Creativity, Innovation, and Ingenuity Summer Enrichment Program – Collaborating with a Cultural Institution and Assessment Results

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Mrs. Paula Gangopadhyay, The Henry Ford (museums)

Paula Gangopadhyay is the Chief Learning Officer for The Henry Ford which includes the Henry Ford Museum, Greenfield Village, Benson Ford Research Center, Ford Rouge Factory Tour, IMAX and Henry Ford Academy. She brings more than twenty years of experience in the cultural, education, policy and business sectors to her position.

In her current role as one of the core members of The Henry Ford's senior management team, Gangopadhyay is responsible for providing leadership, strategic direction, concept, design and development of 'education and learning' in a broad and comprehensive sense. The Henry Ford collectively attracts over 1.7 million visitors a year, and has a mammoth collection of 26 million artifacts. Gangopadhyay is responsible for a vast array of onsite, online and offsite programs, products and experiences for a diverse set of audiences including students, educators, youth, families, adults as well as for higher education and organizational leadership.

Gangopadhyay led the visioning of a dynamic education strategic plan at The Henry Ford as well as the conceptualization and development of many paradigm-shifting educational products and programs. She spearheaded and developed game-changing curricula, Innovation 101 and Be an Innovator series which are currently being enthusiastically adopted and implemented by educators nationwide. This initiative was accepted as a national commitment to action in the STEM category, at the Clinton Global Initiative, America in 2013.

President Barack Obama appointed Gangopadhyay as a member of the National Board of Museums and Libraries for a four-year term in 2012. She is the recipient of the 2012 American Alliance of Museums (AAM) EdCom Award for Excellence in Practice, the 2014 Michigan Informal Educator of the Year from the Michigan Science Teachers Association and the prestigious 2014 Faraday Science Communicator Award from the National Science Teacher's Association.

Gangopadhyay has a master's degree in history, certification in archival, museum and editing studies and a fellowship in education policy.

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Abstract

Creativity, innovation, the ability to identify a customer need, and using creative problem solving to develop new ventures/products/solutions are vital skills for entrepreneurship. These are also some of the most highly sought skills by employers of engineering graduates. Thus many engineering colleges are incorporating innovation and creativity into the engineering curriculum, but often the topics are delivered piecemeal over multiple courses, losing focus and continuity. Therefore, Lawrence Technological University in collaboration with The Henry Ford (a nationally renowned cultural, historical, and educational destination in Dearborn, Michigan) developed and administered a week-long summer enrichment program (i.e., summer camp) for undergraduate engineering students focused on progressively building from the foundations of the creative process/competencies to the application of innovative techniques coupled with engineering design and problem solving. The program was available to students of multiple engineering disciplines from across the U.S.

Throughout the week, the students explored the core competencies of creativity and innovation through activities and games, and they studied and implemented various methods of creative problem solving through teamwork on various problems and product development projects/tasks. To further emphasize innovation (and its relation to American history), two of the five weekdays were spent visiting The Henry Ford which includes the Henry Ford Museum, Greenfield Village, a Ford F-150 truck assembly plant, and the Benson Ford Research Center where they participated in a college-level version of The Henry Ford's Innovation 101 curriculum.

This paper will explain the objectives and format of the program, summarize the benefits of collaborating with a local cultural institution, explain how this program can be transferable to other universities, discuss sustainability of a multi-college summer immersive experience, and present assessment results compiled from three separate camp offerings over three summers. Three unique assessments were performed. The first assessment was a pre- and post-camp survey conducted to determine the students' general perceptions of creativity, problem solving, teamwork, leadership, the role of creativity in engineering, and their personal view on their own creativity. A comparison of the pre- and post-camp surveys yields a positive shift in student perceptions. The second assessment was a survey administered to the students at the conclusion of the week to measure student perceptions of the effectiveness of the program, the delivery techniques, and the format. Based on this student input, these assessment results allowed for the program to be optimized between summers and in fact yielded increasingly positive results from year-to-year. The third assessment was specifically focused on the visit to the cultural institution. The results helped to streamline the connection between the curricula of the University and the cultural institution as well as strengthen the connection between the tour sites and the entire week's curriculum.

1. Introduction

While many engineering courses focus on design and problem solving, at the same time familiarizing the student with basic technical content, very few also focus on the entrepreneurial mindset – a way of thinking increasingly required of engineers entering the workforce. Skills associated with the entrepreneurial mindset such as effective communication (written, verbal, and graphical), teamwork, ethics and ethical decision-making, customer awareness, persistence, creativity, innovation, time management, critical thinking, global awareness, self-directed research, life-long learning, learning through failure, tolerance for ambiguity, and estimation are as important in the workforce as technical aptitude. In fact, employer feedback has indicated that graduates with these skills are more highly sought than those with an overly technical education since technical engineering skills can be readily obtained on the job; the entrepreneurial mindset takes years of practice/refinement. In particular, extensive feedback from employers indicates that creativity and innovation are two of the most highly sought skills of engineering graduates. "Established companies understand the value of creativity…. IBM surveyed 1,500 chief executives in 33 industries around the world in 2010 to gauge how much they valued characteristics like creativity, integrity, management discipline, rigor, and vision in an increasingly volatile, complex, and interconnected world. Creativity topped the list."[1] Another survey of 305 employers conducted on behalf of the Association of American Colleges & Universities found that the one of the "most important skills employers look for in new hires" is innovative and creative thinking.[2] Further, 70% of the surveyed employers believed that colleges should place more emphasis on the ability to be innovative and think creatively. Earlier surveys have indicated the need for "creative thinking and problem solving"[3] or "the ability to define problems, gather and evaluate information, and develop solutions"[4], all of which are crucial to the creative problem solving process. More recently, an extensive survey of science and technology based employers found that making decisions/solving problems is one of the top skills needed in recent graduates, and that the skill has the largest gap between what an employer needs and what the graduate has.[5-7] It was further discovered that this is a skill that colleges should be responsible for developing. To summarize all these results, colleges of engineering need to be responsible for fostering skills in creative problem solving and innovative thinking. More specifically engineering graduates should be able to identify a customer need and use creative problem solving to develop new ventures/products/solutions. Therefore, Lawrence Technological University developed and administered (over three years) a week-long summer enrichment program (i.e., summer camp) for undergraduate engineering students focused on the creative process/competencies and the application of innovative techniques as these pertain to engineering design and problem-solving.

Why employ a week-long summer camp for fostering skills in creativity and innovation? Recently many engineering colleges have begun introducing innovation and creativity directly into the traditional semester-based engineering curriculum engineering curriculum[1], and in fact much of the camp content is derived from Lawrence Tech's Creative Problem Solving course.[8] A previous study revealed that either a camp or course format can accomplish the same goals and objectives.[9] Unfortunately, credit hours to obtain an engineering degree are limited, and introducing a new course into an already packed engineering curriculum may not be feasible. Students may not even have the option of adding the course as an elective. Thus many colleges introduce techniques for learning innovation piecemeal over multiple courses. Consequently,

teaching the processes of creative problem solving and innovation becomes disjointed among multiple courses. Alternately, the content could be integrated into an existing course (e.g., capstone/senior project). Unfortunately with this approach, the students will all be from the same institution and potentially all from the same major. A multi-institution, multi-disciplinary experience is highly conducive to learning creativity and innovation. More details are available in reference 9, but in particular, one camp student noted, "Having all of us work as groups from different schools made it so that we were able to solve the problems given to us using the skills taught at all of the different schools." In summary, a summer camp approach allows a student to supplement their packed standard curriculum, allows for concentrated focus on the topic, and allows for a multi-institution/discipline experience.

With this in mind, the program was open to any students within a multi-institutional collaboration known as the Kern Entrepreneurial Engineering Network (KEEN) composed of ≈19 engineering colleges spanning the U.S. dedicated to instilling an action-oriented entrepreneurial mindset in engineering, science, and technical undergraduates. Over three summers, the camp engaged students from twelve institutions and from at least seven engineering disciplines. While this summer enrichment program was hosted by the University, the program was facilitated in close partnership with The Henry Ford, a nationally renowned cultural, historical, and educational destination.

The KEEN program provides access to vital resources for building quality entrepreneurship education programs that engage engineering and technical students including grants, faculty fellowships, capacity building workshops, networking opportunities, and resources. More specifically, KEEN provides financial and developmental resources to grantee institutions for the development of entrepreneurship curricula, modules, and extracurricular activities like business plan/innovation competitions, speaker series, student entrepreneurship clubs, and seminars.

Despite exposure at their respective institutions, many students had a gap in learning experiences that promote creativity and innovation in problem solving and the engineering design process. The most successful entrepreneurs and entrepreneurial engineers are typically those that have creatively identified a need and continuously use creative problem solving to stay on the cutting edge and develop new ventures/products/solutions. Therefore, the week's instruction was designed to progressively build from the foundations of the creative process/competencies to the application of innovative techniques and creative problem solving (coupled with engineering design). Monday's theme was creativity, Tuesday focused on ingenuity, Wednesday focused on innovation, and Thursday/Friday focused on applying the creative problem solving/design process (see also Table 1).

Some wonder if creativity and innovation can be taught or if it is a gift that one either does or does not possess. It has been widely proven that creativity can be taught and learned at all levels of education.[10-13] Creativity and creative problem solving have specifically been taught successfully in engineering curricula for years.[8, 14-16] A review of teaching creativity in engineering and the need to do so has been done by Stouffer et al.[10] and is beyond the scope of this paper.

2. Objectives and Format of the Program

Throughout the week, the students explored the core competencies of creativity and innovation through activities and games. In addition, the students studied and implemented various methods of creative problem solving through teamwork on various problems and product development projects/tasks. To further emphasize innovation (and its historical relevance), two of the five days were spent visiting The Henry Ford which includes the Henry Ford Museum, Greenfield Village, a Ford F-150 truck assembly plant, and the Benson Ford Research Center[17] where they participated in a college-level version of The Henry Ford's Innovation 101 curriculum.[18]

The objectives of the program are upon completion of the week-long program, the student will be able to:

- use techniques/competencies to inspire creativity.
- define invention, innovation, and discovery as core competencies of the entrepreneurial mindset.
- identify the various processes of innovators.
- use a variety of creative problem solving methods or strategies.
- approach and analyze unfamiliar situations and open-ended problems while using various methods to define the "true" problem (i.e., real versus perceived).
- assess the constraints, benefits, and risks of problems and their various solutions.
- formulate a plan of action for solving problems following various methods.
- formulate multiple creative solutions to a given problem or design.
- interact confidently in a multi-disciplinary team.

Various teaching and learning strategies were implemented to reach the objectives. While there were some short lectures, the major portion of the instruction was completed through interactive activities.[11, 19-22] The games/activities are crafted to emphasize core creativity competencies and/or steps of a creative problem solving method. In addition to the daytime activities, a short-term design project was assigned as "homework" that was completed in teams. Students created teams of three or four that collaborated for the week with the stipulation that students from the same institution could not be on the same team unless necessary.

The instructional portion of each day was approximately eight hours (including breaks and lunch) although often the students were self-motivated to work through breaks and lunch! The days of the week were formatted so that basic skills and tools were developed before moving to subsequent skills that relied upon the previous ones. For example, before creative problem solving can be learned and put to good use, 1) creativity and teamwork must be understood and 2) being creative must be practiced. Therefore the general format of the camp was as follows in Table 1.

The first half day entailed discussion of what creativity is, who is creative, and broke down any myths about creativity. As will be seen in Section 6 of this paper, these discussions (and later activities) helped change some preconceptions of the students. The team-building exercises emphasized various functions of teams and also required the students to come into physical contact with one another to break down any barriers and quickly "break the ice." This proved to be very valuable as the camaraderie among the students was conducive to a strong learning

environment. In addition during the team-building exercises, various students were asked to take a lead role given unusual constraints/circumstances which illustrated good and bad traits of team leaders.

Table 1. Format of the camp.

Day	Theme	Activity
1	Creativity	Define creativity and teams, perform team-building exercises, and investigate the core competencies of creativity (Capturing, Challenging, Broadening, Surroundings)[11] through games, projects, and problems.
2	Ingenuity	Overview of the culture of innovation and ingenuity, with "Through the Lens of Innovation" Self-guided Itineraries: Henry Ford Museum, Ford F-150 Rouge Factory
3	Innovation	Tour of Greenfield Village and Innovation 101 (process of innovation, traits of an innovator, keys to innovation, intellectual property rights)
4 and 5	Creative Problem Solving	Investigate six creative problem solving methods and their various strategies. Team design projects and presentations.

During the second half of the first day, the four core competencies of creativity were investigated and practiced. The creativity competencies were derived from Generative Theory research[23-24] and were summarized for classroom instruction by Epstein.[11] They are:

- Capturing – preserving and producing new ideas
- Challenging – seeking challenges and managing them to spur new ideas
- Broadening – exploring new skills, knowledge and training outside your area of expertise
- Surrounding – changing your physical and social environment

Each competency has one or more accompanying in-class activity (i.e., game) that reinforces the skill (Figure 1). The students commented that the games emphasizing and using these competencies were especially worthwhile, not simply because they were fun, but because they reinforced retention. At the end of the day, the students completed a shortened version of the Epstein Creativity Competencies Inventory for Individuals (ECCI-i).[11] A full, validated test is available[25], but for the purposes of the week, the shortened version allowed each student a general determination of which creativity competencies were strongest and which needed more focus.

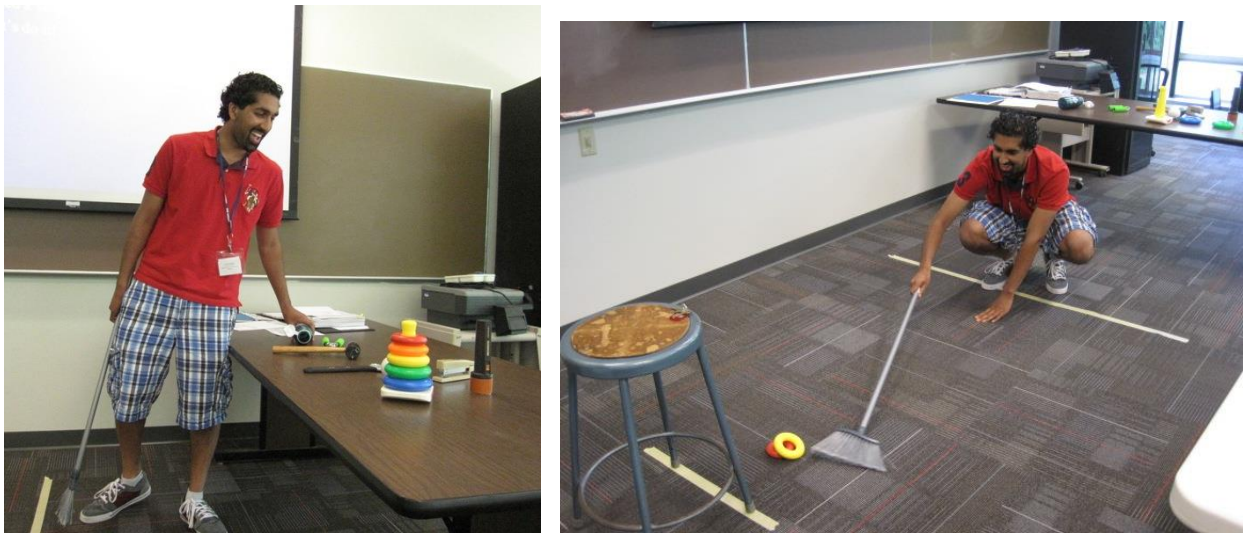

Figure 1. A learning activity to emphasize the core competencies of creativity. For further information see Reference 11.

The second and third days were dedicated to exploring ingenuity and innovative progress while also visiting innovative sites as the students toured the Henry Ford Museum, Greenfield Village, and the Ford Rouge Factory where F-150 trucks are assembled. While each of the three sites requires a full day or more to explore, the students used self-guided itineraries focused on innovation and developed by The Henry Ford to allow efficient exploration in a shortened format, with questions and reflections. The Henry Ford Museum includes areas focused on "Made in America – Manufacturing and Power" which showcases some of the earliest Watt steam engines and allows participants to fabricate an actual Model T (Figure 2). Also on display is the ahead-of-its-time 1950s Dymaxion House which featured a quick-build time, post war material construction, and efficient floor plan. The Henry Ford also features automotive, rail, and airplane innovations. Additionally, social innovation is highlighted; one example displays artifacts and information on the Civil Rights movement where visitors can board the Rosa Parks bus. Greenfield Village features actual historical buildings from around the world which Henry Ford himself purchased and relocated to Michigan. The students visited the Wright Brothers' bicycle shop where the first airplane was developed and fabricated, Thomas Edison's Menlo Park Complex and Fort Myer Lab, and George Washington Carver's home in addition to many other historical buildings from the past 200+ years (Figure 3). Finally at the Ford Rouge Factory, the students observed modern manufacturing in a plant that serves as a leader in environmental sustainability.

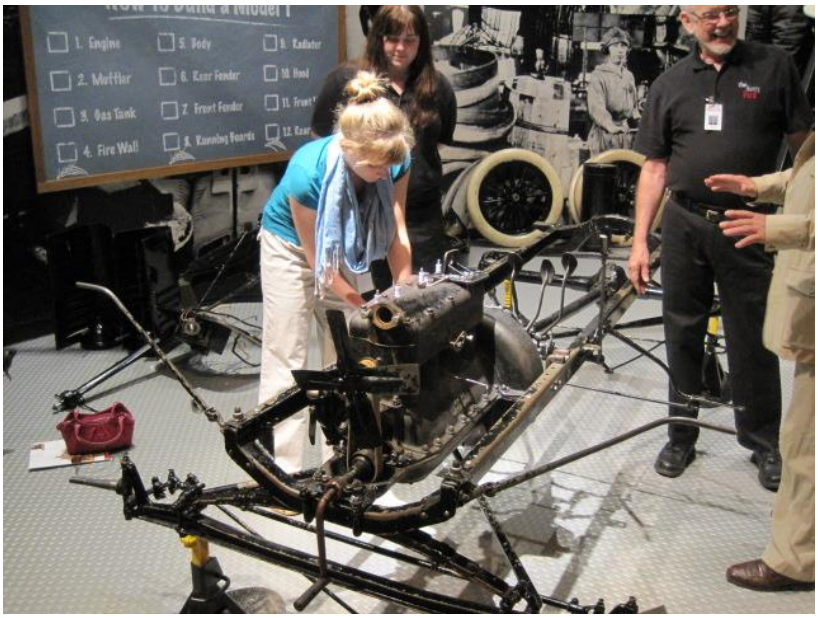

Figure 2. Student fabricating a Model T at the Henry Ford Museum – a hands-on experience of the changes in production over the past 100 years.

Figure 3. Students at Greenfield Village where they were able to encounter the environs of American innovators such as Edison and the Wright brothers.

A portion of the third day was held at the Benson Ford Research Center. The Henry Ford has many extensive educational outreach programs, and the camp participants were able to participate in an abridged version of an innovation workshop with elements of the Innovation 101 digital curriculum.[18] The curriculum was originally developed for middle to high school students but was customized for college students. The students explored innovation through active-learning modules (Figure 4) and reflected on The Henry Ford-exclusive interviews from innovators such as Steve Wozniak, Pierre Omidyar, Bill Gates, Dean Kamen, and Elon Musk. They compared innovative processes of current-day innovators and analyzed their common traits. The students brought together their observations to identify the keys to innovation such as curiosity, breaking rules, power through collaboration, meeting needs, and embracing risk and lessons from failure.

Figure 4. Students participating in Innovation 101 at The Henry Ford.

By the fourth day, the students were prepared to use their foundations of creativity and innovation to solve problems. While many creative problem solving methods exist, the instructor identified six popular and commonly used methods, which vary in the number of steps from four to eight.[12, 19-20, 22, 26-30] Upon investigation, all six methods have very similar or identical steps. To facilitate learning of the methods and allow for more efficient use of classroom time, the methods were organized into one "grand" creative problem solving approach that consisted of five steps as follows.

A) Planning your approach
B) Defining the correct problem/understanding the challenge
C) Generate Ideas/Alternatives – Brainstorm
D) Decide course of action/Preparing for action/Carry through/Implement
E) Acceptance and Evaluation

Table 2 shows the six methods from which the general steps originated. The letters beside each step correspond to steps A-E listed above. These "steps" are lettered instead of numbered to emphasize that there are instances when the problem-solver will return to a previous step and repeat it (more than once perhaps), or even skip it altogether. In fact, each team at the camps typically followed a slightly different method from the others to solve problems even though the overall steps were similar.

Table 2. The six creative problem solving methods studied.

Question and Answer[26, 27]	**CPS**[26, 27, 28]
A What is wrong? A What do we know? B What is the real problem? C/D What is the best solution? D/E How do we implement the solution?	A Mess Finding A Data Finding B Problem Finding C Idea Finding D Solution Finding E Acceptance Finding
CPS Version 6.1[12]	**Simplex**[26, 27, 29]
A Planning your approach B Understanding the challenge C Generating Ideas C/D/E Preparing for action	A Problem finding A Fact finding B Problem defining C Idea finding D Evaluating and Selecting D Action planning E Gaining Acceptance D/E Taking Action
Lumsdaine[22, 30]	**McMaster 5 point**[19, 20]
A/B Problem definition C Brainstorming C Creative evaluation C/D Judgment D/E Implementation	A/B Define the problem C Generate solutions/alternatives D Decide course of action D Implement solution / carry through E Evaluate solution

During the final two days of the camp, a team project was assigned that encompassed all creative core competencies and all creative problem solving steps. The students watched an ABC News Nightline program titled "Deep Dive."[31] A "think-tank" company, IDEO, was asked by the ABC program's producers to develop a new design for a shopping cart within one week – an extraordinarily tight timeline. In camp, a team assignment was given wherein each student identified the core competencies used by IDEO, the method followed by IDEO, and potential problems with the final cart design (likely due to the short timeline). The problems identified by each team were collected, and using the list, a capstone team project was assigned wherein the students had to re-design IDEO's new shopping cart while using the entire creative problem solving method. The students were given 24 hours to complete the design and create a presentation. For the week's finale, each team presented their new shopping cart design (Figure 5) to the instructor and other teams (and thoroughly critiqued by all).

Figure 5. Final Team Presentations

In addition to all of the learning activities and The Henry Ford visit, the students were treated to other Detroit-area highlights in the evenings such as a Detroit Tigers baseball game and a Detroit River boat tour.

3. Benefits of Collaborating with a Local Cultural Institution

There are multiple benefits of collaborating with a local cultural institution. First, the university benefits from the national recognition of the cultural institution which aids in marketing the camp program.

Second, museums and science institutions often have program materials developed and tested that extend or emphasize the university curriculum. In the case presented here, The Henry Ford's Innovation 101 focused on the basics of innovation which logically follows the prior day's lessons on creativity at Lawrence Tech. While the connection between a local institution and the university curriculum may not be as streamlined (as has been in the case presented here), adapting an existing (and tested) program entails less work than developing one from scratch.

Third, local institutions have experiential learning resources, which are often resources that universities simply could not obtain today (e.g., Edison's Labs or the Wright Brothers' shop). They also have the connections/access to obtain an audience with high profile people (e.g., Bill Gates interview). The resources are not only material, but can also be personnel. The Henry Ford has a staff dedicated to the study of innovation and ingenuity. They are also able to facilitate a portion of the curriculum, relieving the university instructors for what would otherwise be five days of continuous teaching.

Fourth, the students can experience historical artifacts that place perspective and emphasis in the processes and methods that they are studying/practicing. Whether the artifacts are art, history, or social culture, this leads to an additional benefit of allowing the engineering student to look beyond their field of study and its inherent emphasis on math and science. The student will gain a multi-disciplinary or global viewpoint which is essential to creativity and problem-solving.

Finally, as discovered from student commentary, getting outside of the walls of an engineering college is fun, exciting and, memorable.

4. Adaptation and Transferability to Other Universities

For a partnership to develop between a cultural institution and a university, a program must be identified at a cultural institution that allows continuity with the university curricula. The educational program related in this paper focuses on creativity and innovation, so naturally The Henry Ford fits as a partner/resource. Other institutions focused on creativity exist around the country such as San Francisco's Children's Creativity Museum. While seemingly focused on K-12 education, their "Creativity Fellowship" is college-age appropriate, and their "Innovators Program" connects participants to innovative thinkers and designers. Fine arts museums also are potential partners with their inherent focus on creativity. If the focus of a particular camp is not creativity, there is a possibility that a local cultural or scientific institution can serve as a partner in a different capacity while still containing the benefits related above in Section 3. Perhaps the institution can focus on technical aspects connected to one of the entrepreneurial skills. Example "technical" partners could include Boston's Museum of Science (which has a strong focus on education), Chicago's Museum of Science and Industry, or its Field Museum of Natural History.

Admittedly, it would be more difficult to replicate a summer enrichment program partnership at universities that are isolated from major cities where most cultural institutions are located. The program works very well when the students can reside in on-campus dorms which necessitates the cultural institution to be within approximately a one to two hour drive. If on the other hand, the institution is two or more hours away, one or two night accommodations near the institution could be arranged. Another option is to use a digital platform (such as the on-line version of Innovation 101) to incorporate the educational assets of a cultural institution into the university's curriculum. While this would negate the benefits of witnessing artifacts or hands-on displays in-person, many of the benefits of a partnership would still be valid.

For a partnership to be feasible, there must be benefits to the cultural institution. In the present case, The Henry Ford is able to further develop its Innovation 101 curriculum for college-aged students, and when each student returns home, he/she essentially becomes a spokesperson for the institution, essentially marketing the organization nationwide. Additionally, the institution can use the program results in their various marketing and educational publications. With a bit more effort, the institutions can partner to obtain foundational grants to further both programs. (The likelihood of obtaining a grant typically increases when partnerships are incorporated.)

5. Sustainable Program

It should be noted that over the three summers in which the program was operated, the students incurred none of the cost. Travel, food, housing, activities, and instruction were all paid for by the foundational grants, host university, and students' home institutions. One of the goals of the grant was to investigate if such a program was sustainable without external funding. In other words, would students be willing to pay for the experience? The original concept in the grant was to pay for the students in-full for one summer and then have the students pay for travel, meals, and housing during the final summer. To generate interest during the final summer camp, besides KEEN email and internet advertising, a promotional video was created and posted on YouTube. The video contains first-hand testimonials and sufficient images of activities to generate interest in attending. During the early period of enrollment, a portion of the student

interest was only talk and no enrollment. Most students actually enrolling in the early months of the third year offering were students within driving range of the host university or had funding from their university. Many KEEN schools could identify a few students to attend, but the cost to fly from the Northeast, Washington, or California was prohibitive within a student budget. With only a few months left to recruit students and enrollment low, the plan to fund only activities and instruction was scrapped. Within a few weeks, the camp was appropriately populated.

Besides cost being a prohibitive enrollment factor, many students have summer jobs, summer courses, or simply want a month off of schooling. A possible solution to enrolling more students from farther afield is to allow academic transfer credit for the students. The educational portion of the camp is between 30 to 40 hours of instruction which is equivalent to a two to three credit hour course (based on a 15 week semester). Unfortunately the roadblocks to this reality are many. First there must be an agreement with the universities to transfer the credit. The bureaucracy involved in creating an agreement is daunting. Second, the students must be willing to work through the logistics and paperwork associated with obtaining guest/transfer credit. Third, the credits acquired from such a program must fit within the student's engineering curriculum.

Another possible solution for increasing enrollment is obtaining industry funding through sponsorships. The projects completed during the week can be provided by a local industry which in turn will pay for the students to find solutions. This is in fact how some senior projects programs as well as multi-university "innovation competitions" are funding. In fact, Lawrence Tech hosts an annual Innovation Encounter in which a local company funds the competition and presents its own challenge to the students to solve within 24 hours. The company provides judges as well. Ultimately in the case of the Innovation Encounter, the companies have been very satisfied with the student results and have noted that the opportunity was well-worth the investment, often stating that the solutions presented would have taken their own employees many weeks to deliver.

A final solution, but possibly most far-fetched is to sell naming rights of the camp and setting-up an endowment from the funding.

6. Assessment Results

Three assessments were performed. First, results from a pre- and post-camp survey focused on specific learning objectives will be presented. Second, a survey was administered at the conclusion of the week asking students' opinion of the enrichment program to measure the effectiveness of the program, the delivery techniques, and the format. Finally, a survey was administered at the end of the two days at The Henry Ford asking student opinions of the specifics of their curriculum and tour sites.

Pre- and Post-camp survey

During the first hour of the first day of the camp and again at the conclusion of the camp, the students were asked about their personal views on creativity, the role of creativity in engineering, problem solving, teamwork, and leadership. The survey was quantified using a 5-point Likert-

type scale where on a scale of 1 to 5, 1 indicates "strongly disagree" and 5 indicates "strongly agree."

T-tests were conducted for the pre- and post-survey statements to determine statistical significance of difference in means. The individual student responses from pre- to post-surveys from 2011 were not paired, so an unpaired t-test was performed on the composite data from 2011, 2013, and 2014. (The camp was not offered in 2012.) The 2013 and 2014 data was paired with anonymous ID numbers, so a paired t-test was conducted on each pair of pre- and post-test statements for the composite data from those two years. For the 2011-2014 unpaired t-test, ten of the fifteen statements have statistically significantly different means between post- and pre-assessment administrations at the $p \leq 0.05$ level. For the 2013-2014 paired t-test, eleven of the fifteen statements have statistically significantly different means between post- and pre-assessment administrations at the $p \leq 0.05$ level. (Twelve of the fifteen statements are $p \leq 0.1$. Note that the three statements – items 3, 11, and 13 in the tables below – which do not show significantly different means were those that were not a particular focus of the camp content and were perceptions not necessarily intended to be changed. In a sense, they are "control" statements.)

Student perceptions of creativity

The public does not commonly perceive engineers as creative professionals. A Harris Poll sponsored by the American Association of Engineering Societies and IEEE-USA "found that only 2 percent of the public associate the word 'invents' with engineering; [and] only 3 percent associate the word 'creative' with engineering." [10, 32-33] This may be the mindset of engineering students, especially underclassmen that have not yet completed significant design and open-ended problem work.

Table 3 displays the mean responses from the 5-point scale of students agreeing with statements concerning creativity before and after the camp. The results for statement 1 exhibited the largest pre/post change in perception. This result (in addition to growth in problem-solving abilities) was the point of the camp (as noted in three of the program objectives listed in Section 2) and may be the result of one of two possibilities: either the camp content proved this to them or the camp experiences improved their creative capacity. There is not a major change in the response to statement 2, but notice that the students understood that creativity is an important part of engineering before the camp began. Note also that the post-mean (4.90/5.00) is the highest of any mean from the entire survey. Statement 3 shows little shift in perception as is expected from an engineering-focused camp. Statement 4 exhibited a substantial change in perception and is counter to the Harris Poll quoted in the previous paragraph. The cause of this upward shift could be twofold. First, it is possible that the visits to the museum, village, and factory (as well as the innovators' interviews in Innovation 101) opened their eyes to the creativeness of engineers. It is also speculated that once the students realized that they were creative, then logic would indicate that anyone may be.

Table 3. Students' mean rating of statements concerning creativity before and after the camp. On a scale of 1 to 5, 1 indicates "strongly disagree" and 5 indicates "strongly agree."

	Average		Standard deviation	
	pre	post	pre	post
1. I am a creative person.	3.92	4.52	0.82	0.50
2. Creativity is important to the engineering profession.	4.77	4.90	0.47	0.31
3. Artists (painters, musicians, poets, etc.) are creative people.	4.42	4.44	0.61	0.58
4. Engineers are creative people.	4.00	4.52	0.92	0.55

Student perceptions of problem solving

Table 4 displays the mean responses from the 5-point scale of students agreeing with statements concerning problem solving before and after the camp. For statements 5, 6, 7, and 8, it was encouraging to see an upward shift in perception. It appears that the camp has met these goals. Most notably, statement 8 experienced the largest shift which is encouraging to note that engineers can be more divergent than convergent thinkers, a major facet of creativity. The responses to statement 9 decreased as was hoped. The activities used for the core creativity competency "challenging" and the "Innovations 101 – Keys to Innovation" module appear to have helped the students to realize that solution failure is a necessary part of creating new, better solutions. One student commented that during Innovation 101, one of the most valuable lessons was "*realizing how many failures it may take to succeed.*" Another commented, "*The failure aspect of [the Innovation 101 workshop] was very important. It is inspiring to see how much some people have failed.*"

Table 4. Students' mean ratings of statements concerning problem solving before and after the camp. On a scale of 1 to 5, 1 indicates "strongly disagree" and 5 indicates "strongly agree."

	Average		Standard deviation	
	pre	post	pre	post
5. I enjoy solving problems.	4.50	4.79	0.55	0.41
6. I am a good at solving problems.	3.96	4.35	0.50	0.56
7. When confronting a new problem, I am good at devising many possible solutions.	3.80	4.53	0.76	0.56
8. When solving a problem, I will try many possible solutions.	3.72	4.36	0.86	0.74
9. I am discouraged when my solution to a problem fails.	3.17	2.59	0.83	0.97

Student perceptions of teamwork and leadership

Table 5 displays the mean responses from the 5-point scale of students agreeing with statements concerning teamwork and leadership before and after the camp. The students showed an upward shift in leadership and teamwork for problem solving and an increased preference to work in teams (with an accompanying downward shift in the reference to working alone). As most activities were performed in teams, the students discovered that one individual will not solve a

problem (or develop a product) as effectively as will many minds working toward a common goal.

Table 5. Students' ratings of statements concerning teamwork and leadership before and after the camp. On a scale of 1 to 5, 1 indicates "strongly disagree" and 5 indicates "strongly agree."

	Average		Standard deviation	
	pre	post	pre	post
10. I am an effective team leader.	4.04	4.23	0.80	0.63
11. It is important for engineers to be effective leaders.	4.40	4.52	0.68	0.62
12. It is important to work in a team to solve problems.	4.17	4.69	0.81	0.51
13. I prefer to work alone when solving a problem.	2.78	2.52	0.84	1.13
14. I prefer to work with others when solving a problem.	3.47	4.02	0.93	0.89

Statement 15 was only included on the surveys from 2013 and 2014, and it focuses on turning ideas into reality. While building a prototype was not a focus of the camp, gaining acceptance among stakeholders for a solution was practiced in the problem solving process. As indicated in Table 6, this practice appeared to give the students confidence in forward progress of problem solving.

Table 6. Students' ratings of a statement concerning ideas to reality before and after the camp. On a scale of 1 to 5, 1 indicates "strongly disagree" and 5 indicates "strongly agree."

	Average		Standard deviation	
	pre	post	pre	post
15. When I generate an idea, I am confident of the procedure necessary to build the idea into reality.	3.64	4.32	0.91	0.77

Overall Perceptions

To visualize overall responses and changes from pre- to post-camp, Figure 6 presents the means from Tables 3-6 in a bar graph. While most differences in perception are statistically significant, are they evidence of meaningful changes in attitude, especially considering that the pre to post differences appear small, and the students were already interested in the subject-matter? One could argue that the students' interest in the subject-matter and prior education in entrepreneurial programs (due to the influence of KEEN at their home institutions) are exactly what makes the pre to post differences meaningful. One would assume that the students would give high ratings for the statements before the camp (and in fact they did), which would make any shift in perception difficult or even unlikely. The fact that the ratings did increase with 5 days of activities may indicate meaningful change. Further studies would have to be performed to verify the theory.

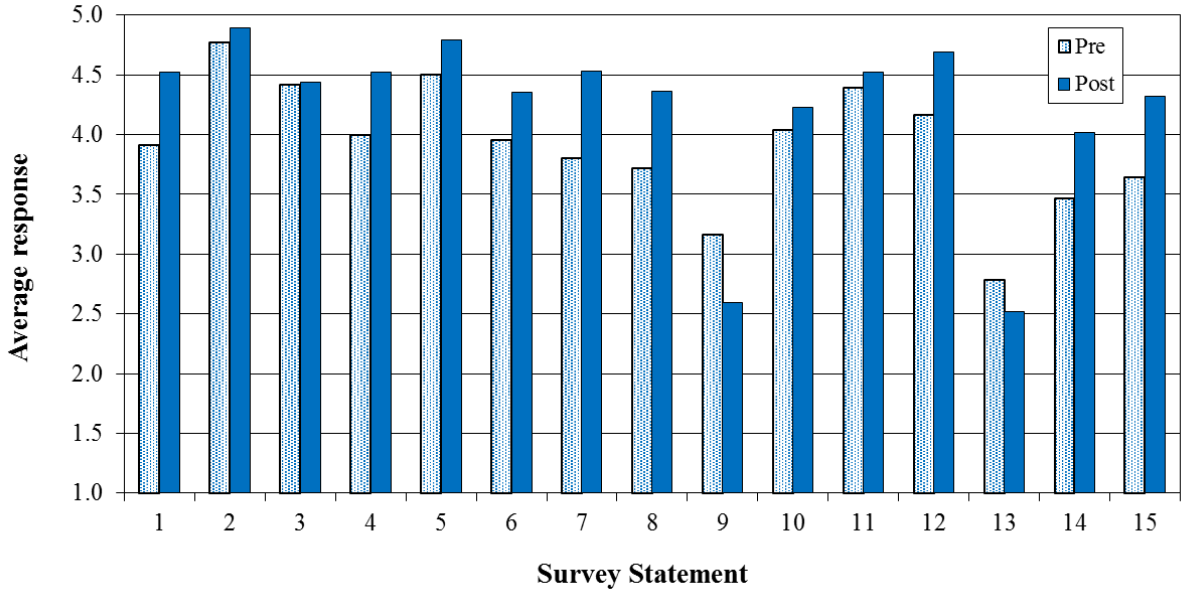

Fig. 6. Students' ratings of statements concerning creativity, problem-solving, teamwork, and leadership before the camp and after the camp. On a scale of 1 to 5, 1 indicates "strongly disagree" and 5 indicates "strongly agree."

Students' Opinions of the Camp

Upon conclusion of the week, the students were surveyed on their opinion of the enrichment program to measure the effectiveness of the program, the delivery techniques, and the format. Table 7 shows the results. Overall, the results are very good. The 2011 averages missing from the table result from a slightly different format of the survey. Instead of separate questions 2 and 3 regarding The Henry Ford's tours and instruction, a single question was asked: "How would you rate your experience for the two instructional days at The Henry Ford?" The average was 4.29. Statements 5 and 6 were asked on a "yes," "no," "maybe" scale. For statement 5, all students responded "yes." For statement 6, 82% responded "yes," and 18% responded "maybe." Statement 7 was not included on the 2011 survey. At that time, the organizers never considered that the students would share the camp content. They later discovered that faculty at St. Louis University (SLU) asked the students before embarking for the camp to bring back what they could to teach others. The result, two months later, was a successful workshop facilitated by the camp students for 80 of their peers at SLU. It was later learned that similar interactions were experienced by the other institutions who participated. Thus for 2013-2014, statement 7 was added, and in fact it has the highest average indicating that the learning does not end with these students; they are enthusiastic about sharing the content with others. In 2013 at least two of the students were delivering selected content to STEM students in their community. In 2014, a junior engineering student from Lawrence Technological University further spread the content beyond higher education: "*The summer camp awoke my passion for innovation, and led me to create multiple S.T.E.M. programs throughout the Dearborn Public Schools System. Since the programs run all year long, I visit the schools twice a month to lecture and assign a new innovation challenge. I work with 120 students when I visit, and the students I mentor range in age (7-14 years old). I have witnessed enormous growth within the groups of children, and I am positive they will use the skills I have taught them to enrich the lives of others – just like I have.*"

Table 7. Mean Student ratings of statements about the summer enrichment program. For statements 1 through 3, on a scale of 1 to 5, 1 indicates "unsatisfactory" and 5 indicates "excellent." For statements 4 through 7, on a scale of 1 to 5, 1 indicates "strongly disagree" and 5 indicates "strongly agree."

	2011-2014	2011	2013	2014
1. How would you rate your experience for the three instructional days at Lawrence Tech?	4.61	4.71	4.47	4.64
2. How would you rate your experience for the tours at The Henry Ford?	4.43		4.60	4.23
3. How would you rate your experience for the instruction at The Henry Ford?	3.76		3.27	4.29
4. I got what I wanted out of this week (the week met my expectations).	4.59	4.65	4.53	4.57
5. I would recommend this summer experience to other students.	4.76		4.80	4.71
6. I want to keep in contact with the students I met from other institutions.	4.76		4.60	4.93
7. I will share with others some of the tools, techniques, and activities of creative problem solving and innovation.	4.90		4.87	4.93

The obvious outlier from Table 7 is the 2013 average for statement 3. The instructors from Lawrence Tech and The Henry Ford have speculated two reasons for the low score. First, the Innovation 101 curriculum was originally developed for K-12 application, was intended to be more than a four hour session, and was not yet perfectly aligned with the Lawrence Tech curriculum. After two years of streamlining the curriculum, the student opinion rose considerably for 2014. Second, the timing of the instruction in 2013 was not optimal. Innovation 101 was delivered in the afternoon after a previous day of touring the museum and F-150 factory, and a morning of touring Greenfield Village (in the heat of August). The students were simply "tuned out" by Wednesday afternoon. When asked what should be changed about the two days at The Henry Ford, one student in 2013 specifically stated, "*Report back [for Innovation 101] first thing Thursday morning instead of touring all [morning]*." Thus, for 2014, the workshop was moved to the morning before touring the Village with considerably better results as will be discussed further with Table 8.

Table 8 shows the results concerning the length, amount, and level of instruction, as well as instructor results. For statements 1-2, on a scale of 1 to 5, 1 indicates "too short/too little," 3 indicates "just right," and 5 indicates "too long/too much." For statement 3, 1 indicates "too advanced" and 5 indicates "too easy." Eight hours of learning for multiple days can be daunting/exhausting, and the results reflect that the days are slightly long, but nearly "just right." Much of this may be attributed to the active learning and teamwork. The "fun factor" certainly helps keep student motivation. As indicated, there were more and longer activities at The Henry Ford (noting that not all was formal instruction but included self-guided learning tours), but this is offset by them being slightly easier. Of note in 2013, the length of days was perceived to be especially long. As mentioned above, this is likely due to the timing of the Innovation 101 workshop after an overwhelming amount of sightseeing on the preceding 1 ½ days; it was difficult for students to remain as engaged. As noted above, moving the workshop for 2014, showed a marked difference.

To ensure that poor instruction was not a factor to student perceptions presented in this paper, using statements 4-8, the students rated statements concerning the instructors on a scale of 1 to 5, where 1 indicates "strongly disagree/unsatisfactory" and 5 indicates "strongly agree/excellent." The instructors performed above-average to excellent. The instruction material used at Lawrence Tech had been time-tested in a classroom setting for multiple years before it was deployed in a camp setting,[8, 9] so the instructor rating show little change over the three years. On the other hand, it is worth noting the rather dramatic increases from 2011 to 2014 for The Henry Ford instructor ratings. It required a few trials to develop Innovation 101 for college students in a shortened format, but by 2014 the instructor ratings are at an excellent level.

Table 8. Student ratings of statements concerning the instruction/activities.

	Lawrence Tech (three days)				The Henry Ford (two days)			
	2011-2014	**2011**	**2013**	**2014**	**2011-2014**	**2011**	**2013**	**2014**
1. The length of the instructional part of each day was:	3.43	3.24	3.73	3.36	3.76	3.76	4.13	3.36
2. The amount of activities/instruction was:	3.00	3.06	2.93	3.00	3.11	2.94	3.40	3.00
3. The level of material that we covered was:	3.45		3.53	3.36	3.86		4.00	3.71
4. The instructor's presentations/materials/ activities were well prepared.	4.70	4.76	4.73	4.57	4.17	4.18	4.07	4.29
5. I felt comfortable asking the instructor questions.	4.87	4.82	4.93	4.86	4.07	3.94	3.80	4.50
6. The instructor was willing and able to answer questions.	4.93	4.88	5.00	4.93	4.54	4.47	4.27	4.93
7. How would you rate the instructor's ability to impart the course material?	4.79		4.73	4.86	4.34		3.87	4.86
8. How would you rate the instructor's overall performance?	4.96	4.94	5.00	4.93	4.28	4.12	4.07	4.71

Students Opinions of The Henry Ford Curriculum and Tours

An extensive survey was administered to the students at the conclusion of their two days spent at The Henry Ford. Much of the information gathered is specific to details of the Innovation 101 curriculum and the three tours. This information is beyond the scope of this paper, but it was used to improve the experience each year that the camp was offered to much success as noted in the previous section. A general overview is presented here.

Table 9 displays the student ranking of the four elements of The Henry Ford visit. Only two ratings are below 4, and both of those occurred in 2013. For the factory tour that year, fewer docents were accessible, and the students were not able to get many of their questions answered. For the workshop, as noted in the previous section, the students were fatigued during the offering.

Table 9. Student general perception of the four elements of The Henry Ford visit. On a scale of 1 to 5, 5 is the highest rating and 1 is the lowest.

	2011-2014	2011	2013	2014
The Henry Ford Museum	4.81	4.90	4.79	4.71
The Ford F-150 Factory Tour	4.44	4.68	3.73	4.81
Greenfield Village	4.30	4.30	4.27	4.33
Innovation 101 workshop	4.08	4.00	3.93	4.31

When asked which of the three tour sites was most educational, the students' choices were fairly equally distributed among all three.

An important key to the surveys was detailed student commentary. Some of the highlights are presented here.

In 2011, a majority of the students commented that the Innovation 101 curriculum needed more hands-on activities. After further refinement of the workshop, only one student in each of 2013 and 2014 thought that more activities were needed.

The motivation behind a university program partnering with a cultural institution is the explicit connection to history and society. When asked, "What was the most valuable part of the two-day immersion experience? Why?," 25% of the students in 2014 mentioned the ability to see the past-to-present development of innovation with comments such as "*Being able to see the progression of inventions and innovations.*" In 2013, a student commented that an "a-ha" moment occurred with regards to innovation at "*Greenfield Village. You could be immersed in the surroundings/era of the time and better reflect on the societal needs and factors during that period that led to each innovation.*" Another student commented on the question "How can you apply what you learned from 'Innovation 101' or the site visits in your work as an engineering student or a citizen, now and in the future?" with, "*The sites satisfied much of my curiosity and have shown me the path of technological progression. I now know where to start my research.*" Regarding the F-150 Factory tour, a student commented, "*It showed innovation in the works, especially since it is a lean factory, which focuses on continuous improvement.*" With these comments and other feedback like it, the authors are confident that the collaboration between a university program and a cultural institution was valuable to student learning. In fact, the students wanted more; over half the students in 2013 wanted more time for the tours. One particularly poignant comment was, "*My time [at The Henry Ford] was like the Disneyland of Learning.*"

Regarding the Innovation 101 workshop, the content is neatly streamlined with the tour sites. A student in 2011 stated that the most valuable part of the workshop was, "the introduction to innovation that was reinforced by the tours and discussions." By 2014, the workshop was also neatly streamlined with (i.e., complimentary to) the Lawrence Tech curriculum. A student noted, "[The Innovation 101 workshop] collaborated well with the class time at LTU." The survey also showed evidence that the K-12 Innovation 101 curriculum could be adapted to a college-level; in 2011, many students commented that the material needs to be more advanced, and by 2014, only a couple students found the material too basic. (See also Table 8, #3)

It has been noted that the students time at the tour sites is very limited. The instructors of the program met after the 2011 and 2013 programs to address the concern. In particular, the students would like more time visiting the "artifacts of innovation" at Greenfield Village and The Henry Ford Museum. Unfortunately, there is little slack in the timeline, and each student was given slightly more than a half day at each site (as well as two hours for the Ford Rouge F-150 plant tour). For a typical tourist, completely visiting each site requires at least a full day. To alleviate the issue, the students were given specific maps and instruction of "hot spots" to visit at each site (i.e., artifacts which relate directly to the week's theme). It was observed that the students need this information at least 24 hours before the visit, as many of the students would spend time studying the map and marking the key areas of interest to focus attention.

Another solution to time limits could involve having multiple guides supplied by the cultural institution for small student groups. As was learned from the assessment results, some groups wanted only a few hours at one site (Museum or Village) and more than half-day at the other. This was not feasible from a logistics point-of-view. In addition, each student wanted to spend differing amounts of time at specific exhibits within a site that catered toward their interest and engineering field. It was difficult to identify student groups with a common proposed schedule, so many students paired up instead. Ultimately, the tour guide option proved to not be worthwhile. It may be an option at other cultural institutions with which a university partners.

7. Student Comments Regarding the Camp

The comments in the previous section were gathered mid-week after the conclusion of the time spent at The Henry Ford, and those comments were related only to The Henry Ford. After the week was concluded and there was some time for reflection, additional comments were gathered regarding the entire week.

First, the students were asked to comment on what they liked about the days spent at Lawrence Tech (with the focus on creativity and creative problem solving). Twenty-seven of the 44 comments pertain to liking the games, activities, and project (no surprise there). One student commented, "*My mind was opened to the multitude of possibilities of innovative thinking.*" Another student commented, "*I loved how [the instructor] helped us challenge our traditional views and got us thinking more creatively.*" One stated, "*I didn't know how much I didn't know.*" One more student stated, "*The intimate size of the group, the mix of students, the instructor...could not have asked for better. I want to do it again!*"

Next the students were asked what should be changed for the days spent at Lawrence Tech. Nearly a third of the students stated/implied that nothing should be changed. Six of the students wanted more time/days, two of which requested a second full week or a second level for returning students. In 2011, the classroom games were mostly incorporated to reinforce the core creativity competencies which occurred at the beginning of the week. Therefore, three of those students implied that the games/activities should be more spread out and interspersed with the lectures during the fourth and fifth days. In 2013 and 2014, additional puzzles (reinforcing concepts) were added to the fourth day, so instead of comments requesting to spread out the games, three students simply asked for more of the hands-on activities. One student requested

that time/space/materials be made available to actually construct the final design project, and a few others wanted the design project to be more in-depth. With the limited time for the program, fulfilling these requests would be difficult.

The students were asked to comment on what they liked about the days spent at The Henry Ford (with the focus on innovation and ingenuity). Nearly every student attempted to name their favorite tour site, but most of them could not narrow it down and would list two or even all three. Thus these students often went on to describe what the experience meant to them. Perhaps the most poignant comment is, "*Visiting the Rouge, Greenfield Village and the HF Museum were incredible experiences that changed my life outlook in the most positive way.*" In particular one student stated that he liked "*the creative inspiration I received behind the exhibits and presentations. They worked very well together to spark my interest in inventing and creativity.*" Another stated, "*It helped me to understand the transformation in history with technology and other innovation.*" One student that most enjoyed the Ford Factory tour commented, "*As an engineer, the factory was astounding to look at and experience and incredibly innovative.*" Five students specifically mentioned how they liked the Innovation 101 curriculum. One of these students commented, "*The lesson was valuable because it gives us an advantage to be a successful innovator and dig deep in our aspirations.*"

Finally, the students were asked what should be changed for the days spent at The Henry Ford. Three students in 2011 commented that the Innovation 101 curriculum needed to be more advanced; in 2013 only two students made that comment, and by 2014, only one. The conversion of the curriculum for college students appears to have been successful. As with the mid-week survey, many students (ten) implied that more time was needed for the tour sites, which is no surprise.

In general (either for the Lawrence Tech portion or The Henry Ford portion), two students in 2011 wanted more information on patents: "*The program should have some more focus on Patents*," and "*…more help with what to do once you have a good idea (patents, who to contact, etc.).*" Due to time constraints, it was not deemed feasible to add this content into the camp curriculum, and this was made fairly clear to the students in 2013-2014. Nonetheless, a student in 2014 asked to "*incorporate [content] on how to realize your ideas (i.e., crowd funding, venture capital, patent process, etc.).*"

In 2013, no students from Lawrence Tech enrolled in the program. In 2011 and 2014, there were at least a few. Having local students involved has a major impact. One student commented, "*It…helped to have some Lawrence Tech students in our group to provide a local perspective.*" Having a local student who knows the campus and surrounding areas, has a car, and/or knows what to do in the evenings (when no formal activity is planned) makes a great impact on the group dynamics and the general enjoyment of the experience. It seems to keep everyone at ease in a new environment. While this impact is difficult to quantify, the difference in mood can certainly be sensed.

8. Conclusions

A summer enrichment program was successfully developed and facilitated for a multi-institutional collaboration. The program broadened the students' skills in creativity and innovation. The multi-institutional collaboration allowed for a multitude of benefits that could not be realized through a single institution's effort. The model presented herein could be replicated by other institutional collaborations. Information on making the program sustainable was also presented. Pre- and post-program assessment results indicate that a positive shift in their perceptions of creativity, teamwork, problem solving/design, risk taking, and learning through failure. The interactive, team-focused format of the camp encouraged excitement toward key entrepreneurial skills. Student commentary indicated a positive impact. In general, the assessment results indicate that the program appears to enrich engineering students, and improved over a period of three offerings.

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