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Hk Maker Lab: Creating Engineering Design Courses for High School Students (Evaluation -or- Other)

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HYPOTHEkids Maker Lab: Creating Engineering Design Courses for High School Students

INTRODUCTION

With the ascendance of the Next Generation Science Standards (NGSS), there is increased emphasis on the role of engineering design in a comprehensive K-12 STEM education [1]. While the NGSS has been adopted by nearly half of all states, there are still major deficits in the quality of STEM education in the U.S. [2-5]. In particular, engineering design education opportunities are rare and underdeveloped at the primary and secondary school levels, and secondary teachers often lack the specific content knowledge to teach engineering [6]. There is a need for both engaging engineering curricula for primary and secondary students, as well as for well-trained teachers who are prepared to teach engineering.

In order to address the need for high-quality secondary school engineering education opportunities, the HYPOTHEKids (Hk) Maker Lab has implemented a curriculum development effort based around the engineering design process (EDP). We emphasize engineering design because the open-ended nature of the EDP gives students greater accountability and ownership over their learning and it has been demonstrated to be an effective method for improving student knowledge of STEM content areas [7]. The goals of this effort are to (1) introduce secondary STEM teachers to the engineering design process and its utility as a framework for engaging students with STEM content and practices and (2) create a set of engineering design curricula, course materials, and activities that can be adapted for wide use in high schools, as both stand-alone EDP courses and as frameworks for teaching design in the context of existing science or engineering courses.

Previous efforts to address the deficit of teachers trained in engineering have demonstrated the importance of linking professional development to the classroom environment and student responses [8]. Teachers who learn new engineering content in professional development environments that mimic the student experience show significant increases in both content knowledge and comfort with teaching the new material [9]. This curriculum development effort utilizes the existing Hk Maker Lab high school summer program in engineering design as a co-learning environment for teachers, exposing them to EDP within an active classroom. The high school summer program, an overview of which was presented at the ASEE annual meeting in 2016 and in a recent publication [10, 11] challenges students to learn the EDP and use it to develop solutions to biomedical problems. By participating alongside students, teachers develop their knowledge of engineering content while gaining valuable insights into student responses to EDP instruction. These active observations inform the curriculum development process, in which teachers and the program team adapt the EDP course progression from the high school summer program into full engineering courses for implementation in high school classrooms. The courses that arise from Hk Maker Lab's curriculum development efforts are to:

1. Enhance student interest in pursuing STEM education and career opportunities;
2. Enhance student STEM self-perception;
3. Develop student engineering design skills.

This paper describes the structure and programmatic activities of the curriculum development effort, as well as preliminary assessments and future plans for refinement.

PROGRAM COMPONENTS

Program Participants

New York City science, math, and engineering high school teachers are recruited to apply for the EDP curriculum development program. Teachers are primarily recruited from schools with high underrepresented minority enrollment or that have economically disadvantaged student populations. They submit a comprehensive application package that includes: essay question responses pertaining to their commitment to and passion for STEM education, a letter of recommendation from a colleague, and written endorsement of their school's principal, confirming institutional investment in the creation of EDP-centric courses. From the applicant pool, a maximum of three (3) teachers are selected to participate in the curriculum development and summer program immersion. The selected teachers are part of the Hk Maker Lab curriculum development program's four major components:

1. Pre-program virtual workshops (4 workshops)
2. Professional development via co-learning during the summer program (6 weeks, Monday – Thursday)
3. Curriculum development workshops (5 workshops)
4. Curricular implementation, evaluation, and refinement (within one year of program participation)

Pre-Program Virtual Workshops

Participating teachers are prepared for the co-learning environment through a series of four online preparatory workshops. One month before the start of the co-learning experience, teachers are sent the course materials from the Hk Maker Lab summer program sessions, including seven sets of lecture slides and video recordings. These lectures are meant to introduce the teachers to the progression of the engineering design process, relevant concepts and vocabulary, and basic in-class activities. Teachers are expected to review these materials and prepare questions to ask the Hk Maker Lab program team during the subsequent virtual workshops.

Table 1 provides an overview of the virtual workshop schedule. The teachers and Hk Maker Lab project team virtually meet using online conference tools (appear.in, Google Hangout, Skype, etc.) The engineering design process is previewed, providing teachers with the opportunity to ask the program team preliminary questions about the design process. This gives the program team the opportunity to share their knowledge of the engineering design process, engineering design pedagogy, technical vocabulary, hands-on research, and engineering experience. Reciprocally, teachers provide insight into their school's resources, available equipment and working space, assessment requirements, standards requirements, and current STEM offerings. They also share their pedagogical practices and STEM knowledge. Initial discussions of the curriculum development take place during the workshops, with an emphasis on the scope of student design projects with respect to available school resources and program support. The pre-program workshops prepare the participating teachers to think about how the knowledge, skills, and experiences they will gain during the co-learning experience can be applied to the creation of new EDP coursework for their own students.

Table 1. Virtual Workshop Schedule for Hk Maker Lab Curriculum Development Program

Virtual Workshop	EDP Topics Reviewed	Points of Discussion
1	• Problem definition and need statement • Research and design inputs	• Teachers' pedagogical practices • School resources (lab space, fabrication tools, materials)
2	• Solution ideation • Solution screening	• Teachers' STEM knowledge • Teachers' STEM courses taught (current and prior)
3	• Proof of concept testing and prototyping	• Problem spaces (what types of problems will their students work on) • Project scaffolding • Resources for student designs
4	• Business planning • STEM communication	• Grading and assessments

Teacher Co-Learning Environment

Hk Maker Lab Summer Program

The Hk Maker Lab summer program is the mechanism by which high school teachers are introduced to EDP in a co-learning environment. It is a six-week, hands-on course in the engineering design process within the context of biomedical engineering. Rising 11th and 12th grade students are recruited from throughout New York City, primarily from schools with large underserved minority populations or significant numbers of low-income students. Twenty-four (24) applicants are admitted to the program, which takes place at Columbia University in the Department of Biomedical Engineering. The course has three main components: EDP workshops, bioinstrumentation laboratories, and a prototyping period. Students are introduced to the EDP (Figure 1) during the workshops. They learn a variety of technical skills including computer programming, electronic circuit design, and fabrication methods during the bioinstrumentation laboratories. In coordination with the workshops, they use the design process to define and devise solutions to biomedical device needs. Once a need is identified and they have developed foundational knowledge of the underlying problem, customers and their needs, and prospective solutions, the student teams (3-4 people per team) engage in prototyping activities to create biomedical device solutions to their identified problems. The resultant prototypes are tested with respect to pre-established design inputs and refined or optimized based on their performance (see Table 2 for an overview of the high school summer course progression and content.)

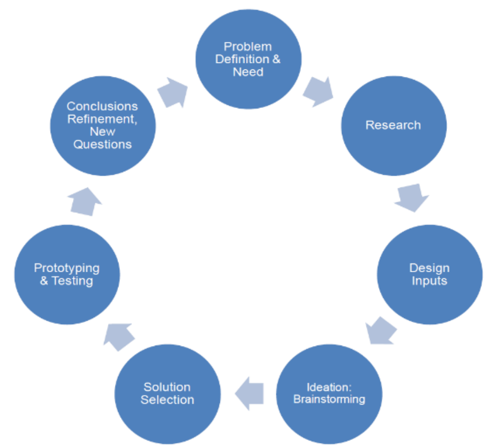

Figure 1 Iterative EDP model taught and utilized in Hk Maker Lab

Table 2. Schedule of Hk Maker Lab Summer Program

Week	Engineering Design Process Workshops	Laboratory Activities	Technical Skills Imparted
1	Problem Identification and Needs Finding	Body Temperature Monitor	Basic electronic circuits (Ohm's law, resistive voltage divider, thermistors), data measurement, calibration curve
2	Design Research, Design Inputs	Breathing Rate Monitor	Data acquisition, digitization of analog signals
3	Ideation, Solution Selection	Cardiac Monitoring	Analog signal filtering
4	Proof of Concept Testing, Business Planning	Electromyography	Computer programming, microcontrollers (Arduino)
5-6	Prototyping		3D printing, laser cutting, basic machining skills Creating research posters, effective communication of technical/scientific ideas

Summer Program as Co-Learning Platform for Teachers

By utilizing our existing high school summer program as a co-learning environment for teachers, we provide an applied professional development experience that prepares teachers for the challenges of implementing engineering design coursework. In coordination with introducing teachers to engineering design, we draw on their classroom expertise to adapt the summer course materials for their classes. Teachers are active observers throughout the program – they participate in all the EDP workshops, bioinstrumentation labs, and prototyping sessions alongside the students, with additional time to reflect on their own experiences and observations. The workshops consist of a series of lectures that teach the critical components of the EDP. The sessions are interactive, providing students opportunities to develop and employ the various components of the EDP. For example, during the concept generation phase, students are given some example problems and challenged to brainstorm as many potential solutions as possible; the exercise is then repeated, this time challenging students to conceive and outline new problems before brainstorming solutions to them. This exercise both scaffolds a new skill, allowing the students to practice with increasing levels of confidence, while also re-engaging a skill from earlier in the EDP (problem definition). Throughout this instruction, teachers work with the student groups or independently, augmenting the content knowledge they developed during the pre-program virtual workshops with hands-on experiences in the classroom. Direct observation allows teachers gain insight into the difficulties students experience while learning this new content.

Teachers also participate fully in the bioinstrumentation laboratories. Many secondary school teachers, even those with STEM degrees, possess limited hands-on technical skills, which makes this extra instruction critical. During the lab sessions, teachers work with the students to build and test the instrumentation. The procedures provide teachers with time to learn and become comfortable with an array of technical skills and laboratory tools. Technical competency is further emphasized in the prototyping phase of the program, when teachers and students learn how to use a wide range of fabrication tools, including 3D printers, laser cutters, and PCB printers. While the students build and test their prototype designs, teachers act as members of the program team, assisting groups as they do research, fabricate components, and test their devices, giving teachers direct experience with the challenges that accompany prototyping solutions to design problems.

Throughout the co-learning experience teachers are given extensive preparation by the program team so that they can focus not only on participating in the activities and learning alongside students, but also on documenting the students' reception of the course materials and the open-ended nature of the engineering design process within a functioning engineering classroom. Teachers are encouraged to document their observations during the co-learning experience, with emphasis on the challenges students experience during the EDP instruction and suggestions for the improvement. At the end of each day of the summer high school program, the Hk Maker Lab program team holds brief (<10 minute) discussions with teachers during which their observations are discussed for future curriculum development.

CURRICULUM DEVELOPMENT

Curriculum Development Workshops

The curriculum development workshops take place for six hours each Friday during the co-learning experience (the students are not in session on Fridays). The curriculum development workshops serve to synthesize teacher experiences from the co-learning environment and use them to form engineering design course content.

Each workshop begins with a period of reflection. The program team first reviews the content and lab activities covered and asks teachers to express their interpretations of the content. Teachers share their understanding of the material as well as observations of the students during those lectures and labs. Teachers are encouraged to focus their observations on the difficulties students encountered with the EDP to identify issues that may require additional support for translation into their classrooms.

The reflection leads into the discussion period, which last between 30 – 60 minutes. Teacher observations in the co-learning environment are synthesized with the learning goals of their specific schools and the local STEM education standards to clearly define the performance outcomes expected of students upon the completion of the corresponding portion of the new course. For example, during the problem definition phase of the EDP, the performance outcome for students is to "construct a complete problem definition based on a situation/problem space and informed by research." Teachers are asked to discuss how this outcome can be imparted to students in their classrooms, using observations of the Hk Maker Lab summer students to help them define their understanding of successful student performance. This discussion helps the teachers to formalize their observations and prepares them to identify the educational outcomes that they will strive to achieve in their resultant courses.

The discussion leads into the creation phase, which encompasses the bulk of the workshops (typically 2.5 hours). During this phase, the week's EDP concepts as well as the performance outcomes defined during the discussion period are used as bases for creating curriculum content. This phase is more structured than the preceding two portions. Teachers and the program team plan out the number of weeks that will be spent on each EDP concept, a process that requires significant input from teachers as the standard class period (45 - 75 minutes) is significantly shorter than the two- and three-hour lessons and activities during the Hk Maker Lab summer program. Each class day is then given an objective, student performance outcome, essential questions to guide students, and an activity. Each day is also mapped to the engineering education standards that correspond to the key competencies and skills (see an example in Table 3).

Table 3. Example of an EDP course day designed during curriculum development workshops.

EDP Focus	Key Questions for Students	Lesson Objectives/Goals	Activities	Performance Outcomes	NY State Engineering Design Standard(s)
Problem Definition	• What defines a problem? • What questions do we need to ask to fully define engineering problems?	Introduce students to the concept of a problem definition and major components with a focus on *why* that information is useful.	Oceanic plastic example problem: students read one-page article about oceanic plastic pollution and work in groups to extract the embedded problem definition components (and identify any missing information). Groups present their findings to the class.	Students are able to construct a complete problem definition (including consequences, statistics, and existing solutions) after observing a situation/problem space and carrying out supplementary research.	Asking Questions and Developing Problems - Ask questions to clarify and refine a model, an explanation, or an engineering problem.

The last hour of the workshops is devoted to de-risking the course content. De-risking entails developing strategies for teachers to address challenges anticipated to arise with novel, open-ended coursework and unfamiliar concepts. It also entails devising a simplified EDP lexicon that can be readily-imparted to high school students. For example, one major component of the engineering design process is the creation of functional requirements, the performance goals of the engineered solution, and design constraints, the limitations imposed on the solution by stakeholder needs and contextual limitations. Both teachers and students tend to struggle with these concepts, often misunderstanding them or conflating the terms and underlying concepts. The de-risking strategy for these topics involves using simple, explanatory language as they are introduced to students:

Functional Requirements = *what a solution must* ***do***
Constraints = *what a solution must* ***be***

Such exercises increase teacher comfort with the EDP instruction, providing them with a non-technical vocabulary that both they and the students understand. Another common method of de-risking is to create clear, concise examples of successful student learning outcomes to help teachers model proper performance of the EDP skills. For instance, multiple examples of complete problem definitions were created for teachers to use in their courses. These de-risking sessions helped teachers better understand the content while also preparing them for common points of confusion or difficulty.

Curriculum Implementation, Evaluation, and Refinement

Upon completion of the summer program, participating teachers will have formed a syllabus and instructional materials for an engineering design-centric course. They are expected to implement the resultant course or modules in their schools within one (1) academic year of program participation. Hk Maker Lab provides ongoing financial and pedagogical support for these classes. The financial support ($1000/year) is used to purchase supplies necessary for the lab activities and design work. Pedagogical support is supplied by an Hk Maker Lab program team member, who joins the teachers in their classes as a *de facto* teaching assistant, as well as for two weekly after-school meetings with each teacher. The after-school meetings allow the teachers and program team members to refine and alter the courses based on classroom observations. These meetings are also used to create new activities based on real-time feedback from the classroom. In this way the curriculum development process extends into the implementation of the course itself –activities are created and revised based on outcomes of the courses in progress.

Evaluation of the curriculum development program is developed in conjunction with the Education Development Center's Center for Children and Technology (EDC/CCT). The evaluation has two components – teacher experiences during the summer co-learning environment and student outcomes during implementation of the resultant EDP-centric coursework. The evaluation of the summer co-learning environment entails a series of interviews conducted by EDC evaluators. The first interview takes place before the start of the co-learning environment and seeks to understand the teachers' teaching backgrounds and prior efforts with engineering education. The second interview follows the conclusion of the co-learning environment and focuses on the teachers' experiences during the program: what they learned about the engineering design process, how the co-learning environment helped prepare them to establish new engineering learning environments, and how they plan to incorporate their experiences into their pedagogy. These post-program interviews will be used to refine the structure of the co-learning environment during subsequent years.

The implemented courses are rigorously evaluated during the two years after teacher participation in the summer co-learning environment. A major part of this evaluation is an instrument that is administered to students pre- and post-completion of the EDP-centric class. This instrument has two components: a survey and a knowledge assessment. The survey aims to capture students' self-reported knowledge, attitudes, and behaviors around their experience with STEM; research, engineering, and communication skills; interest in studying STEM in high school and college; and STEM career interests. The survey questions consist of researcher designed and adapted items as well as pre-existing measures from the Partnerships in Education and Resilience's (PEAR) Common Instrument Suite [12]. The knowledge assessment measures student ability to use core EDP concepts and skills in simulated design scenarios. It includes original items as well as items adapted from National Assessment for Educational Progress (NAEP) Technological and Engineering Literacy Assessment [13].

During course implementation, the teachers complete weekly logs documenting student reactions to the weeks' activities and lessons, lesson efficacy (including challenges they faced and how they addressed them), and any curriculum modifications from the summer program planning. These logs provide a view into how the teachers adapt and adjust the planned curricula based on their actual experiences during implementation. Monthly observations of the classroom are also conducted by the evaluation team. These observations focus on evidence of student engagement and/or disengagement with, and understanding of, the lesson at hand and the underlying EDP principals and skills. These observations provide formative course assessments that can be used to refine specific lessons, activities, or even specific pieces of technical vocabulary that may give students difficulty. Finally, the evaluation team conducts focus groups with participating students after completion of the courses in order to gather further feedback on the courses and students' experiences in them.

These evaluation tools will be used to provide a comprehensive assessment of the teacher preparation, which will inform program refinement. The summer after teachers implement their courses, they are invited back to the curriculum development weekly workshops to share the outcomes of their courses. These alumni work with the new cohort of teachers and program team to identify weaknesses or gaps in the courses created during previous summers and to re-design the curricula to meet these gaps. Returning teachers also provide critical classroom insights to new teachers in the co-learning experience, informing the next round of curriculum creation.

OUTCOMES

The Hk Maker Lab curriculum development effort began informally in 2015, when two engineering teachers from a local high school joined the high school summer program to observe the course and learn about engineering design process pedagogy (Figure 2a). One of the teachers from the informal 2015 co-learning environment returned during 2016 as part of a pilot run-through for the formal collaborative curriculum development effort. In the summer of 2017 the curriculum development effort officially became a part of the Hk Maker Lab programmatic activities.

(a) **(b)**

Figure 2 (a) Two teachers (rear) participating in the informal co-learning environment. **(b)** First teacher to participate in the official curriculum development effort.

One teacher joined during the summer of 2017 (Figure 2b) and is implementing her course during the Spring semester of the 2017-2018 academic year. The participant is a physics teacher with four years of classroom experience at the secondary level. With Hk Maker Lab guidance, she created and is implementing a novel EDP-centric course in a career and technical education school that focuses on students' development of strong communication, problem-solving skills, and technological literacy.

Feedback gathered from the participating teacher during her post-program interview supported the value of the co-learning environment. Firsthand observation of the student groups helped her understand the challenges they faced dealing with open-ended, project-based work: "*I can still see how many students are hesitant to try new things. Each group has its own dynamic. I now feel better equipped to predict what problems might arise in a group dynamic.*" Similarly, she told the evaluation team that the co-learning environment showed her that challenges faced by students carrying out the EDP could be valuable learning tools: "*Observing the summer program helped me realize that not all struggle is negative and that it can actually be productive; I want to bring that aspect of the summer program into my classroom.*" The teacher also said that she developed an understanding that EDP-centric courses push students to become experts within their specific project areas: "*Students are ultimately the masters of their own projects. In the end, I want them to know more about their projects than me. I set myself an end goal of having the kids being the masters of their own knowledge both in terms of content and solving the problem.*" She also provided feedback regarding the value of the curriculum development workshops: "*…I felt like it was essential for the curriculum planning. I liked that*

Dr. Kyle opened up to answer any questions to clarify things. That took up a lot of time, but that clarification was very important for me to gain confidence in what I think engineering is. I liked the open but guided talking points... By the time Friday came around I realized what points I had, what I wanted to work on... This helped me gain confidence to go back to my students and explain these things."

Some critical feedback was provided as well. The teacher commented on the high-performing student participants in the summer program. She noted that in her classrooms, students would not be self-selected and thus would not necessarily bring the same level of enthusiasm as the students in the summer program: "*The amount of guidance [the Hk Maker Lab students] need to keep struggling and not give up, after they hit rough patches, is not an accurate portrayal of what happens in my classrooms.*"

Feedback from the 2017 teacher participant also provided valuable guidance on potential improvements for the curriculum development efforts. Three major suggestions emerged:

1. Consolidate the four virtual workshops into a single, longer workshop that takes place closer to the start of the co-learning experience for ease of scheduling, introducing the EDP concepts closer to the start of the summer program. "*Looking and talking about something theoretical especially for a hands-on topic like engineering; I don't remember anything! One pre-meeting to set expectations and introduce general structure of the program, teacher involvement, what support they will receive, go over literature/articles and slides that were shared before. There were 4 different meetings, coordinating was difficulty, 4 hours over 3 weeks… I suggest one meeting, maybe longer [than the individual 1-hour meetings]*."
2. Formalized, written observation and reflection journals with specific prompting questions to help participating teachers document their observations and preliminary suggestions for how EDP could be implemented in their classrooms. "*I wish I would have kept more of a personal diary. Each day I was going by, hanging out with students; they were working really seriously and I was asking questions. I also would have written about feelings I had, 'this student did this, or that students did that.' It would have been more informative.*"
3. Longer and more comprehensive end-of-day review sessions to further help them collect their thoughts, experiences, and observations.

This feedback will be used to refine the collaborative curriculum design experience in order to better support teacher learning and development. In particular, the last two pieces of feedback indicate a desire by teachers for even more time to discuss, record, and review their observations and experiences with students in the co-learning environment.

The 2017 teacher participant entered the curriculum development program with the goal of creating a physics course that uses engineering design to augment students' engagement. The resultant course is a single-semester physics class structured around the engineering design process. Each week, students will participate in lessons on the EDP, progressing through each stage while engaging in group activities that challenge them to practice and develop engineering skills. Laboratory procedures provide students with the chance to engage these skills in an applied manner while developing physics content knowledge. Each laboratory is one to two weeks long and begins with three days of physics lessons and exercises. The procedures that follow focus on utilizing the physics concepts in coordination with the EDP to solve mechanical problems and machine design (see Table 4). These lab procedures will challenge students to utilize EDP skills like defining problems, creating functional requirements and design constraints, and testing and refining prototypes. The EDP approach is expected to stimulate the students to develop their own physics knowledge through self-guided inquiry. This course begins in February 2018 and will be rigorously assessed using the aforementioned evaluation methodologies.

Table 4. Sample of EDP-centric Physic course from 2017 teacher participant

Day	Focus	Key Questions for Students	Lesson Objectives/Goals	Performance Outcomes	Activities/Handouts
1	Energy and work	What are the physics concepts involved in the design and operation of a mousetrap car?	Introduce students to the physics concepts of energy and work. Focus on distinction between kinetic and potential energy and ways to convert from one to the other.	Students can identify sources of potential energy and begin to conceive of methods for converting it into kinetic energy.	Mousetrap vehicle design lab procedure_01
2	Energy and work, tension, design ideation	How can we use the materials available to design a mouse trap car that can power itself? How can we power the car? How can we connect the energy source to the wheels? How can we connect the wheels to the mousetrap?	Show the students the available materials and challenge them to identify the objects that will form the most important components of the car. Students begin sketching their first mousetrap car design.	Students can identify mouse trap as source of potential energy and realize that tension (via string) can be used to transfer resultant kinetic energy to wheels. Students produce preliminary sketches of their mouse trap car designs.	Mousetrap vehicle design lab procedure_02
3	Design fabrication	How can we turn our design into a physical prototype? What changed from our design to our actual prototype? How well does our prototype work compared to our performance goals?	Students will build their prototypes and execute a basic test to see how well they perform on two parameters: distance travelled and average speed.	Students can convert their sketched designs into realized physical prototypes. Students can explain why they made any design changes when constructing a prototype from their sketch.	Mousetrap vehicle design lab procedure_02

PRELIMINARY CONCLUSIONS AND FUTURE WORK

Hk Maker Lab has created a collaborative curriculum development effort that leverages our existing summer high school program as a co-learning environment for teachers. Secondary school teachers are introduced to the EDP via participation in the Hk Maker Lab high school summer program. This experience allows teachers to observe student reactions to engineering content and practices firsthand, providing valuable insights into the challenges of EDP instruction. These experiences are synthesized during the summer to collaboratively adapt the Hk Maker Lab summer EDP curriculum to high school STEM classrooms. Teachers then introduce the new standards-aligned instructional materials in their schools during the subsequent academic year. The resultant courses are assessed and refined using classroom observations, student surveys, and teacher interviews.

The next major phase of this program is to fully implement our evaluation tools. These tools have been in development since 2016 and are currently being employed for program and course assessment. The initial evaluations will be used assess students' performance with respect to the overarching Hk Maker Lab curriculum development program goals (see INTRODUCTION) and to inform ongoing refinement of teachers' design-centric courses. In this way, the program will adopt a design-based research methodology that will iteratively refine and adjust engineering design curricula to optimize their performance in specific learning contexts. We recognize that each school and even each classroom is different, and a "one-size-fits-all" engineering design curriculum will likely not be applicable for many classrooms. By using an iterative and collaborative curriculum design methodology that invites teachers into the creation process, we hope to produce a range of curricular materials that can be made widely available, even to teachers whom we cannot reach geographically.

Employing the model described in this paper, we aim to create engineering design courses for high schools that increase students' knowledge of engineering principles and their overarching interest in STEM. Engineering and engineering design are critical for students at all levels; we propose that design is particularly important for students from underrepresented minority groups or economically disadvantaged schools, which are the target populations for the Hk Maker Lab. Our hypothesis is that engineering design will be an attractive learning paradigm for these students as it will engage their STEM knowledge while stimulating them to define and solve problems in real-world contexts. Accordingly, it is critical that teachers are properly trained to teach students how to uncover and take on the multi-faceted challenges that arise in design. Our co-learning environment and curriculum development are devised to give high school teachers the tools that they need to create engaging and effective design-centric courses.

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