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Project DECIDE: A K12 Civics and Engineering Education Curricular Partnership (Works in Progress)

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Introduction

Many have expressed concern about ethics and civic-mindedness of engineers and their reflection on their responsibility and public impact of their work[1]. Universities hope to graduate ethical engineers, but may not have intentionality about the education towards civic responsibility. Lin and Hess[2] argued that civic responsibility requires special attention in engineering education. Hess and Zola[3] found that few youth are educated on how to civically engage real-world problems, creating a large burden on civics teachers to have greater knowledge of how to solve community problems, some of which are engineering-related. Thus, that lack of knowledge of the connection between engineering and injustices would follow students into engineering programs. While some engineering educators are attempting to integrate civics-mindedness and responsibility into undergraduate and graduate training, Project DECIDE (Developing Engaged Civic Curricula Integrated with Design-Thinking Education) aims to engage grand challenges in society via a crossover strategy by integrating design-thinking and engineering design principles into K12 social studies education.

The project develops digital civic education modules that can motivate civic engagement in middle and high school students and expand design thinking and engineering design beyond traditional STEM courses only. Project DECIDE teaches middle and high school teachers engineering and design thinking so that they are empowered to teach students outside of STEM courses and apply such skills to social problems. Aligning with American History, Civics, and Government courses, the curriculum helps students understand and address systemic inequities in their communities and demonstrates how civic knowledge and engineering thinking can influence public policy. Project DECIDE links civic purpose, knowledge, and skill with problem-solving, math, science, and engineering to understand historical challenges, identify injustices, and attempt to be change agents within their local communities. The five-year project includes curriculum development, mobile app development, teacher professional development, and

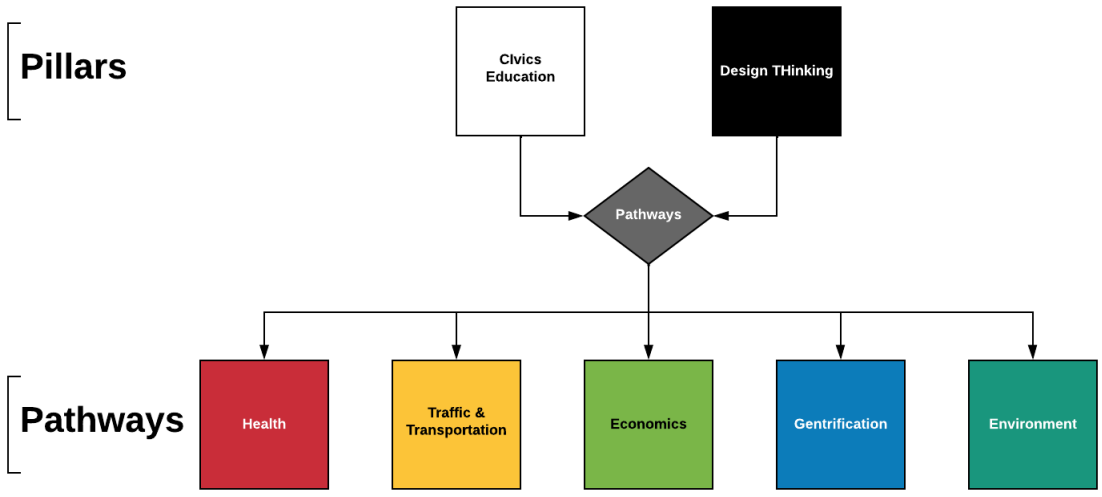

Figure 1 Curriculum organization and sequencing. All students engage in PILLARS, and then teachers choose from PATHWAYS, which are not linear or sequential.

piloting of modules. This manuscript describes curriculum overview, description of development, and progress made in Year 1.

Description of Curriculum

Project DECIDE, a curriculum developed through Backward Design[4], is organized into what the curriculum team have labeled as PILLARS and PATHWAYS (Figure 1). The PILLARS are the foundational modules that all students take to acquire skills in civics education and design and engineering thinking. There are two PILLARS: Civics and Design Thinking. A module is defined as lessons teachers implement that contain content and learning experiences organized to create a clear learning path for students. The civics education pillar will consist of 4 modules (1.a: What is an effective citizen; 1.b: Principles of democracy; 1.c: Democratic practices and institutions; 1.d: Authentic civic actions). The design thinking pillar will consist of 2 modules (2.a: Identifying problems and 2.b Addressing problems) that delineate iterative modes that encourage students to empathize, define, ideate, prototype, and test[5]. There are explicit empathy and ethics exercises to inspire systems thinking. The PILLARS are completed first, integrating citizenship fundamentals and design thinking and the engineering design process into both PILLARS. Though they both integrate both skill families, the content is inversely proportional, as shown in Figure 2. Each pillar presents students with a case to address civically with an appropriate solution. The solutions may be tangible products, processes, or models. After students complete both PILLARS, they will practice both civics knowledge and design thinking skills repeatedly through engaging in the PATHWAYS.

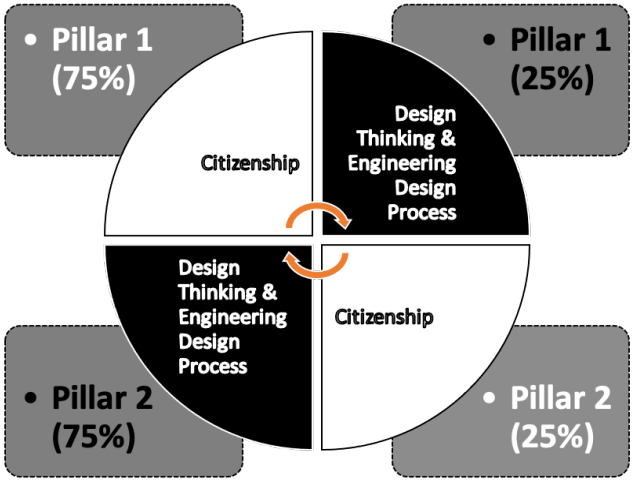

Figure 2 Graphic showint the composition of PILLAR 1 and PILLAR 2 having both Citizenship and Design Thinking and Engineering Design Process.

PATHWAYS are thematically based curricular units reflecting categories of injustices that have great impact at the individual and community level which can also be connected to each other to highlight systemic consequences. There are five PATHWAYS: *Health*, *Traffic & Transportation*, *Economics*, *Gentrification*, and *Environment*. The PATHWAYS have historical roots and policy decisions intended to sustain inequities which led to engineering artifacts that continue to have impact on students and communities today. One such example is the evolution of transportation systems across the nation. The gentrification PATHWAY highlights a phenomenon that is a ripple effect of redlining, which has connections to housing, schools, pollution, economics, and the environment.

After completing the PILLARS, teachers have the freedom to choose PATHWAYS in any sequence that is most compatible for their local context. Each PATHWAY has multiple cases that allow teachers to address injustices that connect to STEM content while pursuing civic processes. Figure 3 shows how the Environmental Justice PATHWAY will have cases related to

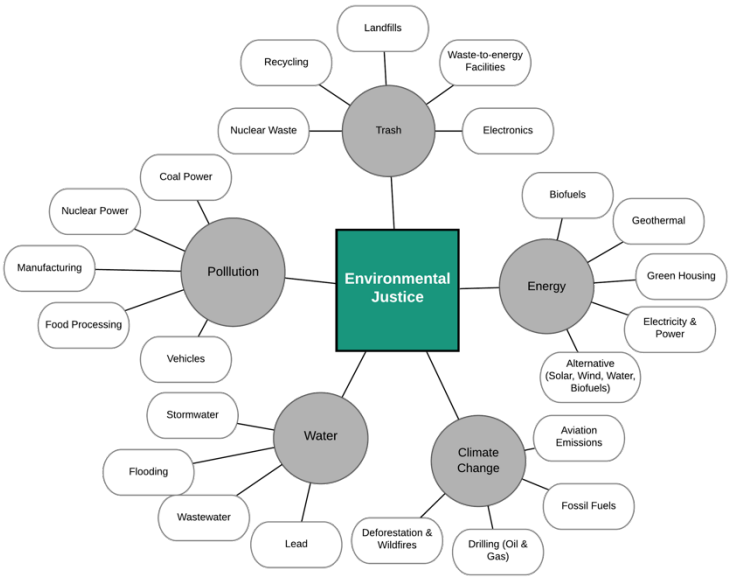

Figure 3 Example map of themes and subunits within the Environmental Justice Pathway.

trash, pollution, energy, water, and climate change. The cases are urban, suburban, and rural locations distributed nationally so that students can choose diverse sites to explore. The cases are wicked, real-world problems[6] selected such that they have historical information about policy decisions and legislation, present opportunities for students to conduct research, apply social study skills and design thinking processes, and attempt to provide solutions as they pursue civic engagement. When the problem or solution is STEM-based, the curriculum provides a developmentally appropriate explanation of STEM concepts so teachers and students can connect constraints, opportunities, resources, and consequences. As students are in the PATHWAYS, they are challenged to identify problems related to their local community and attempt to improve them.

Within each PATHWAY are subunits that may or may not overlap with all modules, but each module has multiple entry points for teachers to situate their local classrooms. Figure 4 shows how Pollution can be a module with different subunits that overlap in different ways the PATHWAYS. For example, Asthma would be highlighted in the Health PATHWAY as a result of Pollution from Plant Sitings or Aviation, and Aviation would be connected to both Traffic & Transportation and Environment. Plant Sitings would be connected to Gentrification, Environment, and Health through Pollution. These connections are made through selected cases of cities across the country where injustices may be layered and systemic and create many problems for citizens.

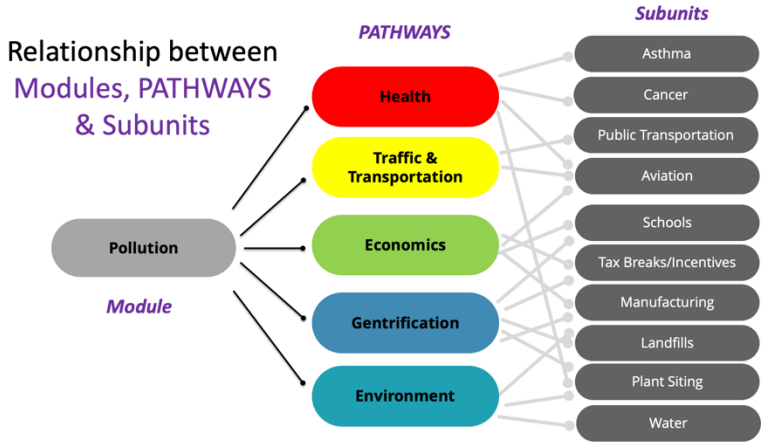

Figure 4 Relationship between PATHWAYS, Modules, and Subunits

Description of Curricular Technology Supplemental Features

To incorporate the digital lives of youth, Project DECIDE is composed of curricular modules and a mobile-enabled web-based app designed to complement the curriculum. The app allows

students to become digital archivists using their personal devices das they navigate their communities daily and identify local problems. Students capture and document problems along with the pathway they are studying. Participatory Archives blend participatory mapping and community-driven archival research methods. In this way, students choose problems that are meaningful to them and apply to their communities[7]. The app also connects to an online community comprised of other classes and students using the same curriculum. This online community creates a community of practice for both teachers and students[8]. The online community and app allow students to crowdsource data points and brainstorm ideas. The app is designed such that GIS, metadata, and student responses to questions are collected for analysis. Figure 5 describes the overall process of the Project DECIDE curricular intervention.

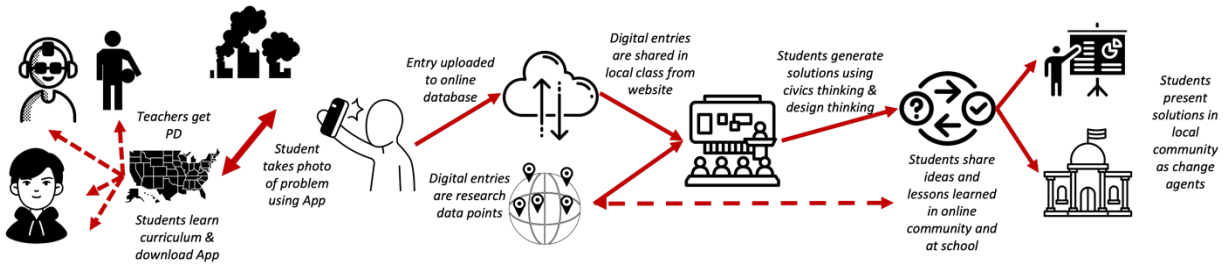

Figure 5 Project DECIDE Intervention Process

ANTICIPATED CHALLENGES AND TAKEAWAYS FOR ENGINEERING EDUCATORS

The project team consists of transdisciplinary scholars that are modeling co-construction of the curriculum and experiencing the tensions created from differences in the language and lenses of the disciplines. We have experienced and anticipate having to overcome perceptions, misconceptions, a managing content equality to reflect equal importance of the civics and engineering thinking. We will have to break down perceptions that impact self-efficacy of the instructors. We anticipate having to correct misconceptions and clarify priorities between civics and engineering which do not align. For example, ethics in civics and ethics in engineering potentially differ dramatically, and the stakeholders need to acknowledge chasms and highlight the overlap. Also, both disciplines have constraints, but the responses to constraints may differ, and we have not discussed or documented them. We anticipate that social science educators at the college level could be intimidated by STEM concepts and reject the nonlinearity nature of engineering problem-solving just as K12 social studies teachers. The benefit of the curriculum is the introduction of STEM concepts in non-engineering courses such that it is digestible by K12 teachers and students, which is one of the roadblocks to this kind of work. Engineers assume a background with foundational knowledge in physics, chemistry, biology, and mathematics when educating that make concepts like biofuels, nuclear power, materials, and climate change extremely abstract for non-engineering instructors. Engineering educators and non-engineering educators need to communicate and generate collaborative third spaces which may reflect importance of civic-mindedness in engineering towards justice.

NEXT STAGES

Teacher and Advisor Feedback

Prior to Teacher Professional Development, the PILLARS and PATHWAYS will be reviewed by teachers and the Advisory Panel for content. Over three sessions, advisors will review and document feedback individually and as a group to share with the development team, clarify questions, and suggest revisions.

Teacher Professional Development

Teachers will participate in a week-long professional development to learn how to implement PILLARS units, improve understanding of engineering design process and design thinking, learn about the PATHWAYS modules, and explore and practice using the mobile App. We will take teachers through cases to increase their comfort level with all the aspects of the curriculum and technology. The teacher professional development plan is shown in Figure 6. Although the PD is only one week, the research team will be providing online support throughout the academic year.

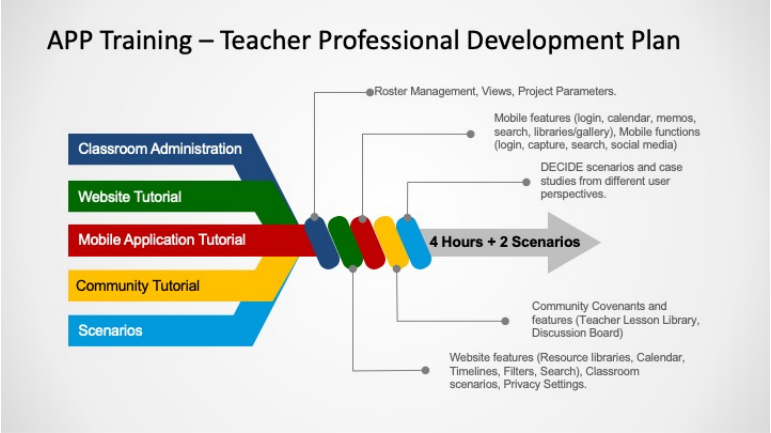

Figure 6 Teacher Professional Development Plan

Usability and Feasibility Testing

There will be usability and feasibility testing of the curricula prototypes. We will run usability studies via thinkalouds with four teachers, and then tests with classes of at least 20 students. We will conduct teacher interviews, conduct observations as curriculum designers, and researchers will address alignment of data formats to the research questions. The research team will be using the Civic Assessment Survey Instrument with pre-, mid-, and post-field tests to assess the impact of the curricula.

FUTURE RESEARCH: PILOT STUDY

After the curriculum is completed, we will conduct a pilot study for 40 teachers (20 treatment, 20 control), totaling about 800 students. The Expectancy-Value-Cost for Professional Development scale (EVC-PD)[9] will be used to gauge teacher motivation to implement modules. The team will measure effect of modules on student civic purpose, knowledge and skill, empathy and self-efficacy. After the curriculum is implemented in classrooms, we will measure if the intervention supports academic success as measured by state standardized tests (i.e., ILEARN, End of Grade, End of Course). We will also measure changes in empathy, ethics, and systems thinking of the students with assessments generated to complement the curriculum.

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