Flattening the Learning Curve: Narrowing STEAM Achievement Gaps via a Research Curriculum

by Hugh Pressley, Will Streit, and Steven McCartt

Introduction

The COVID-19 pandemic has created a plethora of problems globally for school boards, administrators, and teachers of science, technology, engineering, the arts, and mathematics (STEAM). From the beginning of 2020, marginalized students—those who live in low-socioeconomic environments or come from traditionally underrepresented communities or populations—have fallen further behind their non-marginalized counterparts, as the virus has exacerbated existing academic inequalities (Van Lancker & Parolin, 2020). In the United States alone, pandemic learning loss has widened academic gaps by up to 20% for Black and Latino students, which could result in lifetime economic losses of almost $100 billion for this year's K-12 cohort (Dorn et al., 2020). The resulting interruption in face-to-face learning has forced education stakeholders to come up with creative and innovative ways to engage students and create high-quality and equitable educational experiences for even the most vulnerable populations.

One way middle and high school STEAM teachers—with the support of policymakers—can create more rigorous academic environments for these students is through the use of a curriculum that teaches students how to perform independent research on topics of their choosing. Many scholars and educators have lauded the presence of research—or inquiry-based learning (IBL)—in STEAM classrooms; however, rote learning still permeates much of the K-12 landscape (Chu et al., 2008). Thus, in order to combat stagnant pedagogy, school districts can proactively anticipate school interruptions and create flexible options for marginalized students to produce scholarly work, employ research practices, and analyze sources of evidence via a research curriculum. In turn, these young scholars can develop transferable skills to solve real-world problems.

In this article, the authors discuss a top-down approach to creating a research curriculum that includes an inquiry-based learning process that middle and high school STEAM teachers can implement either remotely or in-person. The research curriculum is not a formal certified program, but rather a set of structured best practices that can be integrated into existing or new educational systems. This curriculum gives students a chance to meet ITEEA's 2020 *Standards for Technological and Engineering Literacy (STEL)* while creating solutions for contemporary problems in science, technology, engineering, the humanities, and mathematics. Furthermore, it integrates socially relevant content, which can help students appreciate how research can apply to broader community and global concerns. The curriculum's independent format and emphasis on research characteristics—including assessing a problem, planning an approach, and communicating the reasoning and results—promote college- and career-readiness skills that marginalized students can use to make academic gains.

The Research Curriculum Starts at the Top

As the coronavirus pandemic raged on during the summer of 2020, school boards across the globe—and specifically in the United States—had to first manage the dilemma of whether or not they would require students to return to school face to face. Districts across the country varied on how they would reopen schools and address the impact to student learning; however, the most innovative district leaders, whether they implemented plans for the whole district or individual students, made sure they had a robust remote learning plan in place. These leaders provided students a curriculum that combined face-to-face and virtual options with the rigor, scaffolding, and accountability of traditional learning and the flexibility, technology focus, and learner-centeredness of e-learning.

When establishing a strong research curriculum for a district, school boards in particular can work with superintendents and principals to do the following:

- Create a shared vision: Articulating the overarching purpose and intent of the research curriculum is critical for success. While seemingly self-evident, significant alignment challenges can arise if various stakeholders have different priorities. For example, college-readiness and real-world-experience are both laudable priorities, however each might lead to different emphasis in the curriculum.
- Establish vertically aligned goals and measurements: Since school boards do not develop the day-to-day curriculum, the goals give the administrators and educators a framework within which to create and implement the curriculum. Additionally, clarity on the intended outcomes provides the school board with a tool to a) gauge value and effectiveness and b) communicate intent to the community.
- Communicate with all stakeholders: Parents, teachers, and students need to understand the purpose, method, and practices of a research-based curriculum. In our experience, stakeholders tended to be wary of learning structures that differed from their own experience—particularly parents who are not as familiar with recent education research and best practices.

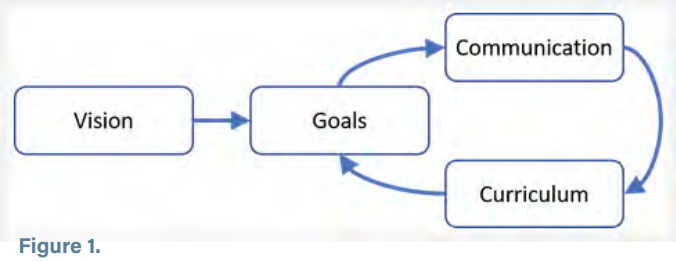


Figure 1.
The journey to a research curriculum.

Note. An interconnected cycle of goal measurement, inclusive communication, and curriculum adjustment helps ensure that outcomes are aligned to the district's shared vision.

This synergy at the administrative level serves as a foundation for alignment across a school district's constituents, which include teachers, parents, and students.

How to Build a Research Curriculum at the School Level

Preparation and Recruitment

Teachers and administrators can prepare at least a year in advance to implement a research curriculum at their school. During this time, administrators can identify which teachers in their school have the skills and training necessary to either teach a stand-alone research class or embed the research curriculum into their content areas. Once teachers are selected, they can begin to identify which students would benefit from a flexible research class that allows them to work independently and more self-paced than traditional classes. Teachers and administrators can use this time to focus on equity by recruiting a diverse pool of skilled students from different backgrounds and socioeconomic statuses.

Teachers can use a variety of different methods to recruit students. They can use student grades as an indicator of success in the research environment, hold interest meetings to help students understand the expectations set forth in the curriculum, and distribute surveys to understand the types of research students would like to perform during the class. Once teachers have identified the students or classes that would benefit from the research curriculum, teachers can start crafting a syllabus and pacing guide for their research program.

Syllabus and Pacing Guide

Before the school year begins, teachers can create a syllabus and pacing guide (see Table 1) to help parents and students navigate the requirements of the research course. The syllabus can include an overview of the program, course textbooks and resources required, a class grade breakdown, and a curriculum framework. The pacing guide can include a graphic organizer displaying the associated *STEL* (2020) and research standards, the specific assignments and sources students will use, and associated dates. Once the school year starts, teachers can review the syllabus and pacing guide with students and parents and use the documents as a guide to implement the research curriculum.

Student Responsibilities and Activities

Picking a Topic and Research Question. Students can participate in a variety of assignments, activities, and learning opportunities throughout the course of the research class. At the beginning of the course, teachers can allow students to pick a topic of particular interest and develop that topic into a research question that will guide the rest of their inquiry. For example, a student who likes the topic of cars might want to know how automobile manufacturers decide safety standards for their vehicles. A teacher could help this student create a research project based on this topic by next having the student:

1) Find scholarly sources about the topic using search engines

2) Synthesize those sources into a critical literature review that assesses how the sources answer the research question

3) Figure out what the scholarship lacks in terms of answering the question (or the gap in the research)

4) Develop a method to address the gap in scholarship.

Once students perform these tasks, they are ready to collect the data necessary to perform their inquiry.

Using Qualitative, Quantitative, and Mixed-Methods Approaches. Students can use myriad methods to conduct their research. They can use qualitative approaches to research, which include conducting interviews, distributing questionnaires, doing field observations, or analyzing documents. They can use quantitative approaches to research, which include distributing surveys or performing experiments. They can also combine both approaches into a mixed-methods research project. Once students have determined which approach they would like to choose, they can design a procedure that will allow them to collect and analyze data to come to new knowledge in the pursuit of answering their research question. The procedure will outline how students conducted their experiments, distributed their surveys, interviewed their participants, or otherwise completed their research.

Analyzing Data, Displaying Results, and Drawing Conclusions. After students have conducted their research, they can analyze their data by coding their research findings (Creswell & Creswell, 2018) or by using descriptive or inferential statistics (depending on their approach). Students can use graphs, charts, tables, and descriptions to display their results (see Figures 2-4). Students can then determine how their research answered their research question and what gaps they have filled in the general scholarship on their topic by performing their research. They should also determine the limitations of their research, the real-world implications their research can promote, and directions for future studies.

Table 1.
Sample research curriculum pacing guide for the first five weeks of a research class.

Standards	Resources and Tasks	Dates
Build Culture; Develop Relationships; Routines and Procedures; Rules; Consequences; Incentives; Teacher Created Diagnostics and Lessons	Establish Procedures/Writing and or Reading Activities	9/8 – 9/11 4 days
STEL Standards 1-5 Benchmarks 1A-R; 2A-Z; 3A-J; 4A-T; 5A-J	*The Craft of Research* Ch. 3 Academic Paper Samples Presentation: Topic Portfolio: Topic Reflection Peer Review: Topic	9/14 – 9/18 5 days
STEL Standards 1-5 Benchmarks 1A-R; 2A-Z; 3A-J; 4A-T; 5A-J	*The Craft of Research* Ch. 4 Academic Paper Samples Presentation: Problem Statement Portfolio: Problem Statement Reflection Peer Review: Problem Statement	9/21 – 9/25 5 days
STEL Standards 1-5 Benchmarks 1A-R; 2A-Z; 3A-J; 4A-T; 5A-J	*The Craft of Research* Ch. 3 Academic Paper Samples Presentation: Research Question Portfolio: Research Question Reflection Peer Review: Research Question	9/28 – 10/2 5 days
STEL Standards 1-5 Benchmarks 1A-R; 2A-Z; 3A-J; 4A-T; 5A-J	*The Craft of Research* Ch. 5, 6, 14 Academic Paper Samples Presentation: Annotated Bibliography I (Reading List) Portfolio: Annotated Bibliography I (Reading List) Reflection Peer Review: Annotated Bibliography I (Reading List)	10/5 – 10/9 5 days

Creating a Research Paper and Performing an Oral Defense. Throughout the school year, students can conduct their research while crafting their experiences in a research paper that has an introduction, methods, results, analysis, and conclusion sections. Students should also expect to have to defend their methods by giving a presentation of their findings to an audience and answering questions about their research choices. In preparation for these tasks, students can give mini-presentations, conduct peer reviews, write reflections, and otherwise engage with their research using teacher- and student-facilitated activities.

STEAM Research Example

During the 2020-2021 school year, McCartt (2021) created a research project entitled *Virtual*

Learning's Impact on High School Students' Academic Performance. In the paper, the student researcher wanted to address the issues that COVID-19 and the implementation of virtual learning introduced during the 2019-2020 and 2020-2021 school years, and how those issues affected student grades. McCartt (2021) attempted to answer his research question by using a survey created in Google Forms to quantitatively determine the changes (if any) in self-reported grades before and after the pandemic. Almost 2,000 students—a majority of them from marginalized communities—from all three high schools in the district completed the survey, which showed that mean student-reported grades dropped after the pandemic for freshmen, sophomores, juniors, and seniors. The student used the research curriculum throughout the school year to plan, implement, and analyze his inquiry-based project in a replicable and equitable way, and much of the student's work was done outside of class using the internet.

Beyond the results, McCartt's (2021) student project illustrates two main benefits. The student researcher was able to choose a topic that was not only timely, but also of personal interest. He was also able to quickly adapt the research and methods based on the changing circumstances brought on by COVID-19. Although demonstrated in a COVID-driven scenario, these same benefits are key for engaging and retaining marginalized students in any type of learning environment.

Challenges During COVID-19 and Related Benefits of the Research Curriculum

Classroom Adjustments

The COVID-19 pandemic has necessitated significant operational and educational adjustments to deal with challenges including hybrid in-person/online learning, campus staffing, and student access to resources. The most significant difference has featured the classroom, which in the fall of 2020 has ranged from completely online to hybrid, where students could choose in-person or remote learning. For example, in one large Texas school district, teachers utilizing a research curriculum have adapted to the new COVID-19 format with minimal changes. Although the restrictions on personal contact in that district did create some challenges for student researchers (such as the inability to do in-person focus groups), the dynamic nature of the research curriculum has allowed students to adapt their projects and their methods to fit the situation. Even separate from the pandemic, this flexibility is especially helpful for at-risk students, who might need to adapt their research based on the resources, time, and topics available to them.

Teacher Coverage

The pandemic has also created increasing numbers of teacher shortages. In many states, districts have required schools to offer both online and in-person classes soon after the start of the 2020 school year. With many educators having health concerns that prevented them from returning to the classroom, COVID-19 has required new staff and changes in teaching assignments. The challenges brought on by the pandemic have mirrored those often seen

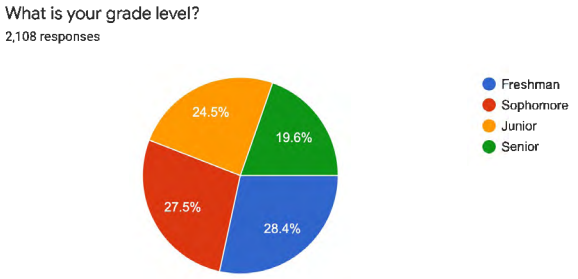
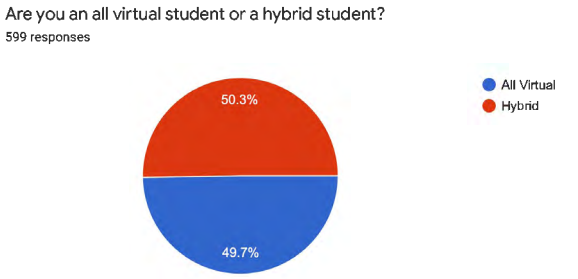


Figure 2.
Student-produced data of answers to survey questions pertaining to the impact of virtual learning on high school student grades (McCartt, 2021)



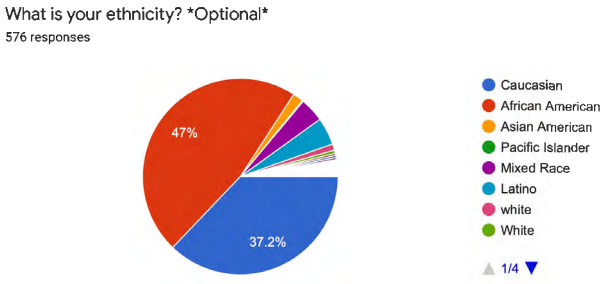


Figure 3.
Student-produced data of answers to survey questions pertaining to the impact of virtual learning on high school student grades (McCartt, 2021)

Note. The student created the Google Form survey in such a way to divide students up by grade level. The figures here represent freshmen in three high schools district-wide.

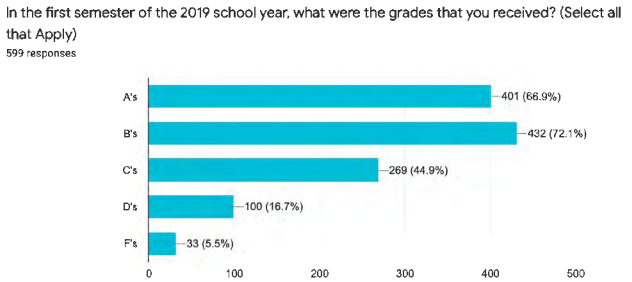


Figure 4.
Student-produced data of answers to survey questions pertaining to the impact of virtual learning on high school student grades (McCartt, 2021)

in high-poverty schools, which can suffer from higher teacher absentee rates or a disproportionate percentage of educators outside of their primary expertise (Milner, 2013). In both cases, traditional instructor-led curriculums can break down as educators find themselves teaching out of their normal subject area or grade level.

Research curriculum classes can offer these teachers a lifeline, because they require only that educators have a knowledge in research methods, not specific content areas. For example, in some districts during the pandemic, research teachers have allowed students to use class time for individual work, consultation with the teacher, or small online breakout groups. Just as with prior to the pandemic, educators have posted information on research methods and processes (but not on subject area topics themselves), and students have used small peer groups to review and brainstorm topics rather than relying on direction from the teacher.

Virtual Flexibility

During the pandemic many administrators and teachers have dealt with uncertainty over whether students (or which students) could participate in person. Similarly, technology issues have also created virtual absenteeism. Since the research curriculum classes have given students online information and directions, but have not used class time for lecture, in-person learning has become effectively unnecessary. Whereas in a traditional curriculum, an absent student would miss core subject information, in the research classes, students have only missed time to work. This flexibility illustrates a benefit for students in lower socio-economic schools, where absenteeism is often higher (Gee, 2018). With a research curriculum, students are less reliant on the actual classroom and can use time more suitably for their circumstances.

Accessibility

In the large Texas district, and in similar districts in the St. Louis area and around the country, the school board and administrators had to ensure technology access for every student during the pandemic. While laptops had already been available, the districts had to extend their focus off-campus to help students and families with home connectivity.

In addition to accessibility issues, students in difficult circumstances may also have home environments that are not conducive to learning (Gee, 2018). During the pandemic, schools have offered alternate options for students who needed a space to learn, such as special library access or on-campus study areas. The Research Curriculum has supported these variations where the locations—or time periods—have not always aligned to teacher availability.

Classroom Connections

In order to meet ITEEA's *STEL* (2020) standards, teachers who use a research curriculum should first teach students basic technological responsibilities and knowledge as outlined by *STEL* Standards 1-5 (Benchmarks 1A-R; 2A-Z; 3A-J; 4A-T; 5A-J). Once students understand these responsibilities, teachers can implement the research curriculum—specifically the end-of-the-year academic paper, presentation, and oral defense—to address Standard 8 (Benchmarks 8A-R) and Technology and Engineering Practices 2-8 (STEL, 2020). By using *AETL's* (2003, p. 33-34) rubric to assess the end-of-the-year project, teachers will adapt *AETL* Standards A-2 through A-5 (Guidelines A-2D, A-3B, A-4A, A-5A) and P-1 through P-5 (Guidelines P-1A, P-2B, P-3B, P-4A, P-5A).

By addressing these standards, teachers can promote a research curriculum to help students use technology to address myriad issues pertinent to marginalized communities, including issues pertaining to the justice system, environment, education, and other concerns. Many examples of administrators' implementation of research literacy in low-socioeconomic schools have illuminated the benefits of this pedagogy in both STEM and other classrooms: Thaler (2013); O'Sullivan and Dallas (2017); and Chu et al. (2008) represent a few.

Conclusion

Marginalized students face extreme challenges during interruptions in education, whether from a global pandemic or individual challenges at home. Oftentimes, students who face these challenges fail to engage in school activities or avoid school altogether. However, students who learn STEAM concepts through a research curriculum can learn at their own pace and solve problems pertinent to their personal situations and communities. Additionally, marginalized students who complete STEAM research projects can increase self-efficacy and make inroads to lowering the achievement gap between them and their wealthier counterparts. This can produce a more diverse pool of college students and professionals who choose STEAM careers, which will increase the impact of engineering and technology programs. The authors' experiences confirm that students were more engaged and excited about learning technology and content-area subjects when given autonomy through IBL and research projects. Teachers, administrators, and school board members who work with and serve marginalized students might help these children experience increased academic achievement and a more enriching educational experience by implementing a research curriculum that allows for students to learn STEAM concepts both face-to-face and virtually.

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