

Finding a Passion and Making It Happen: A Program's Approach to Promoting Entrepreneurship, Making, and Innovation through Hands-On Projects that Benefit Society

Timothy Joseph Balz, Rose-Hulman Institute of Technology

Tim is a student at Rose-Hulman Institute of Technology that founded an endowed program as well as a maker space during his junior year. Before attending Rose-Hulman, Tim founded an international charity that has been recognized by the Red Cross and dozens of other organizations for their work providing wheelchairs to those in need. Tim is a recognized inventor for an all-terrain wheelchair targeted at helping veterans that he built the summer before his freshman year. Tim has been recognized for a device that he created while at an Intel internship, and has since worked on industrial robots in Detroit and rockets at SpaceX.

Dr. Ashley Bernal, Rose-Hulman Institute of Technology

Ashley Bernal is an Assistant Professor of Mechanical Engineering at Rose-Hulman Institute of Technology. She received her PhD from Georgia Institute of Technology in 2011. She was an American Society of Mechanical Engineers (ASME) teaching fellow and Student Teaching Enhancement Partnership (STEP) Fellow. Prior to receiving her PhD, she worked as a subsystems engineer at Boeing on the Joint Unmanned Combat Air Systems (JUCAS) program. Her research areas of interest include piezoelectrics, nanomanufacturing, optical measuring techniques, and intercultural design.

Dr. William A. Kline, Rose-Hulman Institute of Technology

Bill Kline is Professor of Engineering Management and Associate Dean of Innovation at Rose-Hulman. His teaching and professional interests include systems engineering, quality, manufacturing systems, innovation, and entrepreneurship. As Associate Dean, he directs the Branam Innovation Center which houses campus competition teams, maker club, and projects.

He is currently an associate with IOI Partners, a consulting venture focused on innovation tools and systems. Prior to joining Rose-Hulman, he was a company co-founder and Chief Operating Officer of Montronix, a company in the global machine monitoring industry.

Bill is a Phi Beta Kappa graduate of Illinois College and a Bronze Tablet graduate of University of Illinois at Urbana Champaign where he received a Ph.D. degree in Mechanical Engineering.

Jessica Livingston, Rose-Hulman Institute of technology

Jessica Livingston is an associate professor of English at Rose-Hulman Institute of Technology. She received a B.A. from the University of Georgia, an M.A. from the University of Kentucky, and a Ph.D. from the University of Florida. Her areas of interest include engineering communication and pedagogy, humanitarian engineering, the intersections of gender and work in a global economy, and documentary film.

Mr. Stephen Michael Misak, Rose-Hulman Institute of Technology

Stephen Misak is an Engineering Physics Major Senior at Rose-Hulman University of Technology. Tim Balz and Stephen Misak co-founded the Make It Happen Program in Fall of 2015. While Stephen is passionate about MEMS, laser systems, and sensor technology, he also is driven to find innovative solutions for improving the world, one cause at a time.

Finding a passion and Making It Happen: A humanitarian framework for promoting an entrepreneurial and maker mindset through hands-on projects

The Make It Happen program (MIH), at Rose-Hulman Institute of Technology, is aimed at providing opportunities for students to gain meaningful, hands-on design experience and to participate in humanitarian projects while earning academic credit. These projects are focused on connecting a team of motivated students with a client to develop a useful solution to their problem. The academic curriculum does not include many opportunities to connect classroom learning with practical design prior to senior capstone projects. Providing students this opportunity not only helps make the world a better place, but it also changes what it means to be an engineer, instilling a sense of global value into their work. The goal of this paper is to illustrate the entrepreneurial mindset that students develop through this program and to explain the simple steps necessary to create a similar program at another university.

In the fall of 2015, an undergraduate student with previous experience developing wheelchairs, partnered with other students and professors to develop a student-led program that works to find humanitarian clients, connects them with a team of students led by a faculty advisor, and funds their work. Developing a strong work relationship between students and professors is critical to creating the environment for the maker mindset to flourish.

Currently, MIH involves over 20 students per quarter, working on 5-6 projects simultaneously. More than 20 projects have been completed since the start of the program, such as creating a gait trainer for a young child with cerebral palsy, developing science kits for children in underdeveloped countries, developing a voice synthesizer, and creating a custom fit pack for a service dog designed specifically to hold a laptop, etc. See Appendix A for a table of all past MIH projects. These projects have not only transformed the lives of those in need, but they have also helped nurture a culture of diversity and global community on campus. Through the humanitarian structure and maker oriented working environment, these projects foster an entrepreneurial mindset as defined by KEEN's 3 C's (curiosity, connections, and creating value) by promoting creative design while building connections between classroom learning and practical applications.

Literature Review

In "Academic Maker Spaces and Engineering Design," Vincent Wilczynski documents the increasing presence of makerspaces on college campuses as a result of the increasing awareness of the value of open-ended problem solving and team-based active learning. These spaces provide a positive environment for meetings, networking, and they encourage the development of new skills. By learning these new skills, students can understand the connection between the design and fabrication of a product so that they do not design things in such a way that they are difficult and expensive to manufacture. Barrett et al. suggest that "Maker spaces have an opportunity to revolutionize the current system by providing an extra-curricular means for students to engage in more hands-on projects and develop a large range of the skills that are currently being underdeveloped. Maker spaces go beyond the traditional machine shop environment familiar to the undergraduate curriculum offering access to rapid prototyping

equipment and conceptual design spaces coupled with a unique culture that can be transformative to its users.”

In their synthesis on the humanitarian engineering literature, Campbell and Wilson suggest that humanitarian engineering “provides a broader context than is found in mainstream engineering courses” and therefore can better address ABET learning outcomes F (professional and ethical responsibility), H (understanding the impact of solutions), and C (design within realistic constraints), with a particular emphasis on ethics (Cambell and Wilson). Humanitarian engineering programs can also increase the diversity of engineers. The Colorado School of Mines found that while women comprised about 23% of their seniors completing multidisciplinary capstone projects, 50% of the students completing humanitarian senior design projects for the humanitarian engineering minor are women (Skokan, 2005). In addition, the community engagement program EPICS at Purdue has been successful in attracting and retaining women; Matusovich, Oakes, and Zoltowski’s study revealed that participants joined the program to gain engineering experience and they argue that “women are seeking ways to gain engineering experience in a setting that is comfortable to them.” Thus, the combination of humanitarian projects and maker spaces provides an excellent opportunity for creating a diverse community.

Program Structure

The MIH program was created by and is primarily run by students with the assistance of faculty advisors. A core team of students and faculty make up the Executive Board. This Board meets weekly to manage the day-to-day operations of the program, which include communicating with existing teams and clients as well as implementing changes to improve the program. When developing and maintaining the MIH program, the collective mindset of this group is critical to preserving the culture and ethics of the overall organization. The members of the executive board earn their position through involvement with MIH projects and active dedication to improving the program. In addition, an Advisory Board, consisting of a larger, diverse group of faculty and students who have participated in a previous MIH project, provides input on funding for each project and suggests professors to advise each project.

Each quarter, an open forum is held for students to discuss the details of the projects that are available for the following quarter. In addition, a guest speaker is invited to help inspire the students by discussing the importance of helping others. After the open forum, students fill out an application form in which they rank their top project choices and write a paragraph stating the reasons they are motivated to work on the project. Faculty members on the advisory board rank the students using these paragraphs, and the student ranking is then used to create teams for each project.

The MIH program employs a flexible system that can be easily adapted to a humanitarian need without the need to set up an elaborate program. When the founders of MIH wanted to find a way for students to receive course credit (2 or 4 credit hours) for a funded humanitarian project, they had to be creative since they didn’t have the ability to create a class or intricate program. By classifying the project as an independent study, a professor is able to provide credit and structure the project in such a way that matches the need. At Rose-Hulman, if a student has an idea or

topic of interest they would like to study but a class does not exist, they can find a professor to allow them to independently research or work on a project. The professor acts as an advisor for the project in addition to their course load, so the professors are typically already passionate about the topic and motivated to make a difference if they are willing to put in the additional effort. While the additional time required typically brings in the most passionate professors, it does restrict the ability of professors to advise MIH projects in addition to their regular class schedule. The independent study approach significantly reduces the barrier for students to gain practical humanitarian project experience, but it also limits the training that the students can receive in the philosophy and best practices of humanitarian engineering. In contrast to other humanitarian engineering programs that are carefully structured to teach what a humanitarian mindset is, the MIH program focuses on learning through direct experience. While this approach limits the students' exposure to the academic principles of humanitarian engineering, the project requires less up front curriculum creation, and is flexible enough to adapt to the changing needs of students and clients.

The MIH program is structured to provide students with opportunities to utilize their education in applied projects. Through MIH projects, students are able to make the connections between their classwork and the solutions to engineering challenges. Projects operate on a quarterly basis in order to fit with students' class schedules. In addition, the program uses the existing independent study option to structure the program. Students participating in projects register for an independent study which will count toward their tech elective and/or free elective requirements for graduation. The professor who agrees to supervise the project is responsible for mentoring the student team, meeting with them weekly, assessing their work, and assigning a grade for the independent study. Projects make use of work space in the MakerLab space on campus and have access to fabrication tools and materials. It is recommended that students remain under the 18 credit hour overload limit to ensure that they have adequate time to dedicate to the project.

The ideal MIH project team consists of 3-4 members with 1-2 curious and ambitious freshman who do not have extensive experience participating in hands on projects and 1-2 upperclass students who can act as mentors and use their academic experience to help overcome the difficult challenges. In addition to meeting weekly with their faculty advisor, teams are also responsible for providing a weekly update to the MIH Executive Board, presenting their design at mid-quarter, and participating in a poster session with their prototype at the end of the quarter. When possible, these sessions are held in conjunction with an open house for prospective students.

The first group of projects after the establishment of the MIH program were focused on meeting the immediate needs of a humanitarian client. To achieve this goal, the projects were structured as 1 quarter (10 week) independent studies. While this structure worked well for developing solutions to a variety of isolated humanitarian needs, the program has now established relationships with several nonprofit & charitable organizations, leading to more complex projects. In response, the length of the some projects has been extended to multiple quarters which helps further build the relationship. Developing a strong connection adds value to both MIH and the organizations by providing a steady flow of important projects. While these extended projects have helped connect the MIH program with other humanitarian efforts, the logistics of managing

projects has become more difficult. Many dedicated students are willing to help with projects, but they are unable to continue working on it over multiple quarters due to scheduling conflicts. This introduces the challenge of transferring the project documentation and responsibilities over to new students at the transition between quarters. In order to minimize the risk, the project advisor leads through the entire project and assists with the transition to new students.

When procuring projects and identifying clients, it is best to try and find a small grant to fund the project so that the recipient does not feel as though they are paying for the deliverable. It is often best to reach out to local charities with a technical need when trying to find clients. In order to provide the best experience for both the students and the humanitarian client, partners need to:

- Identify a need for a project that is not critical to the organization. This criterion is essential because there is no guarantee that a project will be successful. If a project fails, it can still be a learning experience for the students, but it's important that it's not a significant loss for organization.
- Exhibit a need which can be addressed by a technical team within the constraints of the quarter system at Rose-Hulman. This means that the project provides opportunity for the team to complete at least 10 weeks of work and have a physical deliverable (functioning software programs fall into this category). Projects ending early would be difficult for faculty advisors to grade as it is expected that students earn credits based on working for the entire quarter while multi-quarter projects must provide students with the opportunity to reach a milestone with a deliverable before the end of the first quarter.
- Be available to provide insight on the need, feedback on the project, and respond to communication from the team within two days to ensure students stay busy the entire quarter and have the information necessary to complete the project in a timely fashion.

Selecting students based on motivation

The MIH Program draws upon students' intrinsic motivation to participate in design projects and to contribute to society in a positive way. Each quarter students apply to be part of a project team. In their application, students can identify up to 3 projects in which they are interested. For each project, students describe why they are interested in the project and why they might be a good fit. The students should be driven by the opportunity to improve others' lives and excited about the specific design challenges that their project entails. Applicants are assessed on those criteria, and teams are structured so that there is a balance of experience with the project and/or field. GPA of students is not factored into this decision. By placing the focus on the student's mindset rather than on skillset, the MIH Program creates a unique environment for fostering the growth of curiosity and passion in engineering.

In their applications, many students write about their personal connection to a project, including their identification with the client. For example, one student wrote about their experience as a caretaker for her grandmother with dementia in her application to work to on a safety door handle that restricts access for elderly patients:

The summer after my freshman year I spent taking care of my grandmother as she developed dementia. I understand some of the difficulties associated with dementia, not only from a physical

standpoint but also an emotional. Additionally I know this is not just a problem for this patient in particular, but also a far spreading issue, as when my gran was going through it she was able to go through a "dementia proof" gate and go outside, only to get hurt shortly thereafter...By working on a project like this I hope that I can make not only some of the difficult and emotionally taxing experiences I had to go through as a caretaker easier for another family as they go through it, but also use my skill set better something that has touched my life personally.

In addition to genuinely wanting to help other caretakers, this student would likely bring valuable insight into the client's needs.

Similarly, in an application to design and build an assistive device for a veteran who is a triple amputee (has use of only 1 arm) to be able to cast, set, and reel in fish without the need for both arms, a student writes about their enjoyment of and knowledge about fishing:

[F]ishing is one of my favorite pastimes. I know the joy with reeling in a big one (or even a small one at times). I could not imagine living life without the ability to fish. If there was a way I could use my skills to give the thrill of fishing back to someone, I would do anything I could!I have been fishing my entire life because I come from a family of fisherman. I know different types of fishing (fly-fishing, panfishing, pitching), rods (ultra-lights, medium, heavy), and all the little things that make a big difference in the design of a prototype.

Student's motivation can also be based on a desire to gain and/or apply their technical knowledge in a meaningful way (without personal connection). For a museum app project intended to make the exhibits more interactive and engaging, a student commented:

I have always had an interest in learning about the past and random objects from other eras so an app for a museum would be a great opportunity for me to reignite that passion. I also have experience with programming and designing apps, and will be willing to put in many hours refining it.

Synergies between MIH and MakerLab

MIH also endeavors to foster a maker mindset: possess the curiosity and ability to identify a problem, understand what skillsets and resources are required to solve it, and show passion when carrying out solutions to these problems. MIH has developed a mutually beneficial relationship with the campus MakerLab. This is a maker space open for all students to utilize the tools, resources, and knowledge of MakerLab officers when working on personal projects. The MIH teams are allowed to store their projects within the MakerLab and are encouraged to learn how to use the different tools available. The MakerLab enables rapid innovations through 24/7 access to 3D printers, laser cutters, a cnc router, and an assortment of other hand and power tools. After working with all of the resources in the MakerLab, students often become regular users of the space and join the MakerLab club after their project. Thus, the MakerLab can utilize the MIH program as a recruiting tool to draw more students into the innovative environment.

MIH benefits from the MakerLab not only in terms of space and tools but also via MakerLab's "Ask A Maker" program where the executives of the MakerLab club volunteer to be available in the lab during the week. A schedule of when people are available to mentor can be found online and on a poster in the lab. The schedule includes the skills that each maker can teach, their contact information for asking questions when not on shift, and a friendly picture to help students

find the mentors. While this is available to anyone and not exclusively the MIH program, this tool is especially useful since the makers can provide build advice and an experienced helping hand to the teams whenever needed. By having MakerLab executives available to help teams, they can easily teach students how to safely use the available equipment so that students are confident enough to take advantage of those resources. When students increase their confidence in their technical abilities, they will be more comfortable learning to use other equipment and resources in their future work.

Benefits of Program and Project Examples

Participating in an MIH project enables students to develop technical and professional skills while engaged in meaningful work. The structure of the program--small collaborative groups that meet weekly with a faculty advisor outside of the traditional classroom--fosters a mentoring relationship between faculty and students. Working in a small group setting makes it easier for students to ask questions and even seek professional advice outside the scope of the MIH project. This structure can be particularly useful for freshmen who might gain a mentor who pushes them to do their best and get involved with opportunities on campus early in their academic career. The experience of participating in MIH helps students develop their professional identity and confidence, which can be especially valuable for students who struggle in the traditional engineering classroom.

The combination of the mentoring relationship with the open-ended, real-world problems shifts the focus of students from earning a specific grade to solving a problem. Because there is not a single pre-determined answer, students learn how to break down problems into solvable chunks. Throughout the process, they learn how to work in a team and how to justify individual design decisions. A crucial skill for a professional engineer is to be able to communicate, justify, and defend their decisions to a client or employer. Students who participate in the MIH Program are required to communicate, justify, and defend their purchasing decisions to their professor before any materials are ordered. In much the same way that an entrepreneur must balance their designs, deadlines, and budgets against each other, students gain experience working on a new problem, developing a timeline, and leveraging their budget to meet their deadlines. This dynamic helps students prepare for when they must participate in design reviews and justify their decisions once they enter the workforce.

The opportunities provided by the MIH program help underrepresented populations in the engineering field both through the projects we complete and the opportunity to work on the project itself. The partnership that the program has with Moldova allows students to work with translators to bridge the language barrier and navigate cultural differences. The percent of Asian and African American students in the MIH program is higher than the institute average with 18% Asian and 8% African American students compared to the institute average of 4.6% and 2.6% respectively (according to collegedata.com). In addition, the program has attracted a higher ratio of female students which is likely due to the opportunities the projects provide to use engineering to help others. Approximately 38% of the past project participants have been female while the institute average is only 23% female. Unlike some competition teams where people who worked on cars with their dads might have a predisposition to joining, anyone who has a passion for helping

people can join. For students who choose engineering as a profession because they want to help people, MIH provides students the opportunity to make that difference before they become a professional engineer.

Students also gain experience defining the problem and identifying the needs of the client. In one MIH project a team spent a quarter designing a project that they later learned was not feasible. Through the process they learned the importance of identifying the needs and constraints of the client. The team was working with a local food bank to figure out a method to transport food to the second floor of the building more easily since their volunteers, who are often older individuals, have difficulty with the steep staircase. Rather than visiting the site as a team, a single member visited the food bank and reported back that they wanted a food lift for their staircase and the team began designing immediately. By not analyzing the staircase, the team did not realize that this staircase is an emergency exit that cannot be obstructed by a lift. After analyzing the site and more thoroughly assessing the needs of the client, the team designed an outdoor lift to transport food between two outdoor windows without needing to modify the structure of the building. This project also gave students the opportunity to learn that the grand initial design may not be the best solution for the client.

Open-ended projects often require creativity and resourcefulness and are not easily solved by intuitive or existing solutions. One MIH project challenged a team to find alternative light sources for children in developing countries to help reduce the reliance on dangerous kerosene lamps. The team determined early in the project that within the constraints of ten weeks, they would not be able to make meaningful advancements in the field of solar energy, so they investigated alternative sources of power generation. After stumbling across a technology that converts heat energy into electrical energy using low cost Peltier Tiles, they theorized that the heat wasted from cooking fires might be harvested to charge batteries for study lights. The team performed tests using a hotplate and realized the tiles did not perform optimally at high temps so they began searching for more sustained ways to generate heat. After brainstorming, they realized that they might be able to use the sun to heat up the tiles by using a magnifying glass to focus light onto the tiles with the design shown in Fig 1. The team had to be creative to realize that solar energy could be leveraged in ways other than just using solar cells. The team was able to create a working prototype using page magnifiers and learned the importance of challenging their initial assumptions.

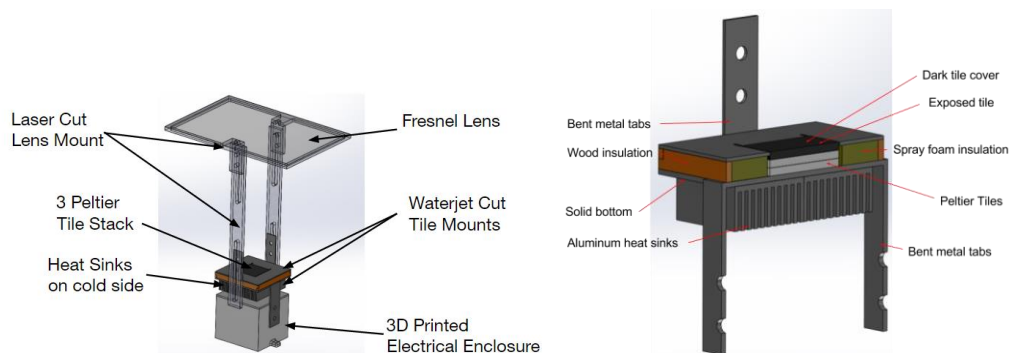


Figure 1: Thermoelectric generator CAD model using a stack of Peltier tiles

MIH projects also enable students to use their technical skills to benefit the community and to develop a humanitarian mindset. Projects that would not otherwise be developed because they are not profitable for the market are realized by students. The first MIH team successfully created a custom gait trainer for a child with cerebral palsy in Moldova, where he has access to limited medical equipment. The gait trainer has helped rehabilitate him to the point where he can walk almost entirely on his own shown in Fig. 2.

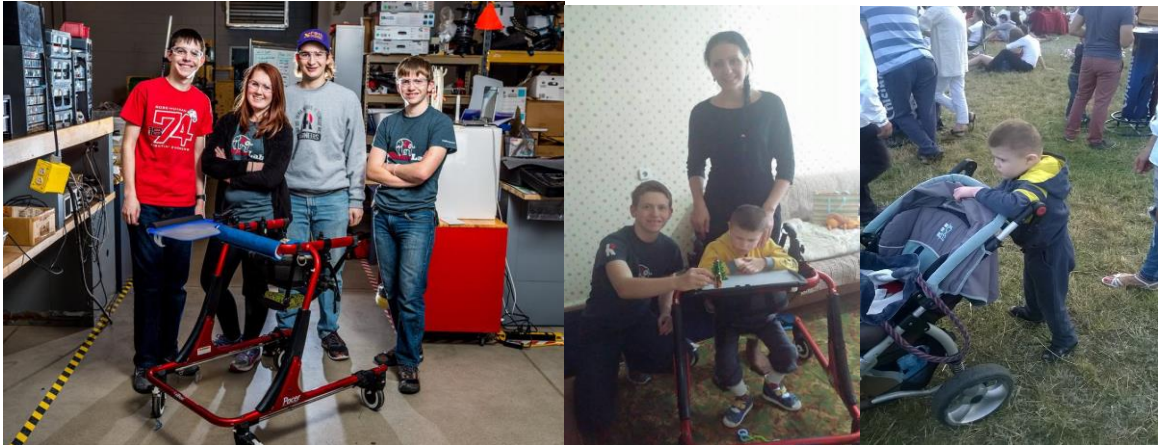


Figure 2: Moldova gait trainer project stages: (left) project team after completing the gait trainer, (middle) delivering the device to the child in Moldova, (right) dramatic mobility improvements after a few months.

Another MIH team developed a custom fit dog vest, shown in Fig. 3, for a service dog who needs to carry a college student's laptop. Most service dog equipment available for purchase is not designed to carry objects of that shape and weight. The custom fit pack enables the dog to carry the laptop and enhances the dog's mobility and comfort. Experiences such as these can be transformative, directly seeing the improvements in someone's quality of life. One of the students from the service dog team improved the design further after graduating. Several other students have continued to support the product or software they developed during their MIH project, even after the course was completed. The MIH program strives to provide opportunities for students to work on projects that make them feel important in a way that is not possible with classroom work.



Figure 3: Custom service dog vest for carrying a laptop case and other velcro attachments

Entrepreneurial Mindset

In order to innovate and create value for their client in only 10 weeks, students must embrace an entrepreneurial mindset. Since many of the projects that students undertake are on an accelerated timeline, they are forced to think outside the box and explore existing technologies to use as inspiration, pushing the Keen C of connections. The freedom to approach their project in whatever way they think creates the most value for their client requires students to carefully consider their stakeholders needs. The MIH program empowers students to see how an engineer must be driven by their curiosity to seek new opportunities, see the world differently as they make new connections between existing ideas, and generate value through the exploration of stakeholder focused opportunities. A student who has completed a MIH project walks away with more than course credit and a line on their resume, they walk away with an experience that demonstrates how all 3 C's of the entrepreneurial mindset--curiosity, connections, and the creation of value--come full circle to make a positive impact on the world.

The Make It Happen program was created to provide engineering students the opportunity to gain hands on experience through humanitarian projects as part of their educational curriculum. These projects teach an entrepreneurial mindset by putting students into situations that empower them to be curious and make connections between existing solutions in the world around them so that they can create value for their client.

Student Results and Feedback

In order to more fully assess the benefits of the program, student motivation, and impact, a survey was administered to all students who have participated in the MIH program. The survey was conducted by emailing the students from past MIH projects a request to complete the survey with a link to complete it using Google Forms. Out of the 60 past participants in MIH projects (several of whom have graduated), 20 students responded to the survey. This survey helps to ensure that the program is having the desired outcomes and to gauge the impact of changes to the structure of the program. As previously stated, the goal of the program is to promote a making and humanitarian mindset through hands-on projects that benefit society. Several questions were

asked on the survey to assess the above attributes. In order to analyze the focus of the survey responses, each survey question was independently coded by two people and the coding categories were compared. For each question, the survey results were used to develop several codes. Included below is an analysis of questions from the survey with an example response for each question.

What is the primary reason you were interested in the Make It Happen Program?

"I really like helping people, and I thought it would be a great way to get to help people as well as develop my engineering skills."

Nearly 70% of the students that completed surveys indicated that they benefited in terms of their making and humanitarian outcomes. Most students started their projects with a vague desire to help improve other people's lives, but they completed with projects with a deeper understanding of the impact that a few dedicated engineers can make on a community. Both sets of coding indicated that the humanitarianism and the desire to help people were strong factors in the decision to join MIH. The coding also showed that most students were motivated to gain project experience and solve real world problems. One of the coding word sets also showed that the academic credit and independence were important factors for a few students.

Having completed your project, what aspect would you say was the most beneficial in terms of your professional development?

"I would say it has been most beneficial to work as a part of a team and also to just be able to apply my knowledge from the classes I've taken. These projects are very true to what you experience in any "real" project you would see at your job. Sometimes you have to define your path when things are ambiguous and that has been so valuable for professional development (and you have to work through that as a team)."

The students consistently discussed the benefit of being put into a semi-ambiguous situation that relied on them to discover a solution much in the same way they would as a professional engineer. Many students find themselves asking why they are learning various things in a classroom, but this is a non-existent issue in a MIH project because students are living the benefit of their learning. When students are solving real problems, they understand not only how their classroom experience is relevant, but are also directing their own learning. In the survey coding, the development of communication skills was heavily emphasized in the responses. Many students discussed the benefits of improving communication within a team and between the team and a client. Student responses also highlighted the importance of increasing skills in engineering design and problem solving. Both coding word sets identified these points.

Looking back, what part of the program was most rewarding for you?

"It was incredibly rewarding we finished building the prototype, tested it, and got very promising results! The fact that we had designed and built a functioning device from nothing was impressive."

Providing students with the opportunity to develop their own solutions from design to prototyping allows them to develop a personal investment in the project. Creating a functional prototype for a humanitarian client can be incredibly rewarding for students as they reflect on not only the skills they have developed but the lives they can improve. This personal investment significantly boosts student motivation and helps them to see their results of their work from a positive viewpoint. Both sets of coding words showed a strong indication of satisfaction from helping people and from the

achievement of delivering a prototype to an enthusiastic client. The sense of achievement from learning new technical skills was also present in both word sets.

Do you feel that doing a second project would provide additional educational value?

“Experience was a big one. Being a freshman it really broke up the monotony of just sitting in classes learning about things and actually allowed me to get out in the world and do stuff.”

The intention of this question was to evaluate the effectiveness at instilling the core values of the programs mission. At its core, the MIH program emphasizes the value of project based learning. Several groups struggled with conflict during their projects, but all of the students surveyed expressed that they would benefit from working on another MIH project. From the feedback it is clear that students value their project learning experiences as highly relevant to their education. A clear “yes” was given in almost 90% of the responses with only a few students indicating a potential “yes.”

What are some changes that could be made to increase the impact that the program has on it's students?

“Simply making sure the projects are clearly defined and asking the clients for a detailed description of their situation before the teams even get started would be wonderful. Teams still need to talk to their clients, of course, but they should have some idea what the original situation is before starting.”

The above quote specifically calls for a better communicated project description from the clients. Improving overall communication was the common theme for a majority of the survey responses for this question. The coding words identified communication and project structuring as the two main areas for improvement. The responses expressed a desire for more communication between different MIH teams and between the MIH officers and all of the teams. A few responses also called for more examination and oversight of the projects to ensure that teams are able to resolve difficult problems and continually make progress.

The program is still refining its structure, so special attention was given to each suggestion and complaint. After much consideration, it was determined that more structure was needed prior to the quarter began so that students could fill out the necessary paperwork for the independent research, get acquainted with their team and client, and choose meeting times. This small amount of effort prior to the first day of the quarter could prevent the first week from being a setup week and allow teams to hit the ground running. Initially it was thought that students could benefit from being forced to discover the more specific details of the project and learn to ask more questions, but with the timeline being so compressed for projects this seems to be creating unnecessary communication issues from the start. To improve communication this quarter we added team liaisons. Each team interacts with a MIH officer on a weekly basis to ask questions in person and provide an update on the project. The MIH officers are also planning more events where all the MIH teams can discuss their projects with each other and build a stronger community.

Closing Remarks

The purpose of this paper is to provide an example of how simple it is for an engineering professor to bring the 3C's of KEEN into their curriculum. Students who participate in a MIH project are not only enabled to pursue their curiosity, it is essential to the success of their projects. Students are solving real engineering problems, so it is inevitable that they will be applying what they learned in the classroom while also seeking the additional knowledge required to create a valuable end product for their client. Engineers are hired to create value for their employer, and if a student only knows how to follow a syllabus, then they will not be prepared to anticipate unknown opportunities to create value. Learning core engineering skills is the single most important part of an engineering education, and by teaching an entrepreneurial mindset through programs that reinforce these skills, we are better preparing the innovators of tomorrow.

References

Barrett, T. W., & Pizzico, M. C., & Levy, B., & Nagel, R. L., & Linsey, J. S., & Talley, K. G., & Forest, C. R., & Newstetter, W. C. (2015, June), *A Review of University Maker Spaces*, Paper presented at 2015 ASEE Annual Conference & Exposition, Seattle, Washington. 10.18260/p.23442

Campbell, R. C., & Wilson, D. (2011, June), *The Unique Value of Humanitarian Engineering*, Paper presented at 2011 ASEE Annual Conference & Exposition, Vancouver, BC.

Gosink, J., & Skokan, C. (2005, June), *Gender Participation In Humanitarian Vs. Traditional Multidisciplinary Senior Design Projects*, Paper presented at 2005 Annual Conference, Portland, Oregon.

Kirkpatrick, S. R., & Watt, A., & Bernal, A. (2016, June), *Developing an Entrepreneurial Mindset in Engineers: An Application of the Three C's (Creativity, Curiosity, and Connections) in a Collaborative Summer Mega-Course* Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana. 10.18260/p.26745

Matusovich, H. M, Oakes, W, & Zoltowski, C.B. "Why Women Choose Service-Learning: Seeking and Finding Engineering-Related Experiences," *International Journal of Engineering Education*, Vol. 29, No. 2, 2013, pp. 388-402.

Martin, Lee (2015) "The Promise of the Maker Movement for Education," *Journal of Pre-College Engineering Education Research (J-PEER)*: Vol. 5: Iss. 1, Article 4. <http://dx.doi.org/10.7771/2157-9288.1099>

Wilczynski, V. "Academic Maker Spaces and Engineering Design." Paper presented at 2015 ASEE Annual Conference & Exposition, Seattle, Washington.

Appendix A

	Project Name	Duration	Brief Description
1	Damiano Accessibility for all Moldova	Fall 2015	Design and build a gait trainer to help a child maintain mobility
2	EdGear	Fall 2015	Design a custom dog pack for a service dog named Edgar to carry a laptop and other items
3	Communication and Synthesizer	Spring 2016	Design and build a communication device for a man with cerebral palsy and hydrocephaly
4	Engineering Education Kits bridge building with elementary school	Spring 2016	Design STEM themed kits for teaching elementary and middle school children
5	Smart Dog Collar	Spring 2016	Design and build a watch-dog collar device to alert a service dog when needed
6	Rein Trainer for Hope Haven	Spring 2016	Improve a horse riding simulation device used for equine therapy training
7	Virtual Classroom	Spring 2016	Design an App to allow teachers to interact with students using virtual reality
8	Chemically Heated Coat for Homeless	Fall 2016 to Winter 2016-17	Design a chemical lining for a coat that can save the homeless from freezing in winter
9	Force Sensing Gloves for Hope Haven	Fall 2016 to Winter 2016-17	Design, build, and develop code for a glove with force sensors to measure the assistance provided over time in equine therapy
10	Local Food Bank Food Transportation System	Fall 2016 to Spring 2017	Design and build a food elevator system to move food from the downstairs storage to the upstairs distribution in a food pantry
11	Accessibility for all Moldova standing wheelchair	Fall 2016	Design and build a mobile stander device for a child in Moldova with medical conditions and limited mobility
12	Engineering Education Kits with Plants	Fall 2016	Design and test an experiment for middle and high school children to examine the factors involved in plant growth using sensors
13	Lighting for Developing Countries	Fall 2016	Design and build a system to provide school children with a renewable source of energy for powering a small light to study at night
14	Floating Weather Station	Fall 2016	Design and build a sensor station for measuring weather conditions while floating on a lake
15	Database for Accessibility	Fall 2016	Design and code a database platform to assist organizations in Moldova with data collection and analytics
16	Electric Bike Assistance	Winter 2016-17	Design a electric bicycle that allows a person with arthritis to continue riding during times when pedaling becomes difficult
17	Fishing Rod for Disabled Veteran	Winter 2016-17 to Spring 2017	Design and build a fishing rod casting and reeling system for a veteran triple amputee
18	Mosquito Agitator	Winter 2016-17	Design and build a device to reduce mosquito population by preventing eggs from developing in stagnant water
19	Museum App	Spring 2017	Design and code an app for a local museum to provide guests with an interactive experience
20	Accessibility for All Communication Device	Spring 2017	Design and build a communication device for a child that is deaf and mostly blind
21	Safety Door Knob	Spring 2017	Design and build a specialized door knob to act as a cognitive check a person with dementia