Madeira City Schools

STEAM @ Madeira

Dave Bergan, Shawn Dickess, Rachna Gajjar, Betsy Henning,
Charlie Ritchie, Brett Starr

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Introduction

STEAM education, which involves a collaborative mix of Science, Technology, Engineering, Art, and Mathematics, is vital to our future. STEAM education programs are changing the classroom landscape for today's students. Schools and educators who incorporate STEAM education are shaping the everyday experiences for today's children, preparing them to be excellent problem-solvers, creative collaborators, and thoughtful risk-takers.

When looking at the future job market and considering the types of roles our future workforce will need to fill, STEAM education is of extreme value. A recent Georgetown[1] University study on job growth and education requirements in the workforce through the year 2020 found that nearly 55 million jobs could go unfilled due to skill gaps, mainly in the fields of healthcare S.T.E.A.M. -related fields. As more educators and lawmakers consider these statistics, S.T.E.A.M. education continues to be embraced and implemented into curriculums and lesson plans.

Even more, in a constantly-changing world, the importance of creativity in the workforce is getting more and more attention. That's why art programs are essential in the STEAM learning process. Employers are in need of more STEAM capabilities in the job market, universities emphasize the latest trends in job need; meaning our public schools must keep pace with the demand for STEAM skills.

Current State of STEAM @ Madeira

During the 2018-19 school year, Madeira City Schools started to design a new STEAM special for students in grades K-4 at Madeira Elementary. As a part of this work, the team completed the renovation of a classroom and launched a once a week special opportunity for all students at Madeira Elementary during the 2019-20 school year. Students also have the opportunity to take a Project Lead the Way elective course in grades 6 through 8. The goal of this study is to provide

[1] https://cew.georgetown.edu/cew-reports/recovery-job-growth-and-education-requirements-through-2020/

recommendations and resources so the district can continue to expand and revise it's opportunities for students and staff in the areas of STEAM..

Design Thinking

Design Based Thinking is a human focused method of problem solving. Design Based Thinking strives to put the consumer at the focus of the problem-solving activity. At its core, Design Based Thinking leverages positive ingenuity and determination to identify and solve problems. Design as a professional discipline has undergone an evolution from being mainly focused on aesthetic style to an explicit focus on the "user". By establishing empathy with the user, designers can work toward outcomes that meet those needs more successfully.

The design thinking process, with its emphasis on iterative rapid prototyping, portrayal of mistakes as learning opportunities, and mantra of "fail early and often" stands in stark contrast with the typical high-stakes, failure-averse culture of the classroom. Educators laud the process as a way to teach integrative STEM curriculum, foster 21st century skills, and engage students in constructivist learning. (site marks study) Design based thinking has the potential to instill persistence in students when the problems faced are vague and require determined experimentation.

Design thinking looks to empower 8 core abilities[2] that lead to creative problem solving from the users perspective. The first core ability is to navigate ambiguity. A frequent challenge when working with people is the lack of certainty around what is needed, what is working, what to do next. Design Thinking acknowledges this ambiguity and certifies it to be normal to be uncertain. Design tactics are tailored for persisting through and overcoming the ambiguity of defining the challenge. Design is loaded with uncertainty. As a result, it involves being present in the moment, re-framing problems, and finding patterns in information. Ambiguity can arise in many places – within a project, a process, or within oneself. It's important to put students in ambiguous situations and give them tactics to emerge from them.
How does a team implement Design Based Thinking? The principles of design based thinking call for flexibility and innovation focused on the customer. First and foremost, focus on user outcomes. Choosing to prioritize the tasks to be done around the needs of the end user is the first step. Leveraging multidisciplinary teams is another key aspect. Start small, prototype everything to determine the best next step. Each next step becomes a small "step" removing fear from failure and paralysis by analysis.

The next core ability that Design Thinking empowers is to learn from others. Diverse viewpoints allow for a team to triangulate on the best answer. This means empathizing with and embracing diverse viewpoints , testing new ideas with others, and observing and learning from unfamiliar contexts. Throughout a design project, it's important to recognize and take the opportunity to learn from others–both end users and other stakeholders and team members. There is a sensitivity to others that develops with this ability.

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[2] https://dlibrary.stanford.edu/ambiguity/the-8-design-abilities-of-creative-problem-solvers

Another core ability from Design Thinking is to synthesize information. There is so much data and information available, a key ability is cutting through the minutia to the salient points. Data comes from multiple places and has many different forms, both qualitative and quantitative. This ability requires skills in developing frameworks, maps, and abductive thinking. Synthesis is hard for new students. It takes time and is interdependent with navigating ambiguity.

Through the Design Thinking approach a student learns and masters the core ability of rapid experimentation. This ability is about being able to quickly generate ideas – whether written, drawn, or built. In order to rapidly experiment, you must be able to relax your mind and reach a mode of acceptance. This will eliminate the natural tendency to block ideas that seem off or unfeasible. Then, let your doing lead your thinking – and lead with your hands. This ability pairs naturally with Learn From Others. In many instances, you are experimenting by both generating a flood of new concepts at low resolution (brainstorming) and testing some of those concepts with potential users.

Furthering the core abilities is the navigation between concrete and abstract. Many aspects of learning will move between the tangible and intangible. Design Thinking embraces the conflicting views. This ability involves understanding stakeholders and purpose in order to define the product or service's features. Everything is connected. When students are building out a new concept –whether a product, service, or experience – they need to be able to nest the concept within the larger ecosystem that relates to it. It involves abstraction to define meaning, goals, and principles, as well as precision to define details and features.

One of the foundational core abilities is to build or craft with purpose. A key tenet of Design Thinking is to begin prototyping early and often. This ability is about thoughtful construction: showing work at the most appropriate level of resolution for the audience and feedback desired. There are many sub-disciplines of design, each with their own set of tools and techniques. This ability requires a sensitivity to the tools needed to create meaningful work in your domain. UX designers have a specific set of tools to create human-centered digital interfaces. Architects have an arsenal of particular techniques to bring new structures into the world. Every discipline – immunology, macroeconomics, K12 education, whatever it may be – has its own building methods, and in every case, the details matter.

The iterative prototyping process puts a premium on storytelling. Communication is key to keep all parties in the loop when working with diverse teams and with less formal rigor. Communicate deliberately is the ability to form, capture, and relate stories, ideas, concepts, reflections, and learnings to the appropriate audiences. Communication happens in a variety of contexts. It may include reflecting on your performance to a project team or crafting a video or many other medium and methods.

A final key ability out of the Design Thinking process is that the students learn to frame challenges as Design problems. This meta ability is about recognizing a project as a design problem and then deciding on the people, tools, techniques, and processes needed to tackle it.

This ability develops with practice. We see it emerge in our more experienced students. It requires using intuition, adapting old tools to new contexts, and developing original techniques to meet the challenge at hand.

Design thinking is not a "one and done" approach but instead has a continuous loop of confirming outcomes with users perspectives. For this feedback to be unbiased assumptions need to be set aside and we must immerse ourselves in the users environment. Where does she sit? How does he access the information? What screens are observed? Literal immersion in the customer's world builds empathy to discover their key needs and the real definition of success. During the end user immersion we are identifying the key needs of our customer, the struggles and their definition of success. Reflection during the end observation is where rigor and ritual help flush out the problem statement. The reflection is the springboard to begin prototyping solutions to the identified problems.

A frequent term for the desired end user outcome is hill. H[3]ills are the complex problems or desired resolution for the user. The hill is comprised of a who, what, and wow. The "who" represents the user or user group. The "what" is the desired outcome or enablement for the user. Finally the "wow" is a measurably method of determining the success of the "what". A student (who) desires the ability to speak Spanish fluently (what) which is measured by their ability to hold a conversation with an exchange student (wow).

The Stanford Design school[4], referred to as the d.school has a recommended approach to piloting a Design Thinking based sprint in schools. The school's mission is "*is to develop students who believe that the world can be a better place and that they can be the ones to make it happen*." The thought of design thinking schools presumes teachers are considered learning experience designers which means incorporating the design thinking mindsets into the teaching

crafting (i.e. curriculum, space, rituals, assessment etc). In addition, as teachers can play a significant role in school-level design through Design Sprints. The d.school believes that design think design sprints help both teacher and student alike.

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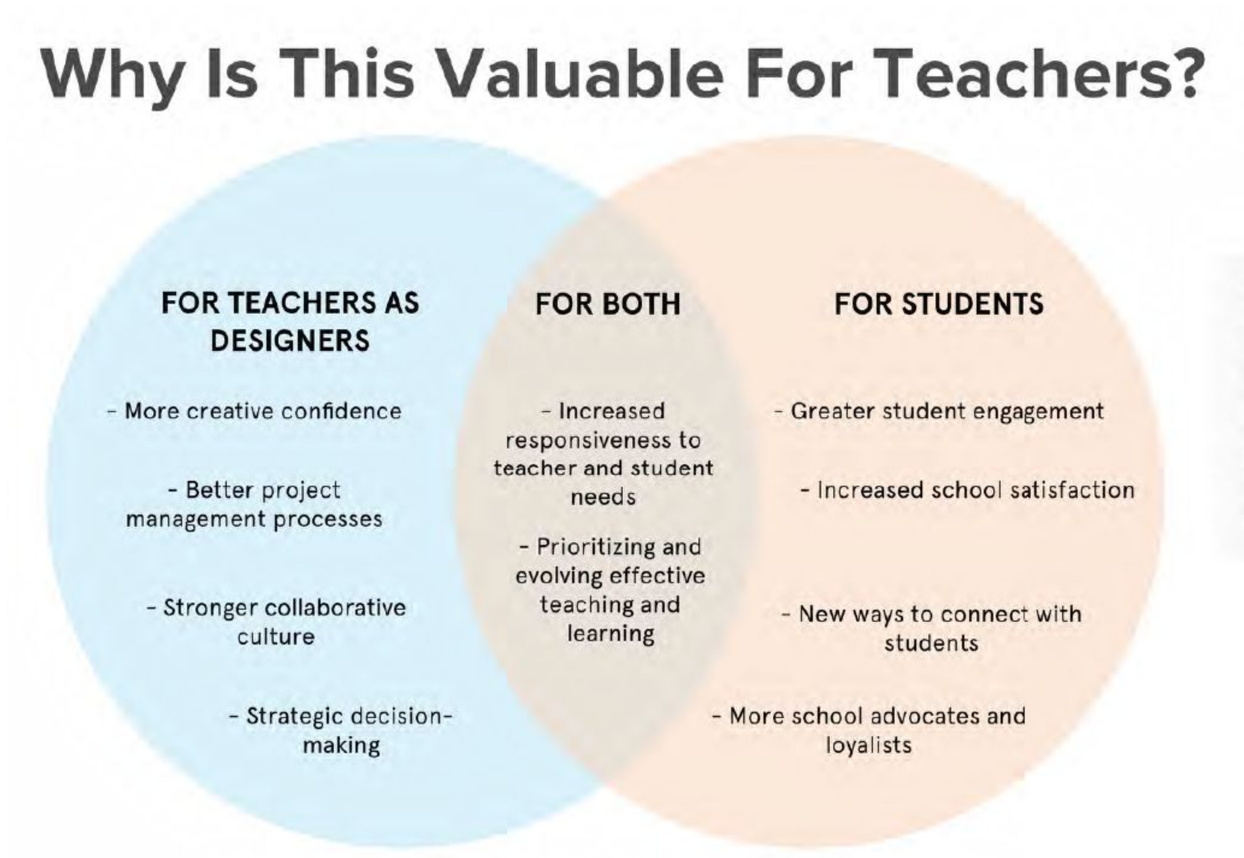
[3] https://www.ibm.com/design/thinking/page/framework/keys/playbacks

[4] https://dschool-old.stanford.edu/sandbox/groups/k12/wiki/ad2ce/attachments/3946e/DESIGN%20THINKING%20PLAYBOOK%20%281%29.pdf?sessionID=8cbdfc6129ceb041dbad2247ffc9d0112fd0ebce



Stanford school's K12 Lab developed a 6-week Design Sprint to help schools use the Design Thinking process to get started, get unblocked, and develop new directions for their various change management initiatives. The sprint is simply a series of steps that alternately flare and focus. The sprint starts by working with the leadership team to determine a specific challenge to work on. Then expands our understanding of the space by engaging with users like students and teachers. The team will then focus by refining our problem statement. After that, it's time to explore many possible solutions to this problem in the ideation phase. Then back to focus work by deciding on one to three solutions to explore in depth. A key is to then prototype and validate the ways those ideas can manifest by getting feedback from our users.

There are mindsets that thrive in Design Thinking, a key aspect of any educator leading a design sprint is that he or she has the following mindset(s):

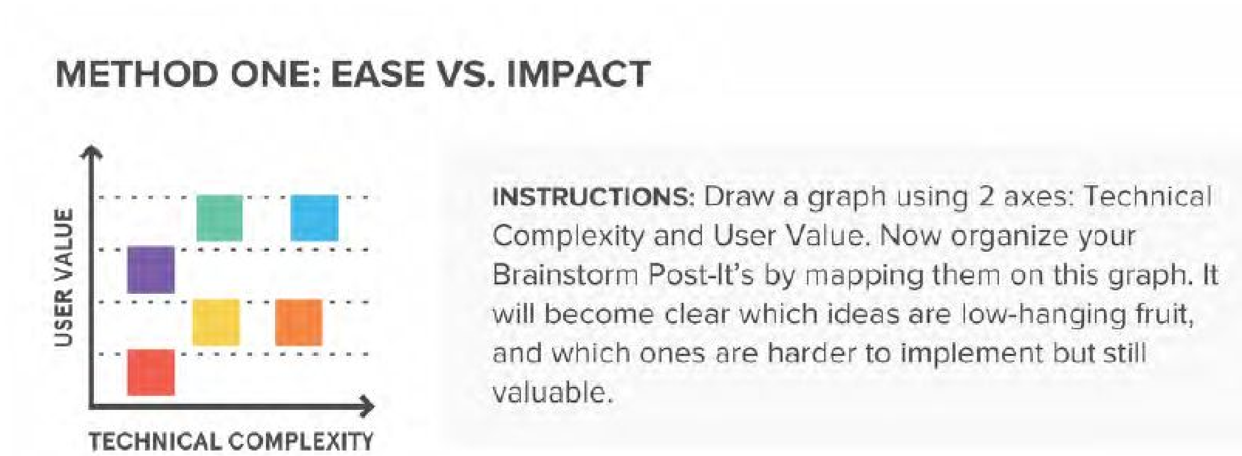
- Focus on Human Values
- Radical Collaboration
- Be Visual
- Bias Towards Experiment over Theory
- Defer Judgment

Design sprints begin with research. Many problems we face (such as teaching algebra) have been tackled before, knowing what others have tried is valuable in brainstorming. Questions such as: Who else is already doing this in our space, and what can we learn from them? This research is helpful as the challenge at hand also needs to be articulated in a problem statement. A statement of the issue at hand that has been reviewed in detail by the team with discussion removing any ambiguity or assumptions from the meaning of each word. (There is a decent amount of jargon that needs explicitly agreed for definition.) We are now ready to interview our users.

How can an educator tell if she is serving her students' needs (student is the user)? She talks to them often. Interviewing is one of the most effective methods of Empathy (a key design thinking tenet). To effectively conduct interviews, one should avoid Leading Questions, and ask questions that move from Open-Ended to Specific to get the data needed. It is good to have a hunch of what your user(s) will say, but the goal of the interview is not to confirm our biases but to surprise us and enlighten us. Asking students to explain the concept back in their own words is a great start.

A common approach to brainstorming with the students on problem solving is do use a technique called "How Might We". Questions are worded as "How Might We" because it encourages imagination, exploration and is ultimately solutions oriented. "How Might We" questions lead to more comprehensive brainstorming sessions. Brainstorming is a way of generating lots of ideas to be prototyped. All should be encouraged to think expansively without constraints. With careful preparation and a clear set of mindsets and guidelines, one brainstorm session can produce many ripe
ideas.

After brainstorming ideas, it's important to decide which ones to prototype. This may be difficult if there are a lot of good ideas to choose from. There are two primary methods research has found helpful: Ease vs. Impact is more formal whereas Pick Your Fancy is more loose.



[5]

Prototyping should be done with low tech artifacts, focusing on speed and validation of a premise over fit and finish. The goal is to maximize your rate of learning by starting with low-fidelity artifacts or experiences that can elicit user feedback quickly, then slowly move on to higher fidelity prototypes to refine the solution. The design thinking process is not always linear. To validate the efficacy of the prototype, testing cards are employed. In order to be intentional about our prototypes, it is important to note the hypotheses (assumptions being made), the questions the team is trying to answer, and the pass/fail condition(s) for the prototype. By having these three things in mind, prototypes can be an excellent way to learn. To use the card, fill one out per prototype by simply following the prompts.

- We believe that…
- To verify that we will…
- And measure…
- We are right if…

We can then collect feedback from our users and land on the best path forward for our solution. Design thinking engages high frequency collaboration between student and teacher to creatively solve problems.

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[5] https://dschool-old.stanford.edu/sandbox/groups/k12/wiki/ad2ce/attachments/3946e/DESIGN%20THINKING%20PLAYBOOK%20%281%29.pdf?sessionID=8cbdfc6129ceb041dbad2247ffc9d0112fd0ebce

Makerspace

Summary of Findings

Seven Hills School: this facility is aspirational in terms of budget and footprint. However, many of the best practices were consistent with what we saw in other schools and in research.

Elementary K-5

- No dedicated Space - STEAM integrated into classroom activities

Middle School 6-8

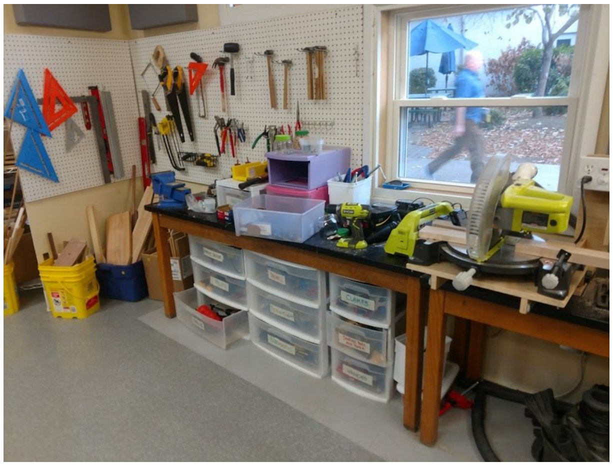
- 6th and 7th Grades – required course. 8th Grade – elective.
- Dedicated Space – 2,000 SF - impressive in terms of layout, materials and tools
- Space is available for drop-ins during recess, IET
- Materials - range from paper towel rolls, to paint, tto programmable robotics
- Tools - range from sewing machine, to power tools, to 3D printers

High School 9-12

- Spaces incorporated into physics, engineering and other classes (theater)
- Lab has 3D printers (variety of materials) and laser bed etcher / cutter

Dedicated workstations with software (software becomes critical decision)

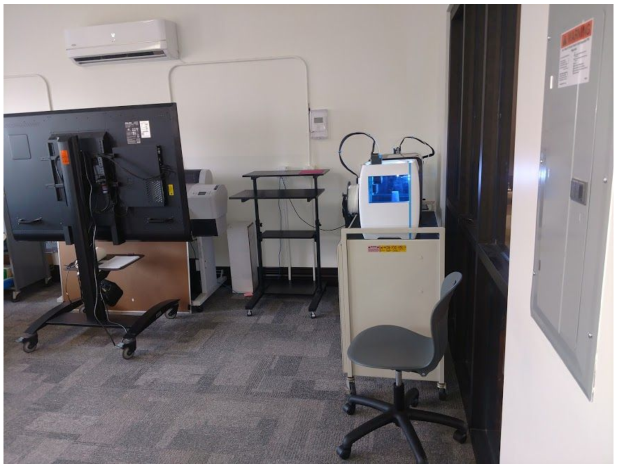
Gallery - Seven Hills Middle School: Clockwise from upper left - Small percentage of storage space, , power tools, portable white boards.



Nativity School: this facility is newly built and faced some of the same constraints as Madeira in terms of space available, budget, etc. A key facet of this space is flexibility in terms of use and layout – coupled with a dedicated (lockable) section for expensive printers and supplies.

- 400 SF Dedicated STEAM Space - printers, workstation, other project storage (locked)
- 600 SF STEAM Space may flex/share with other school needs
- Tools:
  - Storage lockers – many
  - Qty 2, 3D printers
  - Poster printer
  - TV Screen / monitor

Gallery - Nativity School: Clockwise from upper left - Flexible maker space (currently being used to display school items), Dedicated space, View from Maker space into broader "Learning Commons"



University of Cincinnati: this facility was explored to determine whether our Madeira program would lead toward preparedness for the next level.

UC's facility is located near campus and is partially funded with corporate partnerships (major corporations in the region).

Our goal in touring this facility was to gage where our program needs to lead. Are we providing a bridge for students to be prepared for this level? Emulating this facility is not practical

Space is huge: ~4,000 SF

Installed equipment

- Banks of 3D printers – recommended models were Multimaker
- Laser bed cutter / etcher
- Dedicated computer workstations
- Woodworking shop (multiple unit operations)
- Multi-axis metal milling machines (3) with Staff knowledgeable re operation and maintenance

Gallery - University of Cincinnati: Clockwise from upper left - Sewing machines, Bank of 3D printers, Metal milling machine (with spindle probe), Layout of open maker space.

Other Lessons Learned beyond the Maker Spaces themselves:

- **Staff** – passionate about STEAM is required and available in the room
  - Especially needed if goal is to offer a drop-in space for students to explore, retry, learn
- **Cultural Impact:**
  - Service projects
    - Middle school kids create games for Elementary kids
    - Also create solutions for challenges faced by members of our community (refugees, alzheimers, etc.)
  - A place for “Tech Kids” to go / and hang out
- **Re-Loop:** It is critically important for kids to re-try / revise their designs based on what they learn.

Deeper Dive

A. **Specific Guidance** from Each School

Nativity

- Recommended going after a STEM certification - similar to Blue Chip as achievable certification which helps with marketing of our school system.
- Keep a locked space for expensive materials or delicate equipment

Seven Hills

- Don’t fear the power tools: Scroll saws, dremels, drills, soldering, etc.
- Do value “trash” paper towel rolls, bits of paper, etc.
- Portable white boards (30” x 20”) work best - hang on rack when finished
- 3D printers and Robotics are great (Spere O’s, Micro-bits which control Hummingbirds) but don’t lose focus on design learning.
- 3D printers - ensure they ventilate to outside
- Use power drops from ceiling vs. “hard positioned” to enable flexible work space
- Sewing machines and materials are heavily used

B. Some **consistent messages** were heard at the school systems:

- Flexible space - everything is on wheels
- Storage space is needed for materials and in-process projects- MORE than expected
- Ideally, spaces are separated into 1) think and plan, 2) make a mess
    - Floors need to be clean-able (paint, oily liquids) and not become slip hazards
    - Make sure a sink/water is available in the space

Ideally, spaces are separated into 1) think and plan, 2) make a mess! Therefore...

- Floors need to be clean-able (water, paint, oily liquids) and not become slip hazards
- Make sure a sink/water is available in the space
- 3D Design / Printing software and workstation is a critical decision in addition to hardware (note that General Electric has "free" systems for schools)

STEAM Lessons Learned

Schools around the world have embarked on including K-12 STEM/STEAM education in the holistic learning of students. As a result, information regarding best practices have recently come to light in education and scientific journals. Major challenges faced by K-12 schools in the success of STEM/STEAM education are mentioned below.

1. Poor preparation and shortage in supply of qualified STEM teachers

Published studies compiled by Ejiwale (2013) in *Barriers to successful implementation of STEM education*, state 74% of students that successfully graduated from their STEM programs identified poor instruction as a major obstacle. In addition, it was discovered that content knowledge of the teacher had a positive effect on students' learning.

Ejiwale also highlighted studies that asserted that a typical elementary school teacher that has minimal preparation in any STEM field tends to lack confidence in his/her knowledge of the subject and may create confusion and anxiety in the students. Hence, the efforts of two or more subject specialist should work synergistically to support novice teachers.

2. Lack of investment in teacher's professional development

The lack of investment in the professional development of teachers to create comfort and strength in knowledge of content area attributed to poor student performance. More importantly, it was again highlighted that additional mentoring was needed for new educator's work by expert mentor educators so as to produce the most effective teaching and learning environment of the student. (Ejiwale, 2013)

3. Poor preparation and inspiration of students

Microsoft and Harris Interactive recently released findings that most college students studying in science, technology, engineering or math make their decision in high school or before. However, only 20 percent of those students feel that their education before college prepared them "extremely well" for those fields. An interesting finding was that male and female students enter the fields for different reasons: "females are more likely to want to make a difference, while males are more likely to say they've always enjoyed games, toys or clubs focused on the hard sciences". This finding makes it essential for a teacher to prepare content and inspire students with different end goals. (Eijwale, 2013) Also, Herro (2019) stated many students are not independent thinkers; therefore, additional guidance would be needed every step of the way.

4. Poor content preparation

Ejiwale (2013) cites a study that stated ‘Preparing instructional materials is the process by which a sketchy working outline is transformed into finished learner directions or guide-sheets, instructional materials, tests, and instructor directions or guide-sheets” which should continually be renovated in order to attract new learners and provide them with the practical critical thinking skills necessary for evolving times.

5. Poor content delivery and method of assessment

STEM education is a standard-based interdisciplinary discipline; therefore, the method of assessment should not only be based on cognitive domain, but should include affective and psychomotor domains. (Ejiwale, 2013)

Also, 50-minute class periods at times makes it extremely difficult to interact, provide feedback, and assess learning of all groups. Hence, a variety of forms of assessment are necessary to demonstrate learning and student connections between the concepts and applications. (Herro, 2019)

6. Lack of connection with individual learners in a wide variety of ways

As mentioned in the previous section, males and females reasoning to enter the STEM field is different and of course within genders the goals of individual learners vary. To enhance students’ performance in STEM programs, Ejiwale (2013) stated studies that supported the individual learners interacting with a wide variety of ways to learn in STEM fields. For example, project-based learning increases student interest in STEM because it requires students to solve authentic problems, working with peers and specialists, and building real solutions. More importantly, students construct their own knowledge of the world around them. (Ejiwale, 2013)

7. Lack of support from the school system

Unfortunately, lack of support due to funding results in STEM programs being reduced or cut from school curriculum. In this case, external resources, such as qualified volunteers, retirees, or alliances should be recruited in the public and private section.

8. Lack of research collaboration across STEM fields

Many STEM educators fail to collaborate with other STEM educators; this results poor skill development, which results in learners having an inadequate sense of purpose, direction, purpose and choice of career in STEM related fields.

9. Poor condition of laboratory facilities and instructional media

References

Ejiwale, J. (2013) Barriers to successful implementation of STEM education. *Journal of Education and Learning*. 7(2), 63-74.

Herro, D., Quigley, C., & Cian, H., The challenges of STEAM instruction: lessons from the field. *Action in Teacher Education*. 41(2), 172-190.

Peer Benchmark

We were able to gather information about existing practices within several local districts: Forest Hills, Indian Hill, Lakota, Mariemont, Seven Hills, Sycamore, and Wyoming. All of the districts have prioritized the establishment of spaces and programs within the last few years. Their reasons varied but were consistent to those of the Design Thinking mindset, and the importance of teaching children how to ask questions, not just find answers. Portrait of a Graduate Skills were referenced: problem solving/critical thinking, communication, empathy, social awareness, creativity, and adaptability. Additionally, some schools described the skills in another way, the 5 C's: communication, collaboration, creative thinking, critical thinking and citizenship.

Additionally, regardless of the defining career fields within [STEAM, the skill sets] incorporated in STEAM professions are valuable for all learners. These include the thinking skills of handling non-repetitive tasks and promoting creativing thinking. Programs are valued for allowing students the time to work through several iterations of a problem and utilizing the communication skills within collaboration and working through real-world restrictions. The verbalization of identifying mistakes and working to find viable solutions within collaborative situations is an important skill set. As well as exposure and experiences of fields and curriculum outside of the typical mandated curricular areas, especially for girls and minority students.

Through the reallocation of District funds, school foundations and grant writing, the majority of neighboring schools have established MakerSpaces or STEM/STEAM Labs in their schools. Many noted the first year of implementation and space creation is the most expensive.

Established Area (MakerSpace or STEM Lab)

	PS/ES	MS	HS
Forest Hills	X	X	X
Indian Hill	X	X	X
Lakota	X	X	X
Seven Hills	X	X	X
Sycamore	X	X	X
Wyoming	X	X	X

There is variety in program models offered within neighboring districts. At the younger grades (K-6) opportunities seem to focus on a special's rotation model (a block of time during the traditional art, PE, music block) in which all students participate in opportunities. Inclusion is for all students and it non-criteria based. This is in addition to experiences their classroom teachers develop within the regular classroom. Towards the end of Middle School and in High School, the model tended to shift more towards an elective program.

STEM/STEAM Program Model

	PS/ES	MS	HS
Forest Hills	Special’s Schedule	Elective Courses	Elective Courses
Indian Hill	Special’s Schedule	Elective Courses	Elective Courses
Lakota	Special’s Schedule	Elective Courses	Elective Courses

Mariemont	No offerings	Special's Schedule	Elective Courses
Seven Hills	Classroom integration	Classroom integration	Classroom integration
Sycamore	Specials schedule	Elective Courses	Elective Courses
Wyoming	Specials schedule	Unknown	Unknown

Finally, there was also a variety of program implementation methods, most Districts opting for a combination of internally created curriculum and Project Lead the Way at the higher grades.

Curricular Offerings

	Internally Created	**Project Lead the Way**
Forest Hills	X	X
Indian Hill	X	X
Lakota	X	
Mariemont	X	X
Seven Hills	X	
Sycamore	X	X
Wyoming	X	

School districts overwhelmingly reported teacher buy-in as the biggest hurdle for success. Some had requirements for teacher use of spaces and implementation of curriculum, others allowed teachers to set the pace. Interestingly, schools that began with the former requirement, switched to the latter and vice versa. Again, teacher buy-in was the crux of the issue in both cases. Districts with more than one building per grade level band (multiple Elementary schools) discussed equity in spaces, a problem Madeira would not encounter. Middle School also seemed to be an area for growth in some Districts.

STEAM Curriculum

For the planning commission study around STEAM K-12/STEAM Programs for Madeira Schools, the task was to provide a variety of options/resources in the area of STEAM accelerators and curriculum. In the search for providing this information, it was discovered that multiple authors mentioned four key items which are required when building a STEAM program and they are: budget, location, resources, and curriculum. As you will discover, the findings below pertain to the latter two key items while keeping in mind the original task.

There are many pathways which a school district can take in building a STEAM program. Understanding what options/resources are available is key towards creating the pathway to a successfully implemented program. To offer some clarity around the various options/resources which are available to educators, as it relates to resources and curriculum, seven different categories have been created: consultation, training/professional development, STEAM certification, curriculum, materials (lesson plans/guides/instructions), materials (kits) and supporting information. Each area has been subdivided to include services and materials which are free and those that can be purchased.

In relation to the seven categories mentioned above, the research conducted to date resulted in a collection of fourteen sources; thirteen of those are included in the Excel spreadsheet. The purpose of this document is to give as much supporting information pertaining to each source. The Excel document, an extension of this document, is meant to serve as a "quick reference guide" in order to further simplify the information given in this document.

Please note that even if the budget, location, resources and curriculum are in place for the implementation of a STEAM program, the overall success of the program is ultimately driven by the interest/buy-in from the teachers, students AND administration.

Free consulting: Reaching out to other school districts for guidance in building a STEAM program:

https://www.questia.com/magazine/1P3-4054359741/building-steam-in-your-school

Berwick, a K–8 school in Columbus, Ohio, (article from 2016)

https://www.kentuckyteacher.org/subjects/science/2016/10/building-a-steam-program-from-scratch/

Erin Bloomer teaches computer, STEAM, robotics and AP math at Alex R. Kennedy Elementary School (Jefferson County).
erin.bloomer@jefferson.kyschools.us (article 2016)

Reynoldsburg Ohio (Columbus) has a K-12 STEM feeder pattern worth seeing.

Metro Early College on the OSU campus, grades 6-12. The middle school was official designated as an Ohio STEM School by the Ohio STEM committee on April 10, 2014.

- **STEAM Education** https://steamedu.com
    - o Virtual professional, group and program development.
        - · 5 tier membership subscription…
            - § Tier 1: Introduction to STEAM: Theory and Connections.
            - § Tier 2. STEAM Program Creation Package for Administrators.
            - § Tier 3. For members included in Staff and Program Certification contracts, not for individual sale.
            - § Tier 4. STEAM Virtual Professional Development.
            - § Tier 5. STEAM Virtual Professional Development with Certification.
    - o On-line depository of curriculum via a STEAM Curricula-Lesson Plan Bank Package.
    - o Curriculum writer's certification.
    - o Downloads and resources (Example lesson plans, STEAM graphics, ect..

- **STS STEAM consulting services** https://www.stseducation-us.com/ $$$$
    - o They assists schools in planning, procuring, integrating, and implementing a comprehensive STEAM plan.
    - o A standard STEAM consulting package consists of four steps:
        - · Assessing the learning environment

- Integrating technology solutions
- Onboarding teachers
- Reviewing student outcomes

o STEAM curriculum software (STEAM Fuse)

- Teacher's guide
- Lesson presentation
- Coding presentation
- 3D project presentation
- Teacher resource

o Lesson plans/products include:

- 3D Print Design
- Graphic Design
- Computer Science
- Coding/Programming
- VR/AR
- Robotics

- **TEQ** https://www.teq.com/ $$$$

o STEM certified curriculum specialist.
o State certified STEM educator.
o Offer STEM fuse (see above STS STEAM consulting services).
o Offer STEM related equipment/tools:

- Labdisc
- Sparkfun
- pi-top
- SAM Labs
- littleBits
- Bloxels
- KANO
- Osmo
- Farmshelf

o Offer Markerspaces:

- Mobile STEM labs
- STEM Marker station
- Modular furniture
- Electronic and coding bundles

o They will help you plan and build your Evospace.
o Numerous (~145) STEM lessons/courses.
o On-site or on-line professional development services.
o Also offer equipment and software related to:

- AV/VR
- Robotics
- 3D printers
- Sight and sound

- **Class Central** https://www.classcentral.com/ Free
  - o Universities from around the world offer free online STEM courses.
    - Free ~100 courses with ~90 certified to include subjects such as:
      - § Coding
      - § Inspiring students
      - § Innovating Instruction: Learning Design in the STEM Classroom
  - o These courses are collectively called as MOOCs or Massive Open Online Courses.

- **littleBits® classroom** https://littlebits.com/ $$
  - o Curriculum and lessons plans developed around electronic building blocks.
  - o littleBits® kits:
    - Developed for 1-3 students.
    - Includes 12+ hours of curriculum/instructions via littleBits®classroom.
  - o littleBits® bundles:
    - Developed for 20-30 students.
    - Includes 20 + hours of curriculum/instructions via littleBits® classroom.
  - o littleBits® electronic building blocks:
    - Can be bought individually or in large sets.
    - Purchase of the large sets allows access to curriculum, lesson plans and ideas.
  - o "littleBits® offers "educator resources access" where the instructor can gain step-by-step invention instructions, coding tutorials, and project ideas in littleBits® Classroom".
  - o Three professional development tiers:
    - Free introduction to littleBits® and educator quick start guide.
    - On-line training: Implementing littleBits® lessons and using the blocks.
    - On-site training: Inventing your own curriculum using littleBits® blocks.
  - o ***Huge selection of lesson plans and inventions which can be further refined into various subjects and then kits.***

- **Institute for Arts Integration and STEAM** https://educationcloset.com/ $$

- The Institute for Arts Integration and STEAM (IAS) is accredited by the International Association for Continuing Education and Training (IACET).
- On line courses include:
  - STEAM training for K-12 teachers (Designed to STEAM: amongst being trained to accomplish other STEAM related requirements/activities, the teacher will be able to design a curriculum and lesson plans). 25 PD hours
  - The STEAM PD bundle, 85 PD hours.
  - The PBL PD bundle, 85 PD hours.
  - Offer IntegratEd which is an all-inclusive K through 12 arts integration and STEAM curriculum supplement
    - The supplement contains lessons, assessments and resources carefully aligned to national E/LA, Math, Social Studies, Science and Arts Standards.
- Professional development included in order to assist teacher with the lesson plans.
- ***Offer numerous downloads referred to a "Teacher Printables".***

- **Project Lead the Way** https://www.pltw.org/

  - Five different launce modules.
    - PLTW Launch (K-5):
      - 28 interdisciplinary modules, 7 per grade level.
    - PLTW Gateway (grades 6-8):
      - 10 units which include:
        - Apps creator
        - Design and modeling
        - Energy and the environment
    - PLTW Computer science (4 units), PLTW Engineering (9 units), PLTW Biological Science (4 units) (grades 9-12).
  - Professional development:
    - PLTW Core Training:
      - On-line or in-person training or a mix of both.
      - Gain familiarity with PLTW launch modules.
      - Access to on-line training opportunities.
      - Help teachers develop an understanding of the activity, project, and problem-based (APB) instructional approach.
      - " Offer a number of resources to help districts, schools, and teachers build strong PLTW programs including an Implementation guide, best practices, regional and national events, and more".
      - "The PLTW community tool allows teachers to share experiences and connect with other teachers who use PLTW modules".

o Recognition program: If certain criteria is met, PLTW honors districts and schools committed to increasing student access, engagement, and achievement in their PLTW programs.

o AP+PLTW program: program has three elements:

- College and career pathways that connect AP and PLTW courses.
- Recognition for students who participate in the pathways, and recognition for schools.
- A portfolio of career-focused opportunities for students.

o "All PLTW pathways align to Common Core State Standards for Mathematics and English Language Arts and Next Generation Science Standards".

o "Computer science pathway aligns to **Computer Science Teachers Association Standards**; our engineering pathway aligns to **International Technology and Engineering Educators Association Standards for Technological Literacy**; and our biomedical science pathway aligns to **National Health Standards**".

o "PLTW students have exclusive access to a variety of recognition opportunities including scholarships, preferred admission at colleges and universities, internships, industry connections, and other avenues to highlight their achievements".

- **National Institute for STEM Education** https://nise.institute/

o Professional Development:

- Graduate Certificate of Professional Study program
- Master's program
- Ph.D. program

o Offer National Certification for STEM teaching.

- **Concordia University** https://education.cu-portland.edu/college-of-education/masters/curriculum-and-instruction/stem/

o Professional Development:

- M.Ed. in Curriculum and Instructions: STEM Courses (Online)

- **PCS edventures!** https://edventures.com/ $$$$

o Curriculum and lessons plans included in the kits they sell.

o Collections/lesson plans broken down into three categories:

- Elementary (grades K-6): 64 products.
- Middle School (grades 7-9): 47 products.

- High School (grades 10-12): 17 products.
  (Some products require purchase related to additional training).
- ***Treasure trove of free STEM related articles.***

- **Kithub** https://kithub.cc/
  - Offer a variety of kits for sale:
    - 1-2 hr classroom projects.
    - 10 week STEAM projects.
    - Environmental monitoring kits.
  - Free STEAM educator program for K-8:
    - Free Lesson Plans and Instructions. They do not require you to purchase a kit to their our on-line resources.
    - Can schedule a free consultation to help you determine your STEAM education requirements.
    - Download a mini lesson plan right now that you can use with your students.

- **PBS Learning Media** https://cet.pbslearningmedia.org/ **Free**
  - HUGE resource of lesson plans.
    - 130 videos for STEM
    - A multitude of other lesson plans can be used for STEM/STEAM related hands on projects.
  - Able to refine lessons via selecting various standards (under National Standards and Next Generation Science Standards).
  - Pre-K through 12th grade.
  - Offer the following subjects: Science, Social Studies, Math, English Language Arts, Engineering and Technology, Health and Physical Education, Preschool, Professional Development, The Arts and World Language.
  - Resource type: collection, video, interactive lesson, interactive, media gallery, audio, image, document, web page and teacher built.
  - Additional features: Support materials and downloads.
  - Example: By choosing the following criteria: STEAM/STEM learning (lesson plans) + Interactive lesson +Interactive + Lesson plan, up pops 3318 results (of course, all might not be relevant to STEM/STEAM theme).
  - A quick review of several lesson plans it was found that accompanying each lesson plan was: a description about the lesson plan, supporting material, standards related to lesson plan and the types of curriculum which the lesson plan supports (STEM, life science, ect.)

- **Media** STEAM games, apps, site.

https://www.commonsense.org/education/top-picks/steam-games-apps-and-sites

- o Most are free lesson plans:
    - · NOVA
    - · ArtsEdge
    - · Defined STEM
    - · OK GO Sandbox
    - · Math Science Music
    - · WorkBench

- **Hanover research** https://www.hanoverresearch.com/

    - o Top Resources for STEM/STEAM Program Implementation: (not in Excel Spreadsheet)
        - · Indiana DOE's Elementary and Middle Schools STEM Implementation Guide.
        - · The STEM Immersion Guide from Arizona STEM Network.
        - · How to Start a STEAM Program in your School from littleBits® Education.
        - · A Program Director's Guide to Evaluating STEM Education Programs, Massachusetts Department of Higher Education.
        - · STEM Programming Planning Tool from California After School Network and California STEM Learning Network.
        - · "STEM/STEAM Program Models, Components, and Leadership Development"

Website	Consultation		Professional Development		Program certification		Curriculum		Materials (Instructions/ guides/ lesson plans)		Materials (goods/kits)		Grades	Downloads and Resources
	Free	Purchase	Free	Purchase	Free	Purchase	Free	Purchase	Free	Purchase	Free	Purchase		
https://littlebits.com/			Free PD introduction to littleBits®	On-line and on-site PD on how to use littleBits® kits and bundles				When buying LittleBits kits/bundles you get instructional curriculum via littleBits Classroom		Lesson plans contain littleBits blocks. Also offer a huge selection of lesson plans on-line.		Kits and bundles containing littleBits electronic building blocks. Purchase individual blocks or in bulk quantities (large sets)	K-12	White papers, educators and administration guides
https://educationcloset.com/				Various on-line courses. PD included when purchase IntegratED									K-12	Offer sample lesson plans. For starting a program, they suggest two books worth reading. Also offer numerous downloads referred to a Teacher Printables
https://www.pltw.org/		Implementation guide related to PLTW		On-line, in person or both	Must meet certain criteria to earn PLTW Distinguished District or School designation								pre K-12	12 free documents related to PLTW
https://nise.institute/				STEM Certification, Masters and Ph.D.										

Website	Consultation		Professional Development		Program certification		Curriculum		Materials (Instructions/ guides/ lesson plans)		Materials (goods/kits)		Grades	Downloads and Resources
	Free	Purchase	Free	Purchase	Free	Purchase	Free	Purchase	Free	Purchase	Free	Purchase		
Schools with STEAM programs	Reference Word document						Consult with other schools						K-12	
https://steamedu.com/				Individual and staff		Staff and Program Certification		STEAM curriculum writers certification and STEAM curricula-lesson plan bank package				Very limited	K-12	
-														
https://www.stseducation-us.com/								STEM Fuse lessons		STEM Fuse lessons		Hardware/ Software		
-														
https://www.teq.com/													K-12	
https://www.classcentral.com			~100 on-line courses, ~90 with certificates						~100 on-line courses, ~90 with certificates					

Website	Consultation		Professional Development		Program certification		Curriculum		Materials (Instructions/ guides/ lesson plans)		Materials (goods/kits)		Grades	Downloads and Resources
	Free	Purchase	Free	Purchase	Free	Purchase	Free	Purchase	Free	Purchase	Free	Purchase		
https://edventures.com/								Included with each product		Included with each product		Included with each product	K-12	White papers, vidoes and on-demand webinars. Tons of articles
-														
https://kithub.cc/	Free consultation. Probably a one time offer							Included with each kit	Free STEAM lesson plan for K-8 (Not required to purchase a kit). Also, offer instructions on how to make KitHub projects from current and past kits.	Included with each kit.			K-8	Via links offer free lesson plans, activities and curriculum, K-12, from other sites/resources.
https://cet.pbslearningmedia.org/									**HUGE RESOURCE**				K-12	**HUGE RESOURCE**
- https://www.commonsense.org/education/top-picks/steam-games-apps-and-sites													K-12	
Donations via local colleges and businesses.														

Website	Consultation		Professional Development		Program certification		Curriculum		Materials (Instructions /guides/ lesson plans		Materials (goods/kits)		Grades	Downloads and Resources
	Free	Purchase	Free	Purchase	Free	Purchase	Free	Purchase	Free	Purchase	Free	Purchase		
https://education.cu-portland.edu/college-of-education/masters/curriculum-and-instruction/stem/				Master of Education in Curriculum & Instruction										

Recommendation

Recommendation

After the review of research, site visits, and interviews, the committee found STEAM programming allows students to develop and practice problem solving/critical thinking, creativity, and communication. Through collaboration and work on real-world problems,students learn and practice empathy, social awareness, and adaptability. STEAM gives students the opportunity to ask questions, work on non-repetitive tasks and challenge themselves through the iterative process of design thinking. The recommendation is the implementation of STEAM programming within all grade levels. The importance of creating an opt-in culture for teachers is critical. The success of any implementation hinges upon the teachers becoming facilitators and, as recommended by Stanford Design School, “teachers as learning experience designers for students.” Essential for success is empowering teachers and affording them time to tinker. There are a variety of existing resources that staff can leverage to aide in implementation. The pitfalls of previous attempts at creating STEAM programming serve to illuminate areas that require special attention. Teacher training and professional development, as well as the dedication of a space for thinking and problem solving, is more valuable than gadgets. Neighboring schools have shown success with both high and low tech materials. Time and personnel for grant writing is ideal.