers. It was not within the scope of this exploratory study to test these suggestions; they are presented here for consideration and potential future research directions. Recommendations are grouped into two areas of focus: classroom-based strategies and system-level strategies.

<u>Classroom-based Strategies</u>

Professional Development in Metacognitive Strategies for Struggling Learners – The intent of Project MAPLE was to explore the kinds of metacognitive strategies necessary for maker-based learning, as well as how maker-based learning might strengthen the metacognitive strategies of struggling learners. The data collection framework was designed to capture indications of persistence, intentionality and iteration as the salient strategies exemplified by maker-based learning. Only limited intentionality or iteration were observed. There were four potential causal factors observed by researchers: inconsistent persistence, low teacher expectations for critical thinking, lack of sufficient scaffolding to iterate beyond the initial requirements, and insufficient time allotted to each activity.

Persistence is an especially important goal of metacognitive strategies, because if there is lack of persistence or engagement, there is no chance to develop intentionality or iterative processes. Persistence was often observed in terms of a student's ability, or inability, to self-regulate, or problem-solve when they encountered something they didn't understand, or wasn't working as expected. If the student was highly engaged in the activity they were much more likely to persist through any issues, including lack of foundational skills, or their own learning difficulties (e.g., attention deficit, anxiety of failure, learned helplessness). There is a great deal of variation in teachers' ability to promote persistence without diminishing the student's agency, self-confidence, and overall learning. One teacher was able to effectively scaffold student's learning without reducing agency or learning outcomes by preparing the students with advanced organizers, having sufficient help available in the form of a teacher aid and other students, and not interfering with the students' learning process. The power of just the right amount of support and just the right amount of student decision-choice is evident in the following observation.

> The project takes place in an inclusive science classroom with a notable number of students needing supports. In anticipation of the project needs, the teacher and several selected students have received training on the necessary steps to create and convert a 3-dimensional computer model for printing. At the start of the class, the teacher is explicative about the goals of the day and for the complete project. The teacher goes over critical components for insect creation and has a student lead step by step instructions for file conversion accompanied by demonstration on the smartboard. The teacher checks in with each student to ensure their bug is finalized for file conversion. In addition, students are provided a guidance document containing the essential steps along with screenshots to progress through the project. The teacher intervenes when it appears the class is moving off task, to ensure completion of a specific task, or assess whether anyone needs additional support.
>
> During the design portion of the project, the student is fairly independent in his pursuit relying primarily on tinkering and trial and error to learn how to navigate through the software and the development of his insect. The student seems particularly motivated by the choices accessible for determining the insect's aesthetics. There is some task prompting by the aid to ensure that he is including all the requirements needed for his insect model. When the project shifts to file conversion, the student became more reliant on supports to advance through the process. The mechanisms for support are peer coaching by a trained student next to him and the guidance document. It should be noted when time becomes critical the student coach takes over the keyboard, but the student intently follows along for understanding. The student is able to complete his project in the allotted time.
>
> In talking with the student about his project, he felt an extraordinary amount of pride in his accomplishment of designing and printing his insect so much so that he stated, "wow, I actually did something good for once." Through the process, he understood the value of his drawing as a reference point for his insect and utilized explorative disposition to make some thoughtful design decisions for his 3D print. The project held the student's attention; he captivated by the 3D-printing process and how realistic his insect appeared. The student even stated he had plans to display it on his stand at home that he always looks on. The student also garnered insightful advice for his peers who might carry out the project. By suggesting they focus on what they have to do and if they do get stuck to ask for help.

Another teacher was less successful in their approach. This teacher had also prepared a project with objectives and step-by-step instructions, but relies on students using the guidance worksheet packet or examples in Google classroom to determine how to accomplish the project with only a brief demonstration that addresses the operational components omitting explanations of what its relevance and importance is to the student and why it is a worthwhile endeavor. The instructional method implemented by this teacher is typically individual interventions. There were no teacher aides in the class and if other students were available to help struggling learners it was only by chance that they could effectively help another student succeed without doing it for them. This teacher also had a tendency to call attention to the deficits in a student project, rather than recognizing progress made so far and suggesting next steps, which framed the work of the student in a negative light that both reduced their motivation to succeed and contributed to a perception that success was not within their reach.

There is an art to figuring out how to scaffold learning for students without skipping over the learning opportunity, or completely losing their attention because there isn't enough time for individual help before they lose interest. Teachers would benefit from professional development in scaffolding learning for struggling learners, and more generally, Universal Design for Learning (Basham & Marino, 2013).

Develop a Maker Mindset – As stated earlier, one of the arguments for maker-based learning activities in K-12 schools is to promote the "maker mindset" – collaboration, creativity, and critical thinking. This requires some teachers to adapt their notions of what it means to teach and learn. Not all teachers immediately recognize the value of tinkering, nor how to frame projects as student-centered learning experiences. One teacher in the Project MAPLE study had low expectations of students' critical thinking ability and structured projects as recipes to be followed exactly. Although there were also other confounding factors, students in that classroom exhibited less interest and engagement than students in other classrooms. In that classroom students who tinkered were viewed as being off-task, whereas in other classrooms where tinkering was encouraged students appeared to develop a sense of agency and control over their learning. At an after-school site, when students were presented with more open-ended projects where tinkering was encouraged they seemed to have more self-confidence and more persistence when confronted with a problem. This is not conclusive evidence since these two cases were dissimilar environments, with different levels of support, but it does suggest that further study on the benefits of tinkering and how to encourage learning through tinkering is warranted.

The type of classroom activities teachers choose to implement is also important. Projects that do not give the students control over their learning or are irrelevant to them are less likely to garner interest, engagement or persistence. In one classroom, two students, both successful in the class in terms of completing project requirements, reported that the class was not relevant to them and they didn't feel they learned anything useful. They both reported that they would have preferred receiving instructions from the teacher rather than just being given a packet to complete. The following observation of one of these students highlights that simply succeeding in following the packet instructions does not necessarily result in learning.

> She was committed to executing the project with meticulous detail to its appearance even using a ruler to place the images on the foamboard. However, the theme, images, and sound clips appear deficient of intentionality as she often selects the first choice available. Given her approach to the project, the activity seemed more perfunctory than an exploration of voice and choice.
>
> The student is diligent in her project pursuits often only seeking out the teacher assistance for affirmation that she has achieved a task properly. The teacher will provide her step by step directions on how to perform a specific action if clarity is necessary. The student makes heavy use of the teacher's model checking her work compulsively to ensure its perceived accurateness. The student's work is used as a reference example due to how well she executes the final product.
>
> Given her task-oriented nature, the student often finishes with time to spare and does not seem appropriately challenged by the project. The teacher does not prompt her to delve deeper into the project but allows her to actively disengage by playing educational games on her computer.
>
> In evaluation of her navigation on the computer, there were incongruencies that were realized about how she grappled with executing the project that were not apparent from just assessing the completed project. While trying to save images to a Google document, the student did not may seem to make the connecting to the images already saved as her Scratch sprites. This was further complicated by the teacher saying they didn't have to be the same image and not noting their existence. When she saved googled images to the document, it appeared that she was not aware of how to rotate an image. If the image could not be sized according to expectations, she would just select an image instead of working to change it accordingly. The student did not express any tangible connection to the project showing negligible interest.
>
> She did not bring high expectations into the class and perceived it as too simple and lacking relevance. In her explanation of her project, she was able to make it function properly but was missing to some extent the language to describe how critical functions operated.

Choosing the right project, however, even for the teacher who did not do as well at scaffolding learning, can make a difference. The right project depends on the current skills of the students and appreciating what they want to learn and what they find relevant. For one project the teacher surveyed the students to find out what they knew and what they wanted to learn. In the first part of the survey she asked:

Q1 I like making things with my hands?
Q2 I am comfortable working without instructions?
Q3 I like using drawing and sketches to share ideas?
Q4 I like trying new things out on my own?
Q5 I am able to make changes when things do not go as planned?

Students could respond "Sounds Like Me," "Somewhat Sounds Like Me," or "Not Much Like Me." The results of the survey indicated that the on average students somewhat liked to make things with their hands, were not comfortable working without instructions, somewhat liked using drawing to share ideas, somewhat liked trying new things on their own, and somewhat liked making changes when things did not go as planned. This gave evidence of the need to gain comfort with tinkering and the interest in hands-on experiences. With regard to voice, the take away is that they are NOT comfortable working without instructions. This infers possible "risk-aversion" and the need to shift from a playing it safe mindset to one that is comfortable with "productive risk-taking" associated with open-ended projects. This comfort will not be immediate, so there is a need for space and time for this shift occur.

In the second part of the survey she found that the activities students were most likely to have tried included drawing, hand-made craft, and coding/podcasting/video creation. They were least likely to have tried Circuits/Artistic Painting, Jewelry/Basic Power Tools. They were most likely to state good at Robotics, Basic Hand Tools, Hand-made crafts/Jewelry and least likely to state good at Podcasting/Video Creation, Sewing/Circuits/Basic Power Tools. But they were most likely to want to learn Circuits, Podcasting/Video Creation, Coding/Programming/Basic Hand Tools and least likely to want to learn Drawing, Robotics/Jewelry.

These expressed choices about making skills indicated that the Makey Makey fabrication project involving circuits, coding, and the use of some hand tools is in alignment with what the students wanted to learn. However, it also made clear that they are not likely to have tried circuitry or feel confident in it. Thus, there was a fundamental need for understanding circuity and providing accessible entry points and scaffolding for students.

There was ample evidence (observation, interview and artifact analysis) that as a result of this advanced preparation on project choice and formulation, students were significantly more engaged, persistent, and intentional, and reported positive learning experiences. There were also examples of iterative work in some student projects. This was by far the most successful project observed in this classroom.

System-level Strategies

Often systemic changes are the most difficult but also the most rewarding and long-lasting. They also have the effect of encouraging a chain reaction of changes all the way to the classroom. If the state or district values something enough to make a systemic change the resources become available and the teacher is better able to make the necessary classroom-based changes needed to realize the benefits for the students.

As noted earlier the school (or district) level barriers observed by researchers included

- Limited Access to STEM for Students with LD
- Technology Failure
- Limited Professional Development
- Limited Instructional Time

Most administrators and school board members would agree that ideally students with LD would benefit from equal access to STEM, more reliable and better technology, more relevant PD for teachers, and longer blocks of instructional time for core subjects. The issues are priorities and perceived value. Which competing interests for school dollars have higher priority and what is the relative value placed on any program? Relative value is related to resource allocation, but is also about the perception of relative importance based on what is required, and how much of a student's schedule is allocated to it.

In the case of technology failure as a barrier, it is most likely already being addressed across all subject areas, especially since technology has played such an important role in remote learning as a result of COVID restrictions. Still, it is important to note that successful making-based activities and courses often do rely on reliable up-to-date technology.

Professional development is now embedded in many school calendars and shedding light on the need for specific PD topics to support LD students may afford better opportunities for teachers who need additional support to be successful. A commitment to PD in Universal Design Learning would benefit all teachers who work with students with disabilities of any kind.

Both limited access to STEM and limited instructional time are issues of scheduling and priority. This is perhaps where Project MAPLE observations can best inform school or district-level decision-making. In the comparison of cases, a significant distinction is the type of class setting for maker-based learning activities. One MAPLE classroom was a year-long science class that embedded making activities into the science curriculum activities. The other three classrooms were quarter-long project-based STEM labs that are not required (students were permitted to choose among band, foreign language, drama, music and STEM). Foreign language and band were year-long and could prevent the student from taking STEM even if they wanted to. Therefore while the science class is a required year-long class for all middle school students, STEM is not a core class and lasts only 1 quarter of the school year. Moreover high-achieving students often opt out of it in favor of band or foreign language, further lowering the perceived importance of the class. The perception then is that STEM is extra and doesn't really count. This inherently devalues the class, student motivation, and even parents' respect for the course. Worse is that students who do not choose band or foreign language are forced to take STEM, so it is required but has low perceived value. Furthermore because STEM is a project-based class, the 40 minute class period makes it difficult to make much progress and students continuously "restart" their project taking up valuable minutes just to return to the point they left the project the day before.

Our recommendation is that making activities are integrated into existing core classes at the middle school level, most naturally science, so that all students have access to the benefits of making and project-based activities. There is value in offering a making course as a separate class, for middle school students who choose it, but only if it is perceived to have the same value as other non-core courses (band

and foreign language). Because it is project-based it would also benefit from being offered as a double period and for at least 1 semester.

Key Recommendations

To summarize the key recommendations for middle school teachers of maker-based activities:

- Seek professional development in
  - Metacognitive Strategies for Struggling Learners – Learn to nurture persistence without diminishing the students' agency, self-confidence and learning, and
  - Universal Design Learning.
- Scaffold student learning with clear purpose, modeling, and individual support.
- Develop a Maker Mindset to promote collaboration, creativity, and critical thinking.
  - Encourage tinkering.
  - Structure student-centered projects by understanding what students already know and what they want to learn.

Key recommendations for schools and school districts that wish to provide maker activities and classes for middle school students include:

- Ensure access to reliable and up-to-date technology.
- Ensure access to appropriate professional development for teachers.
- Integrate making activities into existing core classes so that all students have access to the benefits of making and project-based activities.
- Offer a makerspace class or STEM lab that has the same prestige as other rigorous optional courses (e.g., band or a foreign language) and is offered as a double period for at least 1 semester.

Sited References

Barba, E. (2015). Cultural change in the twenty-first century shop class. Design Issues, 31(4), 79-90.

Barton, A. C., & Tan, E. (2018). A Longitudinal Study of Equity-Oriented STEM-Rich Making Among Youth From Historically Marginalized Communities. American Educational Research Journal. https://doi.org/10.3102/0002831218758668

Basham, J. D., & Marino, M. T. (2013). Understanding STEM education and supporting students through universal design for learning. *Teaching Exceptional Children, 45*(4), 8-15.

Bequette, J.W., & Bequette, M.B. (2012). A place for art and design education in the STEM conversation. Art Education, 65(2), 40-47.

Blackley, S., Rahmawati, Y., Fitriani, E., Sheffield, R., & Koul, R. (2018). Using a “makerspace” approach to engage indonesian primary students with STEM. Issues in Educational Research, 28(1), 18-42.

Halverson, E. R., & Sheridan, K. (2014). The maker movement in education. *Harvard Educational Review*, *84*(4), 495–504.

Klipper, B. (2014). Making makerspaces work for everyone. *Children & Libraries: The Journal of the Association for Library Service to Children*, *12*(3), 5-6.

Kurti, R. A., Kurti, D.A., & Fleming, L.I. (2014). The philosophy of educational makerspaces. Teacher Librarian, 41(5), 8-11.

Lee, Chung eun, Arnett, Heather, Samuel, Noah, Bievenue, Lisa, Ginger, Jeffrey, & Israel, Maya (2020). Towards an Inclusive Model of Makerspace Educator Professional Development: Implications for Students with Disabilities and At-Risk. ACM International Conference Proceeding Series: 9th Annual Conference on Maker Education: Making as Resistance and Resilience, FabLearn 2020. https://doi.org/10.1145/3386201.3386209

Meyer, L. I. (2017). Planning and implementing a makerspace in your school. T H E Journal, 44(3), 26-28.

Peppler, K., & Bender, S. (2013). Maker movement spreads innovation one project at a time. Phi Kappan, 95(3), 22-27.

Salmon, D., Rossman, A., & Dipinto, V. (2012). Knowing by doing and doing by knowing. Science Scope, 35(6), 70-74.

Seymour, G. (2018). The inclusive makerspace: Working with english language learners and special education students. In H. Moorefield-Lang (Ed.), School library makerspaces in action. Santa Barbara: CA.

Stake, R. E. (2006). *Multiple case study analysis.* New York: The Guildford Press.

Taylor, N., Hurley, U., & Connolly, P. (2016). Making community: the wider role of makerspaces in public life. In CHI '16: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1415–1425). Association for Computing Machinery. https://doi.org/10.1145/2858036.2858073

Willett, R. (2017). Learning through making in public libraries: theories, practice, and tensions. Learning Media and Technology, 43, 250-262.