MAkerspaces Promoting Learning and Engagement (MAPLE) Project Year Two Annual Report

09.2019

1. What are the major goals of the project?

The aim of this project is to answer preliminary questions about instructional strategies to support students with learning disabilities in classroom-based makerspace activities. It seeks to address the following research questions: (1) what learning barriers are present during the design-redesign and problem/project process common to makerspace and early STEM experiences, especially for struggling learners, (2) how can instruction that supports metacognitive strategies be integrated within typical K-12 classroom makerspace activities to address those barriers, and (3) how can the effectiveness of those strategies be evaluated by measuring engagement and learning. We believe this work is particularly salient given national efforts that inform DRK-12 research, such as the Reinforcing Education Accountability in Development (READ) Act, which stresses the development of comprehensive strategies to address key barriers to retention and completion (HR601).

2. What was accomplished under these goals?

2.1 Major Activities:

Major activities of Project MAPLE in Year 2 included continued definition and review of literature relevant to the problem space, new instrument development and refinement, focused observations and data collection, analysis, and dissemination. Significant progress and accomplishments have been made in Year 2 in terms of data collection as well as preliminary analysis of data in order to refine instrumentation and develop coding schema.

Instrument Development.

To date, the following types of instruments have been developed and piloted for both teachers and students: (1) classroom and activity observation rubrics, (2) curriculum and artifact analysis based interview guides, and (3) surveys to assess engagement. We also conducted focus groups with selected students and teachers during professional development. Supporting this process included review of existing tools, used primarily as coding exemplars, the construction of coding and terminology guides and sample protocols for work in the field.Several instruments and two coding schema (one for teacher data, one for student data) are available as a product in this report.

Observations and Data Collection

Year 2 data collection was focused on observing and defining evidence of specific metacognitive strategies related to persistence, iteration, and intentionality. Additionally, evidence of levels of engagement and non-engagement continued to be collected to further inform and define the context of barriers and learning.

Year 2 observations were limited to one STEM lab classroom and the Science classroom for two major reasons (1) observational access to specific students with learning disabilities and at risk for academic failure and (2) the teachers in the other two STEM classrooms experienced role changes and ultimately ended up leaving their positions before the conclusion of data collection. To help compensate for this loss of student access an additional after-school homework help and STEM lab data collection site was added. In addition to giving more access to at-risk students this site allowed our team to control several barriers to engagement identified in Year 1, allowing us to more directly compare learning experiences and outcomes as well as focus more on metacognitive processes.

Several iterations of data collection occurred at the beginning of Year 2 as the team explored how to best observe students in each classroom. The student observation protocol was assessed with the use of simultaneous screen capture in mind. The team focused more so on creating an effective direct student observation rubric that would identify the presence of specific metacognitive strategies. This search for specific strategies, however, was found to interfere with overall documentation of the student process and was discarded early in the process. Assignments as designed often did not typically present or facilitate opportunities for observation of intentionality or iteration so our team chose to investigate these through interviews instead. It was concluded that it would be more informative to record as many descriptive notes as possible for later contextualized analysis. In addition, because the observable metacognition was so sparse, the team began to focus on levels of engagement, including a differentiation of passive vs. active engagement, as well as passive vs. active disengagement. Once we could identify instances of various levels of engagement we could also align that with type of activity, associated supports or curricular scaffolding, the level of engagement among nearby students, and teacher intervention.

Teams of two or three observers (occasionally only one observer was available, but at least two were always planned) per day visited classrooms for a total of 137 classroom visits during Year 2, and observed a total of 20 unique students. During Year 1 learners with identified learning disabilities and students at-risk were not specifically targeted during data collection, but in Year 2 these students were explicitly identified and observation focused on evidence of benefits from metacognitive teaching strategies within makerspace experiences. During the last data collection period, when observers were following the same students on consecutive days, and over a three week period, students not identified as at-risk were also observed to serve as a comparison group. At the end of this final data collection period 9 students were interviewed either individually or as part of a focus group, adding to the 11 student interviews conducted earlier in the project.

In Year 2 teacher surveys were also introduced and administered to one of the participating teachers, and other teachers of the target students in that school. The survey targeted the teachers' perceptions of each student's attitude and achievement, engagement and participation in their classroom, the student's problem-solving strategies, the student's motivation, the teacher-student relationship, and direct rating of the student's persistence, iteration, and intentionality. The purpose of this survey used only at this school (where the majority of the Year 2 observation took place) was to compare the student's engagement, motivation and use of metacognitive strategies in their core classes (math, reading, writing, social studies, science) with their non-core STEM lab.

Analysis

Year 1 analysis focused on identifying systemic, pedagogical, and student-level barriers encountered by struggling learners during makerspace activities. Year 2 analysis shifted to grappling more directly with refining accuracy and effectiveness of data-collection instruments with increased emphasis on establishing validity through iteration and cross-comparison. The need for more targeted and robust data drove us to seek it in new ways; our team reworked the instruments to more appropriately work with the teachers, kids and assignments and restructured the coding guide a number of times to better match what we saw and in correspondence with our evolving definition of variables tied to metacognition.

Coding of student data began mid-way through Year 2 as an exploration of what types of evidence (indicators, connections, predictors) of use of metacognitive strategies (persistence, iteration, intentionality) we might be able to observe. Early analysis suggested that such evidence was sparse. The team struggled to look for ways to determine whether the strategies were not being observed because the strategies were not being used, or because the observation notes were insufficient, or because our definition and operationalization of the strategies was inaccurate. Senior research team members joined the classroom observation team and all observers began taking more detailed notes. In addition screen capture, with audio, was used to enhance the detail and completeness. This enabled the team to identify more instances of use of the target metacognitive strategies, but it was still an infrequent occurrence. Engagement was added as an observation goal, mainly as a result of the realization that if students are not engaged observation of *any* cognitive strategy was unlikely, and also because even minimal engagement is often a sign of persistence for struggling learners.

The shift to capture data on engagement led to an expanded coding guide. The research team iterated on the coding guide several times, reviewing and coding data, modifying protocols, refining the guide, reviewing and coding more data, and refining the guide. By the end of Year 2 the team produced a clear and concise coding guide that included engagement, accompanying terminology guide, and has collaborated in the effort to code, cross-code, and triangulate data to ensure reliability. This coding guide is being used to analyze the student observation, survey, and interview data. All data is being reviewed by a minimum of two research team members.

2.2 Specific Objectives

To support the iterative research development process we continually review and clarify approaches to address our main objectives that will form an empirical basis for future work:

Makerspace Curricular Choices

It is important to work with models of makerspace curriculum that are both accessible and comparable, so our study can yield results that are applicable for a variety of school settings. A major objective is to fit makerspace learning experiences into existing teacher-identified curricular needs and STEM subject areas identified in collaboration with our partner schools. Throughout Years 1 and 2, we have ensured that teacher objectives and interests, capacities and goals inform our chosen activities and have continually worked with them throughout the development and execution process.

Instrument Development and Adaptation

Multiple instruments have been used to measure pertinent metacognitive processes. Instruments included student observation protocols, teacher observation protocols, screen capture protocol, a teacher interview protocol, and an artifact-based interview protocol. Persistence (attitudes about making) and iteration (productive struggle) were observable through student observation (both direct observation and screen capture) and artifact interviews. Intentionality (planing with incremental steps) was difficult to observe, but was somewhat observable through student interviews and artifacts (e.g., worksheets and written descriptions of projects).

Observations and Pilot Study

In pre-pilot activities (Year 1) more than 50 classroom observations were analyzed in order to determine barriers to successful implementation of classroom-based maker activities, barriers to student engagement and academic achievement, and to refine instruments that document and measure target metacognitive strategies. We cultivated initial support structures, such as co-constructed makerspace activities, and accompanying strategies to facilitate increased engagement and learning for students at risk for academic failure. We then piloted the implementation of these metacognitive strategies to iteratively refine them throughout Year 2. We also adjusted objectives slightly, as well as our timeline. In line with our original plan to collect data in Year 2, we committed to student observation as the main goal, with less of a focus on teacher and classroom observation. Notes were still kept on teacher interventions and interactions with students, but the main focus was on how the teacher interacted with the student being observed. During Year 2 we narrowed the scale of our sample and focused on students with learning disabilities and/or at risk for academic failure. The timeline of observations was slightly changed in that we started with minimal observations while the teachers were adjusting their curriculum and adapting to new strategies they had learned during the professional development and pushed back the full pilot and student observation schedule to the middle and end of the school year. Project staff worked with the teachers to implement activities that would improve the possibility of the research team being able to observe the target metacognitive strategies. For example, we strongly encouraged the teachers to incorporate pathways for iteration and student choice into their assignment requirements.

At the end of Year 2, there have been enough rounds of data collection and analysis that it will allow us to address the project-related research questions about the relationship of strategies that support metacognitive learning within school-based makerspace activities. This data is also being used for continuous instrument refinement purposes. The intention is that these progressive observations and studies will result in a revised set of metacognitive strategies and support materials for implementing making experiences for struggling learners.

In summary, the types of data collected and analyzed in Year 2 include:

- Transcriptions of classroom observations of students,
- Transcriptions of student interviews
- Transcriptions of student focus groups
- Photovoice artifacts
- Screen capture video
- Artifacts (projects and worksheets)
- Student grades
- Teacher surveys

Artifacts, screen capture video, student interviews, and observations were aligned by student and date in order to create a comprehensive snapshot, as well as progression, of a particular student's work. This aligned representation of the student's work was then used to refine and calibrate a coding framework to be used across all data.

Communication and Dissemination

Dissemination efforts have included:

- Preliminary research findings and sharing of data collection methodology via conference presentations.
- Research briefs that describe components of our work in progress.

Other dissemination efforts still planned include:

- Websites with curricula and strategies, alongside other resources associated with our project.
- Research findings via presentations and publications in peer-reviewed practitioner and research journals.
- Workshops with key middle school makerspace educators with academic and vocational partners, such as the FabLearn community of scholarship or University of Illinois Extension 4H Educators.

2.3 Significant Results

Year 1 revealed several conclusions about barriers to classroom-based makerspace activities, and how teachers engage in and choose makerspace learning activities. These findings led to changes in instrument formulation and implementation in year 2, especially for teacher professional development and the inclusion criteria for makerspace activities and metacognitive learning strategy supports within classes.

Teacher Factors

Observations revealed that ***teachers may initiate some metacognitive strategies with struggling learners, but they often appear to be coincidental or disassociated rather than planned and integrated***. Teachers were not observed articulating steps used to carry out strategies like scaffolding, using failure as a learning opportunity or engaging in open-ended, learner-driven practices to support increased participation or planning processes. In the case of the STEM lab classrooms learners did not have consistent review or documentation of ties between activities and conceptual knowledge. Lesson plans were often not consistently present, and while one of the school districts provided "guidelines" for the non-core STEM class, which is comprised of many makerspace activities, teachers tended to choose thematic units where students were limited to reading from handouts and project worksheets without identified connections to standards or learning goals. The formal science classroom teacher did exhibit some use of metacognitive strategies in instruction, but few activities were generative, maker-oriented projects and instead took the form of more restrictive guided experiments and other classic science workshops.

The foundational aspect of makerspaces and the keynote metacognitive strategy of play leading to intentional and iterative tinkering were largely absent in the classrooms, thus student engagement varied considerably. Disengaged students demonstrated a range of behaviors, from passive resistance to activities to disruptive behavior that affected the entire class. Possible factors that may be responsible for this lack of engagement and metacognitive strategies include:

- ***lack of teacher awareness and training around metacognitive strategy*** and the deeper foundational underpinnings that support these processes.
- ***attitude and openness*** of teachers who are used to a specific set of assignments and expected learning outcomes, or whose presentation of subject material may not be in alignment with student interests and cultural backgrounds.
- ***lack of internal systemic supports and peer networks*** that encourage quality teaching and shared learning practices as well as emotional support and connectedness that may come with being a member of a community of practice.

It is important, when considering the research questions, to be aware that each of the teachers involved in this project operates in "isolation." The ideas behind STEM education and makerspaces are new to a high percentage of their colleagues. Reflections and observations during teacher professional development supported these conclusions, detailed in the Year 1 report.

The team worked to address these barriers through summer teacher professional development at the end of Year 1 in a week-long professional development workshop included sessions on teaching techniques, tools and curriculum design. In addition, project staff met regularly with teachers to make suggestions for scaffolding and engagement strategies to support metacognitive strategy growth. Unfortunately, preliminary analysis and discussion of classroom observations suggest that these efforts did not result in significant change in teacher practice. It is also important to note that only two teachers (and their students) were able to be regularly observed during Year 2 as their changing roles, interests and eventual departure from two schools curtailed opportunities for data collection.

Classroom Factors

In half of the classrooms participating in Project MAPLE, environmental conditions did not facilitate the establishment and perpetuation of makerspaces and a community of makers. ***Space is limited, classrooms may be removed from the larger school community, may be ill-equipped to facilitate the set-up required of a true makerspace, or may be situated in "pass-through" areas with frequent interruption.*** These types of disruptions are especially frustrating to students with learning disabilities and at-risk. Some classrooms struggle with a lack of resources to carry out effective maker activities and teachers do not receive funding that allows for adequate preparation and hands-on experiences.

It also became apparent during the 50 observations conducted by the team in Year 1, as well as the 137 observations conducted in Year 2, that few of what the literature defines as making experiences were occurring in classrooms. Contrary to the literature ***we did not see an alignment of standards-based assessment and the Maker Movement*** that would foster creative solutions through innovative design (Bajarin, 2014). There was not the presence of a combination to both encourage problem-solving, project-based learning, design solutions, student agency and autonomy, and high levels of hands-on engagement (Martin, 2015).

Systemic Factors

Classrooms were faced with rising numbers of students and classroom environments were rarely structured for makerspace activities. Teachers in the non-core STEM classes expressed a sense of frustration because they were ***not well-supported by administrative bodies or policies***. The Project MAPLE PI's met with school administration at the beginning of Year 2 to discuss this issue and were presented with an alternative presentation of the scenario, one in which the administration was attempting to be more supportive, but was hampered by a lack of effort on behalf of the teachers. To our team this indicated a lack of trust and sharing between administrators and teachers. Conversely, the formal science classroom initially had significant support from school administration during Year 1, but a total changeover of most of the administrative staff due to outside factors in Year 2 made it difficult for this teacher to gauge levels of current and continuing support at the time. The teacher was generally not under any threat, but had little incentive to pilot a lot of new curriculum that would rock the boat.

We also discovered in Year 1 that teachers in makerspace classrooms find themselves in somewhat ***tenuous positions in regard to performance standards*** linked to their personal evaluations. The standards in the makerspace classrooms fall under district standards for engineering process and computational thinking including decomposition, pattern recognition, abstraction and algorithms. However, in both districts teachers' personal evaluations are affected by the percent achievement gain of their students as a whole. Many of these classrooms serve students that "don't fit elsewhere" like music, art or drama. The classrooms have disproportionate numbers of students at-risk of failure or with identified learning challenges. This results in a tension between just helping students to get through school and holding them to higher learning standards or expectations.

Barriers that might be overcome may continue due to school policies and expectations. Large class sizes and short durations (both in terms of daily periods and systems like quarterly rotations) exist as tremendous global obstacles to project-based, iterative learning. Makerspaces are active learning environments typically conceptualized as "doing" spaces. Students are not expected to sit quietly in rows and absorb information. The need to balance student freedom to learn in an experiential manner is sometimes challenged by their behaviors and what is acceptable in more traditional learning environments.

Many of our findings seem to match tensions identified by other researchers as more publications on the impacts and possibilities of school-based makerspaces becomes available, in particular the suggestion that "schools start that start a maker curriculum need to undertake cultural and epistemological changes to what they see as a STEM learning." (Campos et. al 2019, Tan 2018).

2.4 Key outcomes or Other achievements:

The week-long teacher professional development workshop held at the Champaign-Urbana Community Fab Lab (summer 2018) initially appeared to be successful in modifying teacher attitude and intention and the research team learned some important lessons as well. Teachers were administered a pre- and post- questionnaire. Responses appeared "modest" and general in the pre-questionnaire. For example, in response to the question "What are your goals for this week of professional development?" teachers responded with general interest in learning new things and " 'tricks' to get students motivated to take ownership in their learning.

In the post-questionnaire responses demonstrate enthusiasm and reflect positive learning experiences. For example, one teacher stated "I wanted to get an idea of technology I can use in my new makerspace, and boy did I get it! I have pages of notes with ideas and ways to implement it which is a huge bonus!"

Also, after the workshop teachers demonstrated positive intentions for modifying their teaching based on topics covered in the workshop:

- I've gotten a lot of ideas for changing the curriculum I plan to teach. The UDL chart will also be my best friend when planning (and hopefully before doing)
- More creativity and fewer "cookbook" projects
- Be more tech-based; have videos to reinforce/introduce ideas. Have more opportunities for student choice
- More purposeful alternative assignments/activities for these students
- Let the students have more input

However, despite the very positive intentions and enthusiasm, teacher participation and commitment to the newly learned strategies was minimal in Year 2. For instance, the STEM lab teacher took up several new maker related technologies and developed new activities around them, but without much regard for the way that they were taught. The primary science classroom teacher integrated 3D printing activities, but into an assignment that was already largely iterative and prebuilt with elements to encourage intentionality in mind.

2.5 References Cited

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3. What opportunities for training and professional development has the project provided?

This project supported two opportunities for professional development for participating teachers and graduate research assistants. One was a week-long workshop led by the MAPLE project team at the Champaign-Urbana Community Fab Lab. This workshop focused on making, design, and educational topics related to teaching struggling learners and students with learning disabilities. A second opportunity was the Maker Educator Collective Bootcamp at the Pathfinders Summer Institute 2018, held at Indiana University Bloomington and sponsored by Infosys Foundation USA and others (http://www.infosys.org/infosys-foundation-usa/pathfinders/#maker-educator). One teacher also participated in the 2019 Pathfinders Summer Institute and another presented in collaboration with a MAPLE RA at the 2019 National Science Teachers Association conference.

3.1 Fab Lab Workshop

Goals for this professional development week (July 23-27, 2018) with all participating teachers (4 middle school teachers) and 1 school technology coordinator included:

- Focus on teaching methods, specifically those that most impact LD and at-risk student populations including Universal Design Learning, Culturally Responsive Teaching, Positive Behavior Coaching
- Learn it + Teach it and the methods of Do It Yourself (DIY) + Do It with Others (DIWO)
- Maker technology implementation plan
- Sustainability of makerspace learning through district administration with diminishing reliance on the University and/or grant support over time

Topics

Key presentations and sessions called upon professors and experts from many units at the University of Illinois included the following:

- Core Principles to Promote Learning in School-Based Makerspace. How do we attain our goals?
- Overview of barriers to student success on maker activities; how our own classroom observations are reflected in the literature, led by graduate research assistants Cheng eun Lee and Noah Samuel
- Positive Behavior Support Coaching, led by Gakyung Jeong (Ph.D. student in special education)
- Universal Design Learning (UDL), led by Drs. Lynn Burdick and Johnell Bentz (staff in educational technology and faculty in special education)
- Integration of hands-on making activities teachers can immediately use in the classroom that address district performance guidelines, e.g., Makey-Makey, Little Bits, experience with FabLab deployment kits; led by graduate research assistants Heather Arnett and Dot Silverman, and PI Ginger
- Creativity and Playfulness; Ken Robinson's premise that schools kill creativity, overviews of observations reflections on Positive Behavior Coaching, 3-D modeling tasks, importance of modeling and mentoring of teaching staff.
- Accommodations for at-risk or LD students, led by Dr. Johnell Bentz
- District level involvement and support of makerspace classrooms
- Cultural Relevance in the design and implementation of makerspaces, led by Dr. Will Patterson

Makerspace Activities

Teachers participated in Makey-Makey electronic controller design activities, allowing them to practice in an open learning environment. Activities ranged from construction of circuit boards in novel ways, e.g., a bracelet, dinosaur games, control boards, remixing functions like music, bird sounds...to activities like constructing a music controller keyboard. This could be used for children with functional learning skills and other students with disabilities. As they engaged in activities teachers asked questions and raised issues related to assessment, inquiry, collaboration, persistence and requisite knowledge

Universal Design Learning (UDL) Session

The UDL presentation was titled "UDL Curb Cuts for Learning." The expert presenters focused on the importance of UDL providing access and opportunities for learning. UDL also addresses the civil rights of those with disabilities. The group was asked to consider the principles and practices of UDL with its curriculum that demonstrates equal opportunity, a flexible approach, and a blueprint that works for everyone.

Cultural Relevance of Makerspace Learning Session

Makerspace teaching should be culturally responsive teaching. Makerspaces draw a highly diverse group of learners of different backgrounds. Different learners require differentiated instruction principles that links content-delivery to assessment-with students' ancestral and contemporary cultures. Two experts presented on cultural relevance, innovation, entrepreneurship and the ways makerspace learning can lead to careers in engineering, business, art and technology. Teachers were encouraged to contextualize learning methods that draw diverse groups of students to re-think learning outside the realm of traditional schooling and to draw from a variety of disciplines to address contemporary issues impacting student's communities and environments around the world.

Supporting Makerspace Classrooms

The week of professional development offered teachers the opportunity to work as individuals or in small groups with staff to plan the feasibility of new projects and approaches in the classrooms. Teachers were invited to explore the FabLab and look at tools and resources they already have or may acquire for their classrooms to enhance making for every student. Each teacher was able to meet with the PI to discuss needs, budget allotment, and planning. Teachers have funds to purchase new tools and resources. Planning and discussion of possible uses facilitates the wise use of funds and allocates funds that can benefit all students, not a select few. Project MAPLE staff were available throughout the days with ideas and hands-on experiences that teachers could quickly learn, make and replicate in their classrooms. Out of the box thinking was encouraged.

3.2 Maker Educator Collective Bootcamp

Two project participants were able to attend this bootcamp at the end of Year 1, one teacher and one graduate research assistant. They shared their experience and materials with the project team at the week-long Fab Lab workshop described above. Sessions included demonstrations and practice on prototype activities, and topics on pedagogy such as Why Making, Visible Thinking Routines, Integration of Content, Digital Design, and Assessment.

4. How have the results been disseminated to communities of interest?

Three conference proposals have been accepted and presented to disseminate findings from the project (Teacher Education Division of the Council for Exceptional Children, TED-November 2018; the National Council for Exceptional Children, CEC-February 2019; and the National Science Teachers Association, July 2019). Additionally, a manuscript, "Understanding instructional challenges and successes to including middle school students with disabilities in makerspace activities: A cross-case analysis", was completed in the fall of 2018 and is being used as a basis for new paper submissions, one which was turned down (FabLearn, April 2019) and one which is currently under peer review (Council of Exceptional Children Conference, February 2020).

Project MAPLE was presented both during the proposal and Year 1 stage at the University of Illinois iSchool Research Showcase as an academic poster. See Ginger, J., Israel, M., Teasdale, R., Bievenue, L., Linder, S., Bentz, J. (2016-17). "Towards a Progressive Model for Metacognitive Strategies and Makerspace Learning." iSchool Research Showcase, UIUC, 10.2016-17 and Ginger, J., Bievenue, L. (2018). "Research Models and Methods to Assess Learning Outcomes in Makerspaces in Formal and Informal Education Settings" iSchool Research Showcase, UIUC, 10.2018. The project was featured as an evaluation technique shared in parallel with a demonstration at the FabLearn conference. See Ginger, J., Butt, E., Kumaran, A. (2019). "Iterative Learning With Lithophane Light Boxes." FabLearn 2019, New York, 03.2019.

In addition, the MAPLE grant team presented on the project research design and in-process data collection instruments at a full day workshop at the Museum of Science and Industry

(MSI) Wenger Family Fab Lab in Chicago. See http://cucfablab.org/research/project-maple/ for the presentation.

Other dissemination efforts include: the development of a project website (http://cucfablab.org/research/project-maple) and dissemination of research findings to participating teachers as part of the summer 2018 professional development.

More dissemination is planned for the final no-cost extension year, including research briefs of lessons learned and research papers.

5. What do you plan to do during the next reporting period to accomplish the goals?

As we enter no-cost extension and final year of Project MAPLE, the primary plan is to complete the coding of data, analyze data, and disseminate results. Our task is to concentrate on further investigating our research questions and examine what has been evidenced through data collection and research literature. Our goal is to assemble a "microcosm" of high quality practices aligned to the theoretical and empirical framework on Makerspaces in K-12 teaching and learning with the most current theories of impacting and building successful learning designs for children with learning disabilities, at-risk, and all others. To do this we ask the following questions:

- How might barriers observed in Year 1 be addressed to facilitate success??
- What opportunities are there for new interventions, strategies and possible relationships between professional development and positive change in STEM classrooms?

5.1 Research Design

- Develop preliminary identification of which metacognitive strategies support student achievement in classroom-based maker activities, and how those strategies can be adopted by teachers.
- Disseminate instruments that will help to measure metacognitive strategies and how student engagement and learning can be measured.
- Disseminate how instruction that supports metacognitive strategies can be integrated within typical K-12 classroom makerspace activities to address barriers.

5.2 Communication and Dissemination

- Publish a website with curricula and strategies, alongside other resources associated with our project, such as research briefs that describe our work in progress and provide sample data collection instruments.
- Draft at least two papers based on the findings from Year 2: one to be presented at the annual meeting of the Council of Exceptional Children (https://cecconvention.org/), and one to be presented at the annual meeting of FabLearn (http://fablearn.org/conferences);
- Plan future professional development for those interested in accessible middle school makerspaces for diverse learners, based on MAPLE experiences and CU Fab Lab expertise for bringing accessible and engaging makerspace instruction to broad audiences.