

Entry Points for Authentically Integrating Social Justice into the Engineering Design Process

Engineering, both a profession and a framework for problem solving, has become a buzzword in education over the last decade. Outside of the classroom, we hope that engineering practices and policies are harnessed for social good. We hope that when engineers design, they design for change: to make lives better, easier, safer and more just. The reality is, there have been plenty of engineering projects that have actively harmed historically marginalized groups, ranging from **civil** to **biomedical** engineering. How do we support the engineers of the future in being empathetic, socially conscious designers? We have faith that the current students being attracted to careers in engineering love STEM, but that they also see a purpose and goal to their practice. What we, the Knowles Engineering leadership team, made up of classroom teachers, coaches, consultants and curriculum designers, have struggled with is this holy grail—engineering for social justice—in the secondary classroom itself. We hope that middle and high school students learn about engineering as STEM for social justice **before** they learn about engineering as a job that is dominated by white men, one that has math classes as gatekeeping tools. We hope that **before** they reach university, they see themselves as engineers and designers of a better future, and that they have an important role to play in the engineering community. However, creating this impact during standard high school classroom hours has been hard to achieve. Teachers are constrained for time, engineering design is a relatively new way to run a classroom, and the teaching profession, made up of mostly white women, has yet to be supported politically and socially to talk about how engineering can bring different communities justice, and that different perspectives are essential for designing an optimal world for our posterity to live in.

The Knowles Engineering leadership team has thought about how to give classroom teachers entry points into merging social justice with engineering design. It has taken us two years of conversations and feedback to articulate what it would actually look like to authentically bring engineering for social justice to the secondary classroom. Our conversations together have helped us draft a framework with four levels of integration that we hope will begin a conversation in the education and engineering community about how to expose students to engineering for social good early and often, so that more students see themselves as engineers, and when they move to post-secondary opportunities, they have an understanding of how they can use their skills to help their communities change

for the better.

A grounding idea in our conversation was the importance of voice, choice and empathy when supporting engineering design in the STEM classroom. Many engineers are designing for a community that they are not a member of; helping our students with empathy and perspective-taking is crucial to embodying just engineering practices. We also recognize that engineering design in the classroom can empower students by encouraging their voices, especially voices we may not hear often. The “other” perspective could be the key to solving a community issue, and we feel that a curriculum centered on justice encourages the learner to use their voice. Finally, engineering promotes choice and decision making in the classroom. Students have agency over what design they choose to pursue, and they have to think consciously about the consequences of their decisions. These throughlines—voice, choice, and empathy—are the foundation to what we believe are classrooms, learners, and curriculum that center on justice. The four-level framework is below and each level is summarized. Our foundational level is focused on good engineering practices that allow for student voice and choice, and provide students with the opportunity to learn empathy by taking into consideration the perspective of different stakeholders. Collectively, Knowles Engineering believes that **all** strong engineering design curriculum will reach Level 1.

Level 2 considers an engineering project that is linked to a social justice issue. A classic example is having students engineer a better crumple zone for a car or for an egg drop project. This alone does give students voice and choice (Level 1), but can be brought to Level 2 by thinking about who seat belts and car safety were originally designed for. This original stakeholder—a mid-sized man—does not represent the population that cars serve. Giving students this information and asking them to integrate it into their design process associates an engineering project with social good.

Level 3 uses engineering to address a social justice issue. One we have discussed as a team is heat islands. By asking students to consider the issue of heat islands, they will learn about red-lining and housing discrimination. By having them understand thermodynamics and specific heat, they can use STEM knowledge to propose a solution. An important consideration here is to make sure you are being clear with your students about whether their design mitigates, reforms, or abolishes unjust systems. It is important that students and teachers recognize the

limitations of time and resources in the secondary classroom. We hope that whatever type of solution a student designs, they are able to recognize its limitations and tradeoffs and will feel inspired to pursue this problem in the future when they aren't constrained by the standards, time, resources and materials in a high school curriculum.

The final level, Level 4, is a project that is fully student-driven. This level is something that we consider to be attainable for teachers with the time and freedom to design their own curriculum. This is an opportunity for students to be the expert in what is unjust in their own community, and create a plan using the iterative design process to solve this problem.

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
<i>Integrates equitable practices and culturally responsive teaching in engineering</i>	<i>Integrates engineering AND a social justice issue</i>	<i>Engineering design FOR a social justice issue</i>	<i>Fully student-driven engineering for a social justice issue</i>
All engineering should include: • Student choice • Student voice • Narrative • Empathy • Perspective-taking	This level takes a rich engineering project and associates it with a social justice issue and its implications.	This level uses STEM information to support a deeper understanding of a social justice issue; students will design solutions to a social justice issue based on their STEM knowledge.	This level turns the project over to the students. Students solve a social justice problem in their own lives using the design process.

Questions to consider: • Does my curriculum have students consider various stakeholders' experiences? • Does my curriculum offer student choice?	Questions to consider: • Does my curriculum expose students to the intended and unintended impacts of engineering design decisions? • Does my curriculum connect what we are learning in class to something outside of the classroom?	Questions to consider: • Are my students designing solutions that mitigate, reform, or abolish current unjust systems? • Does my curriculum center on a social justice issue and a stakeholder? • Does my curriculum use STEM content to design solutions that could be shared with those outside of our community?	Questions to consider: • Does my curriculum provide scaffolds for my students to consider other perspectives? • Does my curriculum have the tools needed for students to choose a social justice issue and design a solution independently?
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We still have kinks that we need to work out with this tool. First, we are working through what language to use instead of “Levels.” The language “level” implies that one is better than the other, and that this framework is a hierarchy. While we feel strongly that what we call “Level 1” is foundational for the other levels, we don’t want teachers to view it as a failing if they are repeatedly doing “Level 2” work in their classrooms instead of “Level 4.” We feel strongly that all “levels” help students connect the work they are doing to improving their communities. Again, we feel this will not only increase student engagement, but also help students see engineering as a profession for social good. The “level” that a teacher chooses to pursue is based on what works best for their classroom setting. Secondly, we realize there is a stigma around “engineering” for teachers as well. For example, we have found that many biology teachers think engineering is only for physics classrooms. The Knowles Engineering leadership team feels strongly that engineering is for **all** STEM teachers and students, and it is a framework for curriculum, not a content topic. This idea is reinforced by the Next Generation Science Standards (**NGSS**) and the Common Core State Standard focused on **modeling**. We want to support teachers and students in seeing that they use engineering design principles already in their classrooms, and they can identify these with students to design solutions to community issues.

This tool, which was drafted in the summer of 2022, is meant to help educators

work towards the ideal of authentic social justice integration into the STEM engineering curriculum, and we know this will take time and practice. The Knowles Engineering leadership team recognizes that this framework is just the first step in creating a community around social justice in engineering, and we are excited to share our work to receive constructive feedback on our initial ideas. Our hope is that if we start having this conversation now—about how we can support teachers in bringing justice into their designs—then we can expose all high school students to their value and the importance in engineering socially just solutions to the design problems of today and those of the future.