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I2D2: Imagination, Innovation, Discovery, and Design*

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A large-scale collaborative learning project involving first-year engineering students and fifth graders from local schools was developed and implemented during the fall of 2010. Entitled 'I2D2: Imagination, Innovation, Discovery, and Design,' the program's success in the first year inspired program continuation during the 2011 school year and beyond. The program was developed for an intended dual benefit of both college and intermediate school students. The college students worked with the intermediate school students on LEGO® activities and then had the opportunity to talk with them about their ideas for a Robotic Pet—in this way serving as a 'customer' to a first-year engineering design project. For the intermediate school students, the goal was to offer exposure to a university setting and instill an interest and recognition of the engineering/scientific process to help prepare them for their science fair projects. The results indicate that while intermediate school students are already interested in going to college, exposure through hands-on activities with college students can increase their interest level in STEM fields. For the first-year engineering students, differential responses were indicated by women and students with younger siblings. Finally, the intermediate school teachers were interviewed after the event for their feedback and reaction to the event. Future plans for improved program administration and assessment are discussed.

Keywords: K-12; outreach; first-year engineering design; STEM education

1. Introduction/background

While engineers are a necessary component for solving many worldwide problems, students are largely unexposed to engineering in popular culture or their everyday lives [1]. This is a concern given declining enrollments in engineering and science fields in colleges across the United States, while the anticipated workforce demands for engineers are expected to continue rising [2, 3]. In many cases, students are deterred from engineering and science jobs early because they perceive the difficulty level as being out of reach, or they have few engineering mentors to learn from [4]. Increasing the number of engineers produced in the United States is a two prong problem: (1) students need exposure to early science and engineering education and (2) colleges and universities must develop programs to increase retention rates of engineering students [4, 5].

In recent years the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine have advocated for increasing the number of students in science and engineering pipeline through K-12 initiatives, including outreach and exposure programs [5]. The I2D2 project conforms to STEM outreach goals of providing a low cost program [6] for the betterment of the community in schools especially those with high minority populations [7] with a broad goal of increasing student interest in science and engineering [8]. Other studies have shown that it is imperative to provide exposure to engineering and science for students at a younger age [9]. And outreach has also offered the additional benefit of providing a meaningful experience to undergraduate engineering students which has been shown to increase retention and offer a sense of purpose [8, 10]. This outreach also acted as a prompt for a project in the introductory engineering course. Increasing student exposure to the process of designing to meet customer needs has long been held as an integral part of engineering education [11]. Therefore, the 'I2D2: Imagination, Innovation, Discovery, and Design' project was formulated as a duel benefit to university students and the local community.

Specifically, program development began by working with the University's Community Engagement Director to identify schools with high minority populations and an interest in partnering with the university. A description of the proposed University activities was presented to each principal for consideration. Age appropriate state STEM standards, school goals, budget and logistics were considered before the Engagement Director organized a planning session for all stakeholders. In this way, insights from teachers/administrators were included in the development of the program, a recognized outreach program best practice [12]. Based on this input, custom curricular materials were developed to support teaching and assessment of the projects at both the university and intermediate schools. For the fifth grade classes, a workbook included background materials and exercises for before, during, and after the event, including pre and post surveys on perceptions of engineering and science. For the college students, a complete set of lectures and

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laboratory assignments introduced programming concepts in LabVIEW® for a half-semester team design project.

1.1 Program background

The first-year engineering students were tasked to design and build a robotic pet that both looked and behaved like a particular type of pet using LEGO® Mindstorms NXT technology. To support this project goal with meaningful customer feedback a program of dual benefit to both the first-year engineering students and the fifth grade students was developed. Overall, the I2D2 program spans approximately six weeks, although the primary event is a single day. Both the fifth graders and the first-year engineering students participated in a series of pre and post event activities shown in Fig. 1.

Prior the event, the fifth grade students begin the pre-activities in their workbooks [13]. This included a pre-survey on their interest in science, math, and college as well as a class discussion activity focused on the pros and cons of technology (for their teacher to lead). Likewise, to prepare the first-year engineering students for the event with the 5th grade students, there was an in class discussion focused on the importance of customer input in the design of a product. This included the design process introduced by IDEO, international design firm and innovator, for the redesign of a shopping cart [14] which highlights the importance of soliciting feedback from customers to understand their needs. And while the importance of customer feedback was well motivated, there was no formal discussion or practice for the first-year engineering students as to how to draw information out of the customer.

The I2D2 event encompassed two primary activities during a day-long visit to the university: the *Freewheeling Derby* and the *Irish Pet Project*. In the first activity, the *Freewheeling Derby*, the fifth grade students were challenged to predict how the weight of a vehicle would influence how far it would roll down a straightaway, starting from an inclined ramp. The *Irish Pet Project* was a small group meeting with the first-year engineering students.

For the *Freewheeling Derby*, the long term goal was to spur the thought process for science fair projects for the fifth graders. The fifth graders began with pre-activities from the workbook that were developed based on the state requirements for fifth graders [15]. The events of I2D2 were intended to guide fifth grade students towards a scientific process of forming a prediction and then testing that hypothesis and drawing conclusions in the same way their teachers were encouraging for science fair projects. After making their predictions the fifth graders built vehicles using LEGO® components and then ran trials and collected and interpreted their data to see if their hypotheses were correct. This approach of mentoring teachers and students has been reported to result in higher student achievement in science fair competitions [6].

For the *Irish Pet Project*, the first-year engineering students led LEGO® 'Serious Play' activities in which LEGO® kits were used as props to construct something in response to a question such as, 'If I were a scientist or engineer I would (do, build, etc.) _____' as a form of ice breaker. This lead into discussions of the design of a Pet Robot that was required of the first-year students; this meeting was their opportunity to ask the fifth graders as their 'customers' what types of pets would be most appealing and what the important design features would be to incorporate. A YouTube video depicts the energy level at the I2D2 event when so many creative minds of diverse backgrounds and ages are brought together [17].

In addition to these hands-on activities, the fifth graders and their teachers were also given a tour of campus engineering and science facilities. And while the I2D2 event was a single day, the preparation and

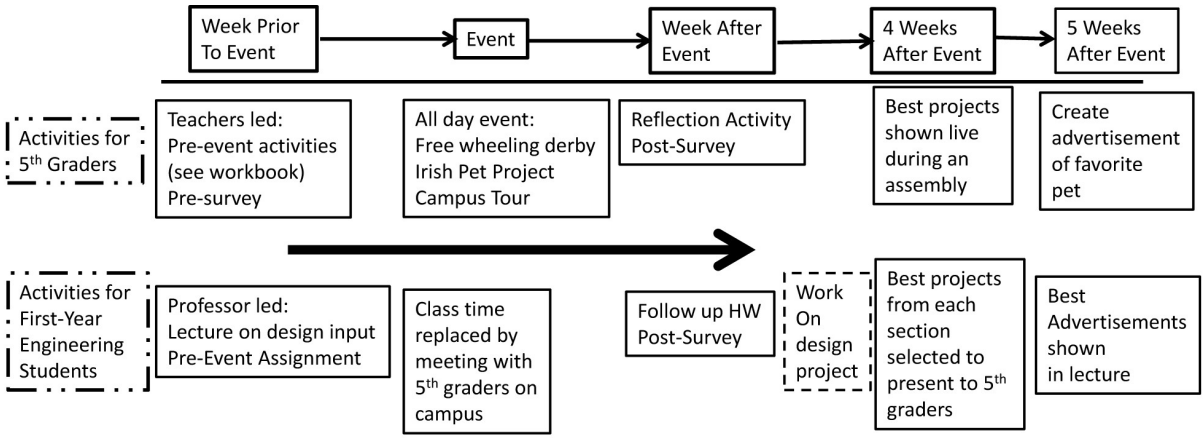

Fig. 1. Timeline of the I2D2 Program for Fifth Grade and First-Year Engineering Students.

follow on activities in the workbooks that the fifth graders completed at their school extended over several weeks, which has been recognized as important by others who have engaged in outreach activities [6, 12]. Over the six weeks following the event, students at each school continued to work on aspects of the project, after which 60 of the college students visited the intermediate schools to demonstrate their pets [18].

After the event, the fifth grade students completed a post-survey, a reflection on the event, and finally a series of teacher led follow up discussion points. The first-year engineering students also completed a post-survey on their experience working with the fifth graders. They also formally documented the feedback they received from the fifth graders on pet and feature ideas. Finally, they then had ~4 weeks to design, build, test, and demonstrate their project. The best designed robotic pets from each section of the first-year engineering course, as voted on by their peers, were invited to attend a follow-on event at the intermediate school where the fifth graders evaluated the designs. The fifth graders then completed an assignment to create an advertisement for their favorite pet. Fig. 2 shows an example of a Turtle that was designed by a group of First-Year Engineering students and the corresponding advertisement of the Turtle created by a Fifth grade student after seeing the live demonstration at their school.

2. Methods

Program assessment was considered from multiple vantage points: Fifth Grade Students, First-Year Engineering Students, and Fifth Grade Teachers. The Fifth Grade Students were given the same pre-survey and a post survey and responses compared. The surveys were collected via paper and pencil (separate pages in the program workbook) and the responses were entered into an Excel Spreadsheet and analyzed statistically using STATA®. The First-Year Engineering Students were given a reflective survey on-line using SurveyMonkey® after the event that asked them to consider their viewpoint before and after the event and how it changed. There were many open response areas which allowed for more candid, unguided responses. Finally, the teachers were individually interviewed based on their experience with the program and how they felt it related to the state curriculum requirements.

2.1 Setting

The administration site for the current study was a medium sized, Midwestern, private institution with a traditional student composition, i.e. the vast majority of students completing their undergraduate studies in four years and are in the age range of 18–22. The overall student body is 53% male and 47% female, while the College of Engineering is approximately 72% male and 28% female.

2.2 Population

There are two distinct populations in this study: Fifth Graders and First-Year Engineering Students. For both administration years, the Fifth Graders came from two public intermediate schools in close proximity of the host university that designed the activities and the study. During the first adminis-

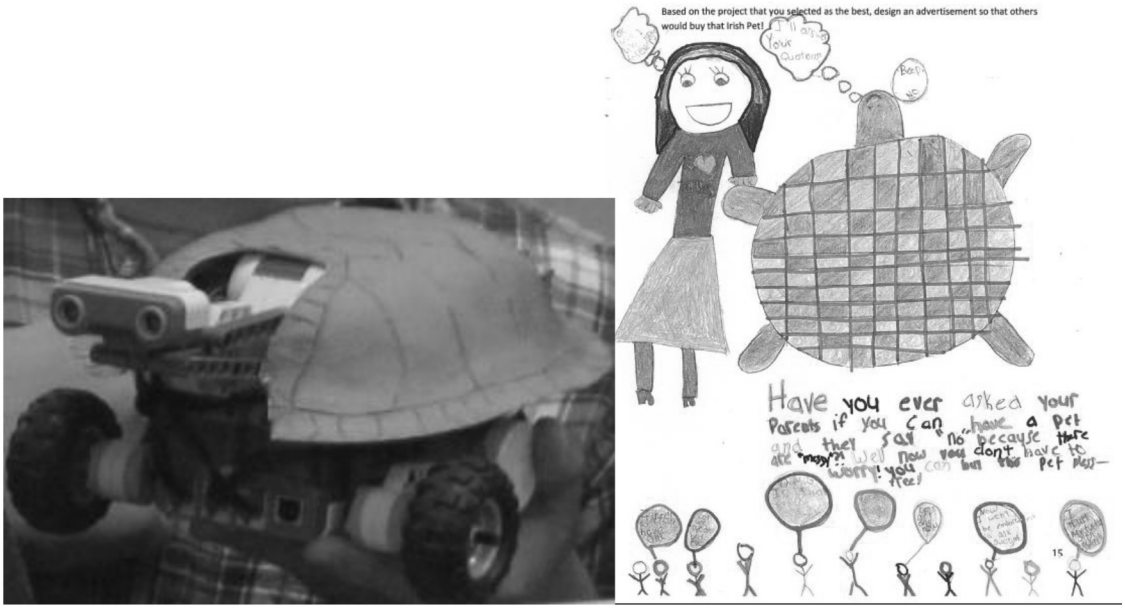

Fig. 2. 'Turtle Robot' (Left) and Turtle Advertisement (Right).

Table 1. Breakdown of Respondents by Administration Year

	Total Respondents	Boys	Girls	Not Reported
2010	142	66	65	11
2011	141	60	71	10
Total	283	126	136	21

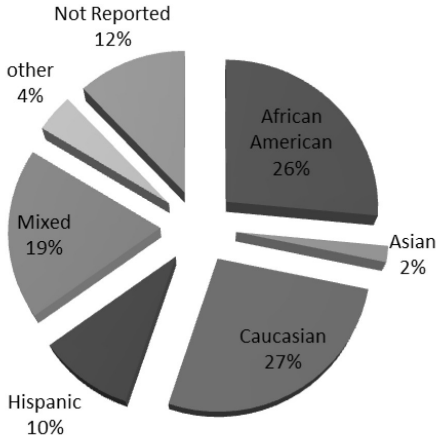

Fig. 3. Ethnicity Distribution for I2D2 Survey Respondents.

tration, fall 2010, there were ~350 Fifth grade participants. During the second administration, fall 2011, there were ~300 Fifth grade participants. As part of the post survey, gender and ethnicity were optional questions in which most students provided information. Table 1 shows the breakdown of completed survey responses (these were datasets in which both the pre and the post survey were completed and returned to the researchers). There were a total of 283 usable data sets which is ~44% response rate from all program participants. Preliminary data analyses showed that the composition and responses of the 2010 and 2011 administrations were similar (gender, minority status, number of responses) such that it was reasonable to collapse administration years together for portions of the analysis. This approach was confirmed by statistical analyses that compared the schools survey responses that are discussed in the next section.

The two intermediate schools both have significant minority populations. The self-reported ethnicity data from the fifth graders (which was optional but was completed by ~88% of students) is summarized in Fig. 3.

There were ~400 First-Year Engineering Students that participated in the program during the fall 2010; however, we did not assess their experience directly through a post event survey. Rather, students filled out peer evaluations based on the interactions with their teammates during the design process. It was determined that a more direct assessment of the students experience was needed. During the fall 2011 administration, all 463 students in the course were required to take an anonymous on-line survey as part of a homework assignment. Of those, 444 responses were collected for a 96% response rate. The gender split of respondents was: 33% (146) female and 66% (293) male and 5 that did not report. Ethnicity of the students was not asked as there are a small percentage of underrepresented minorities and there was concern that students would feel identifiable by disclosing this information.

3. Results

The results for this study are broken down into three groups: the fifth-graders, the first-year engineering students, and the fifth-grade teachers.

3.1 Fifth graders

A primary purpose for conducting pre and post surveys of fifth grade program participants was to determine if there was a change in their interest in science, math, or college in general. Fig. 4, shows the questions asked on both the pre and post survey that relate to interest levels.

Comparison by administration year showed a similar trend in terms of an increase in interest levels pre vs. post event but there was no statistically significant difference in pre-interest levels of science, math, or college (2010 vs. 2011) nor was there a statistically significant difference in post-interest levels (2010 vs. 2011). Further, there was little difference between administration sites. One of the schools showed a slightly larger change in interest between the pre and post interest level for math only. Based on these preliminary results, it was

Please circle the number that best tells us your interest level for questions 1-3.
1) How interested are you in Science? (1 = Least interested, 5 = Most interested)
1 2 3 4 5
2) How interested are you in Math? (1 = Least interested, 5 = Most interested)
1 2 3 4 5
3) How interested are you in going to college? (1 = Least interested, 5 = Most interested)
1 2 3 4 5

Fig. 4. Pre and Post Survey Question for Fifth Grade Student Interest Level.

determined that the data from the two administration years and sites could be collapsed together.

Table 2 reports the mean survey responses with a scale of 1–5 in which 1 = least interested and 5 = most interested; so a negative t test result indicates increase interest after participating in the program (based on a paired t test). It was found that in all three categories, science, math, and college, there was an increase in interest, however; it was only statistically significant for science and math.

The data were further broken down for comparison between male and female students as shown in Table 3. The only statistically significant differences were found in interest level in science. For female students, their interest level in science starts out slightly higher than male students (4.16 vs. 4.06); however, they show almost no change in interest level after the event. As a result the delta or change in interest between the pre and post administration is statistically significant for male students for the two sample paired t test, and further the comparison between female and male students in terms of the delta (pre vs. post) by a two group mean comparison is also statistically significant.

Table 2. Science, Math, and College Interest for all Fifth Graders

	Mean Pre-Survey	Mean Post-Survey	t test
Science Interest (1–5)	4.11	4.23	–2.12*
Math Interest (1–5)	3.82	3.95	–2.48**
College Interest (1–5)	4.57	4.63	–1.24

* p<0.05, ** p<0.01.

The data were also analyzed by comparing Caucasian students (76) to all other students combined (170). These schools are ethnically diverse, with the combined group including African American (75), Asian (5), Hispanic (28), mixed (53), other (12). There are other ways that the population could have been compared, but it was determined that comparing groups that have traditionally been considered minorities relative to Caucasian students would be of greatest interest. Table 4 breaks down student's interest in science, math, and college and the biggest difference found was in interest post survey level for math in which the Other Ethnicity group was higher than the Caucasian group.

3.2 First-year engineering students

After the meeting with the Fifth Grade Students, the First-Year Engineering Students were given an assignment that included a survey on their experience (which included questions relating to their viewpoint both before and after the event). Fig. 5 shows the questions most pertinent to this assessment in terms of how helpful the experience was in the design process. Further questions relating to a student's prior experience with younger people were asked, including if they have experience with the age group and if they have younger siblings. Finally, students reported their gender and were given opportunities to give open-ended, written feedback on the experience. The questions were coded on a Likert type scale with a more positive response being a lower value (1) and a more negative response being a higher value (5).

Table 3. Science, Math, and College Interest by Gender

	Female				Male				Female vs. male
	Mean pre interest	Mean post interest	Delta (pre vs. post)	Two sample paired (*t*-test)	Mean pre interest	Mean post interest	Delta (pre vs. post)	Two sample paried (*t*-test)	Two group mean (*t*-test)
Science	4.16	4.18	0.02	–0.17	4.06	4.32	0.26	–2.90**	2.01*
Math	3.82	3.92	0.10	–1.37	3.89	4.00	0.11	–1.40	0.11
College	4.66	4.66	0.00	0.00	4.46	4.58	0.12	–1.43	1.24

*p < 0.05; **p , 0.01.

Table 4. Science, Math, and College Interest by Ethnicity

	Caucasian				Other ethnicities				Causasian vs. other
	Mean pre interest	Mean post interest	Delta (pre vs. post)	Two sample paired (*t*-test)	Mean pre interest	Mean post interest	Delta (pre vs. post)	Two sample paried (*t*-test)	Two group mean (*t*-test)
Science	4.14	4.26	0.12	–1.10	4.10	4.21	0.11	–1.59	–0.01
Math	3.59	3.69	0.10	0.78	3.93	4.06	0.13	–1.92*	–0.54
College	4.49	4.47	–0.02	0.16	4.64	4.71	0.07	–1.48	–0.97

*p < 0.05.

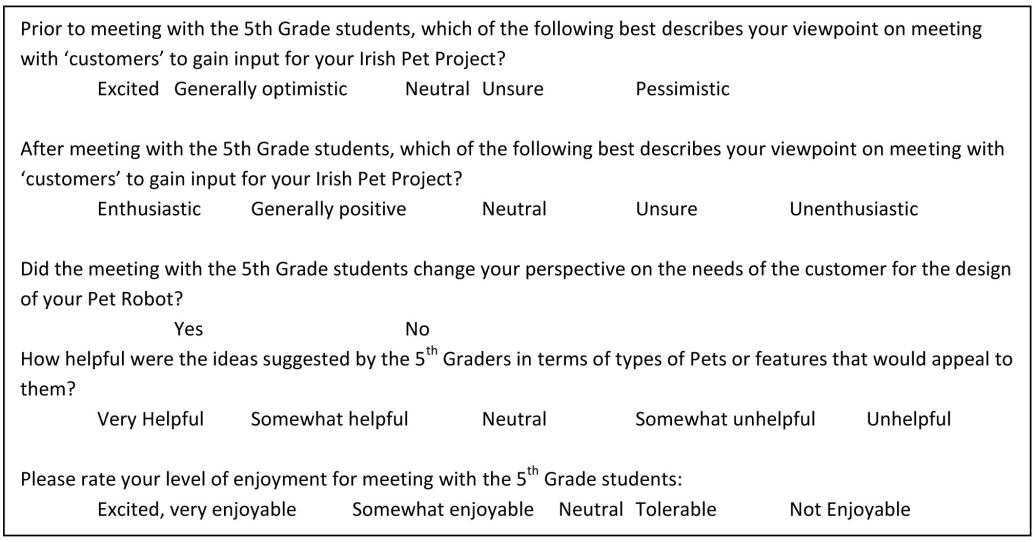

Fig. 5. Key Survey Questions for First-Year Engineering Students.

Table 5 summarizes the responses from key survey questions reported by the First-Year Engineering Students with responses shown for both male and female students separately, and t tests comparing responses by gender. Note that for the mean values reported, a lower number indicates a more positive response with a value of 3 being the neutral response.

Overall, women had a more positive perspective both before and after the event and they were much more likely to indicate they enjoyed the event than male students. Further comparison shows that for all participants, the pre-event ratings were higher than the post-event ratings, which indicates that students were more positive/ enthusiastic before the event than after the experience. Although initially disheartening considering the work that goes into this event, reading some of the open ended comments helps to put these numbers into perspective. Some comments were very positive:

> *It was definitely helpful to meet with a 'customer' instead of designing our Irish pet completely in the dark. The meeting helped us narrow our ideas and it gave us a goal to work towards.*

Others offered good indications as to why the experience did not meet their initial expectations:

> *I think that maybe a video of the capabilities would have helped. One wanted a dog to make counterfeit money.*
>
> *It is a good idea in concept but the problem is that the 5th graders are either shy or expect far more than is reasonable, at least this was in my experience.*

One recurring theme was the ratio of engineering students to fifth graders—in a strange twist from the prior year, there was increased enrollments of engineering students (50 more than the prior year) and lower enrollments for the fifth graders (50 less than the prior year) which resulted in unbalanced groups in some situations. Future administrations will include an additional intermediate school.

> *Because there were so many students in our group in proportion to the 5th grade students, I did not get a great opportunity to talk to the 'customer' and ask questions. While this was disappointing, it was still enjoyable to see how they answered other's questions.*
>
> *Talking to more than just three students would have helped me form a better overall idea of the group of customers wants in a pet.*

In many regards this input was invaluable for the future of the program. For example some First-Year Engineering Students felt that the Fifth Graders should have been prepared with ideas! We need to set clearer expectations that the engineering

Table 5. Summary of First-Year Engineering Survey Responses by Gender

Survey question	All mean	Male mean	Female mean	*t*-test (male and female)
Pre-event perspective	2.21	2.27	2.08	2.00*
Post-event perspective	2.58	2.67	2.44	2.13*
Did it change your perspective?	1.60	1.62	1.55	1.41
How helpful were ideas?	2.87	2.91	2.80	0.93
How much did you enjoy the event?	1.93	2.00	1.78	2.53**

*$p < 0.05$; **$p < 0.01$.

students are responsible for drawing ideas out of the customer not that they are just going to hand them project ideas:

> *Better preparation on their [fifth graders] part would be helpful; overall it was nice to see them here and to see them have fun but in regards to getting our information it did not go as expected.*

As part of the survey we asked questions about their prior experience with children of that age group and also if they have younger siblings at home. Both questions served as critical covariates. As shown in Table 6, having prior experience with children of that age group was significant in the pre event expectations; those with prior experience working with students of a fifth grade age group started with much higher expectations going into the event (pre-event perspective), and they were much more likely to enjoy the event. For students that have younger siblings, they were much more likely to: (1) indicate greater enthusiasm for working with the fifth graders at the event, (2) use the input from the Fifth Graders as input into their design project, (3) view the ideas presented by the fifth graders as helpful, and (4) to indicate they enjoyed the event.

3.3 Fifth grade teachers

After the fall 2010 event, teachers were not assessed directly, but rather intermediate school principals met with the administration to provide feedback on the event logistics. It was decided that more direct and in-depth assessment of the teachers was needed. After the initial campus in fall 2011, the Fifth Grade Teachers were asked to participate in an optional interview to assess the logistics, quality, and merit of the event. Out of the 11 teachers that participated in the event in 2011, 5 teachers agreed to participate in the post-event interview. All 5 teachers interviewed were participants in both the 2010 and 2011 events.

The responses from teachers were largely positive for the event and the student experience when they came back to their schools. While several event logistics were still listed as having room for improvement, the overall purpose and materials were consistently praised. During the first part of the interview, we focused largely on the interest level of the 5th grade students. In all cases, the teachers reported a higher excitement level when students returned to their intermediate schools:

> *Students come back really excited. It makes science hands-on, which the students really love.*
>
> *This is definitely a motivating event and students do think it's cool.*

In addition to motivation, the teachers also drew connections to the state's science curriculum:

> *The event definitely supports the motion and design curriculum. It fits perfectly, but motion and design comes late in the year.*
>
> *The idea of open-ended science exploration is great. Modeling the scientific methods portion fits really well, and having it early in the year helps preview science fair all year.*

Paired with the 5th grade students' responses to the survey, we believe the event is meeting the primary goal of its outreach component. However, our materials or focus may need to be improved to better meet the curriculum needs of the teachers, who often cited the events lack of connection to science topics taught early in the school year.

One unexpected but positive result of the I2D2 program was an increased level of science and engineering interest from the 5th grade teachers themselves:

> *I have always enjoyed science and inquiry, but it [I2D2 event] gets you pumped up for science for the year*
>
> *This definitely helps add excitement. Planning is very difficult so science often gets left behind in planning the curriculum. This is a really awesome as a shortcut to show something cool.*
>
> *It's definitely beneficial to keep teachers in tune with what is out there. It helps get teachers excited for science when seeing the kids really enjoy the day and have increased engagement.*

All of the teachers cited the event as a meaningful and inspirational event for their science teaching.

Table 6. Summary of Engineering Student Responses by Experience with Younger People

	Prior experience	**Without prior experience**	***t*-test**	**Younger siblings**	**Without younger siblings**	***t*-test**
Survey question	**mean**	**mean**	**with and without experience**	**mean**	**mean**	**with and without siblings**
Pre-event perspective	2.08	2.47	–4.06***	2.2	2.25	–0.52
Post-event perspective	2.55	2.68	–1.16	2.52	2.74	–2.05*
Did it change your perspective?	1.63	1.54	1.78	1.56	1.69	–2.78**
How helpful were ideas?	2.86	2.9	–0.3	2.78	3.07	–2.39*
How much did you enjoy the event?	1.79	2.18	–4.54***	1.86	2.05	–2.22*

$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

While the 2010 and 2011 events did not put a primary focus on the response from teachers, future administrations will include more materials and programming focused on training and helping teachers with science and engineering in their classrooms. In the end, the event is viewed as a worthwhile fieldtrip by all of the teachers interviewed.

4. Discussion, limitations and future work

The results of the assessment of the perceptions of intermediate school students showed that there was no statistically significant difference for interest level in College, although the ratings for both pre and post surveys were very high. Collectively we interpret these results to indicate that fifth grade students are already interested in going to college, but participation in an extended program such as this can positively influence the interest in STEM fields [7, 8]. The results further show that the interest level of these young students in science and engineering increased as a result of participation in this program, both for boys and girls (although female students did not show as large of an increase due to program participation). Overall these results support program continuation in the future; although there are several areas for improvement including trying to increase engagement for female fifth grade students.

The results of the assessment from the First-Year Engineering Students showed that in some ways the event did not meet their expectations as they indicated a more positive perspective going into the event than afterwards. The student comments indicate that there were a few issues that could be addressed: (1) increase the number of fifth grade students so the ratio is closer to 1 college student to 1 fifth grader, (2) prepare the fifth graders by showing a video of the prior year's winning projects so they have an idea of the scope, (3) prepare the college students about the fifth graders, that they may potentially be 'shy' or feel overwhelmed—but it is their job to make them feel comfortable and try to draw out feedback. It was very telling that students with prior experience with the age group or younger siblings indicated greater enjoyment and seemed to make better use of the information provided by the fifth graders (or potentially had more realistic expectations). It is recognized that asking the First Year Engineering Students questions about their viewpoints before and after the event at the same time (after the event) has limitations, such that the experience at the event likely altered their reflection on how they felt before the event took place. Prior studies of survey question accuracy encourage pretesting of survey questions to ensure proper interpretation [19]. Further, the time frame that retrospective questions are asked is significant—the more recently asked the better (although it was found that information reported 2 weeks prior was the least accurately reported) [20]. In the current study, the post survey was conducted within a few days of the event which increases the accuracy of the results although future administrations will use a pre/post survey approach.

The female college students were more positive in their survey responses than their male counterparts. Specifically, women had higher expectations for the event but they were also more likely to say that the event met those expectations. Further, they were more likely to indicate that the feedback from the fifth graders was helpful and to incorporate that feedback. Finally, they were more likely to indicate they enjoyed the event. This is not entirely surprising as it has been reported that 'making a difference' is a major consideration in the career choices of women [21, 22]. Finally, one other aspect of the program that will be added for the 2012–2013 school year surrounds parent involvement. And specifically, exposure of parents to STEM fields and the thought process as well. Numerous studies have been conducted to explore the relationship between parental involvement, support, and views towards their child's motivation, self-efficacy, and long term aspirations and achievements. For example, Fan and Williams reported that parent's educational aspiration for their child had a positive effect on motivational outcomes such as engagement and self-efficacy and intrinsic motivation in math and English [23]. It has also been reported that the relationship between parental involvement and college aspirations is dynamic, and in fact has been shown to weaken as the student moves further in the educational process [24] indicating that early and consistent support throughout K-12 education is most significant. But looking more specifically at STEM education, family support for academic achievement is among the best predictors of earning a degree in a STEM field (in addition to predictors such as academic preparation levels in math, science, and reading) [25]. And due to these independent but mutually supportive studies of parental influence on a child's aspirations and achievement, it has been recommended that strengthening support networks, such as parents and teachers, can positively influence the number of students entering STEM fields [26].

Parents whose educational backgrounds are from STEM fields have been shown to positively influence student aspirations and achievement in those fields, especially among women and minorities [27] but what about parents that do not have those backgrounds? How much do other parents know about STEM fields or educational opportunities

made available through that educational path? This presents an opportunity to influence the perceptions of parents about engineering and other STEM fields.

Through an interdisciplinary collaboration with the University's Education, Schooling and Society program, this team plans to include the parents of participating youth in a STEM outreach program in which they have a separate learning opportunity to better understand what engineering is, as well as the diversity of the opportunities available in this broad field of study. This parent workshop would be led by university faculty and community engagement representatives. Authentic parental engagement specifically opens the door for candid conversations between a parent and child about the project they developed during the I2D2 activities. Further, Greene & Long suggest that in a welcoming space, parents can partner with faculty and teachers to appreciate their significant role in their child's current educational choices, as well as their future educational path [28]. Through this focused engagement, parents are predicted to feel more comfortable talking with their children about what is involved in engineering and STEM related fields, what opportunities exist locally, and how to access them. While it is intended that the separate parent workshop would run simultaneously to the student activities of I2D2, flexibility may be required given parent schedules. Alternatives such as 'Saturday Academies' will also be considered pending consultation with parents, school officials, and partners.

A final area for future work involves the performance of fifth graders on their science fair projects. A primary goal of this program is to improve the performance of the fifth graders projects, however; due to the time lag between the I2D2 program and the science fair in the curriculum this has not been directly assessed. Anecdotally, the fifth grade teachers have indicated that their students show an initial increase in excitement for math and science, but there is no formal assessment and this is a significant challenge that will be addressed in future work.

5. Conclusions

Overall, this program is viewed as a success and will continue in future years by building on what has been learned during the initial two administrations. For fifth grade students there is a measurable improvement in their interest in science and math which supports continuation. But for college students the results are less clear in that a student's perception of the program is linked to prior experiences and/or family structure (having younger siblings) indicating program changes are needed. First, additional opportunities for preparation and practice for the first-year engineering students in terms of drawing out responses from their fifth grade 'customers' will be made. In order to aid that process, future administrations will ensure that the ratio of college students and fifth graders is more balanced to make personal interactions easier. Finally, other program improvements such as parent programs will be put in place based on the belief that they will reinforce the program objectives with the fifth grade students.

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