University And High School Collaboration Through An Interactive Outreach Activity

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Abstract

The purpose of this paper was to demonstrate University and High School collaboration through an interactive outreach activity. Pedagogical collaboration between the local Prescott High School and senior level mechanical engineering students from Embry Riddle Aeronautical University (ERAU) in Arizona had great benefits to both schools and the students. The high school students included 9th-11th grades. During multiple visits the high school students were exposed to quizzes, presentations and hands on experimentation. The quizzes were administered to gauge where their level of understanding of fluid dynamics was as well as their interest in STEM and ERAU. The students were then divided into small groups. Each group was asked to draw a shape of their choice and sketch what they believed would be the fluid flow around the object they chose. These objects being analyzed were modeled and then 3D printed. Using Flowcoach, a commercial interactive educational system, students experimentally observed flow around each shape and compared it to their initial flow sketch predictions. Students showed an increased interest in STEM. This was likely because of students being exposed to tools and applications, such as Flowcoach technology, they would not have previously been exposed to in a public high school setting. Another important benefit of the University and high school student interaction was that the students were interested to learn more about the University.

Keywords: university high school collaboration, STEM teaching, interactive learning, service learning, outreach, student evaluations of teaching, Flowcoach, PIV, particle image velocimetry, educational, fluids.

Introduction

Science and technology have been transforming our higher education for a long time. Most countries in the world invest in school science and technology in order to provide the required manpower in their corresponding economies. At the moment the United States is the global leader in science and technology but her global share of science and technology activities is declining as other nations, such as China, continue to rise (NSF, 2020). Recent federal and state policies encourage greater use of technology throughout the education system to improve students' learning experiences (NSF, 2020). Indeed during the past few years implementation and effectiveness of technology in classrooms has been steadily growing but with corresponding budgetary challenges. Funding is the greatest challenge, and using advanced technology is expensive that incurs huge district costs. Innovative ways to overcome this challenge is needed especially in the globalized economy. One way to help high schools to overcome this challenge is to collaborate with local Universities which typically have better access to Science, Technology, Engineering and Math (STEM) educational technology. Students learn better if they are interested in the subject matter, and studies have shown that as children grow their interest in STEM declines (Osborne et.al., 2003). This could be for many reasons. For example, teaching and learning STEM purely from a text book can be very challenging. STEM is by its very nature an interactive subject. The student has to experiment to understand the concepts based on principles that were enunciated by Chinese philosopher Confucius, who stated "I hear and I forget. I see and I remember. I do and I understand." Experimental tools to complement text books, however, are expensive and typically not easily accessible by high schools. This is especially true for accessing state of the art technology that is commonly used in today's industry.

The purpose of this paper was to demonstrate University and High School collaboration through an interactive outreach activity. Senior level mechanical engineering students from Embry Riddle Aeronautical University (ERAU) in Arizona worked with 12th grade students at Prescott High School in Arizona.

Interactive Outreach Activity Methodology

The outreach activity is a pedagogy combining community service and instruction which not only enriches students' learning experience by engaging them in the community but also teaching critical thinking.

Before the project could start an outreach topic of interest needed to be identified that will benefit both the community partner and the University. STEM covers a whole range of subjects. For example, fluid dynamics is an important subject because studying ocean currents, weather patterns, blood circulation, airplanes, rocket engines, wind turbines, oil pipelines, air conditioning systems among others all involve fluid dynamics. So the topic of interest selected was fluid dynamics. However, fluid dynamics is a difficult concept for many students to grasp because of the advanced mathematics and complexity of visualizing flow. But fluid dynamics is a highly visual subject and so during the teaching process one must take full advantage of this fact.

1. Interactive Educational Technology in Experimental Fluid Mechanics

ERAU had access to a new and unique state of the art educational technology, Flowcoach, which could take full advantage of the visual effects of fluid dynamics. Flowcoach, as can be seen in Figure 1 was manufactured by Interactive Flow Studies.

Since fluid behavior is very difficult to calculate manually, there are a couple of options for the visualization of this behavior. These options include Particle Image Velo-

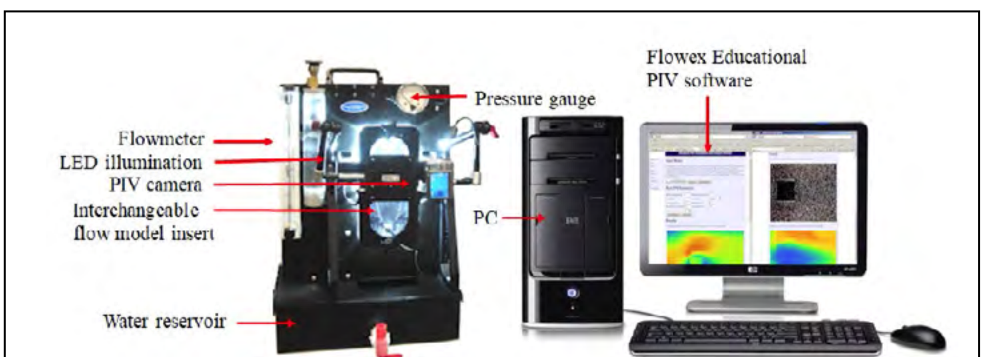

Figure 1. Flowcoach

cimetry (PIV) and Computational Fluid Dynamics (CFD).

PIV is an experimental method used to visualize and analyze fluid flow. PIV provides a hands-on experimental method that allows students to deepen their understanding of fluid dynamics. Flowcoach is a PIV system developed for educational purposes. The PIV device uses a seeding method for flow visualization. The object being analyzed is placed into seeded water, pumped in a closed loop. LED light illuminates the seed particles in the water. A digital camera is then used to record the particles' movement. This method allows real time visualization of the fluid flow around the object. Along with real time visualization, the flow can be analyzed using computer software that tracks the movement of the particles in the water. With a known time step and a known distance each particle travels, the computer software can create a global vector field of the movement of the water around the object, giving experimental analysis of the fluid flow. Additionally, Flowcoach is not limited to laminar flow. Turbulent flow can also be observed.

CFD is a computational method that numerically solves complex fluids problems. CFD is used early in the engineering design process to allow for better designs. CFD enables engineers to accurately predict the behavior of fluids around objects. With these predictions, engineers can determine if designs will work as intended, or if further refinement is needed before building an expensive experimental model.

The objects being analyzed were modeled and then 3D printed. 3D printing has become an important tool in engineering education. 3D printing is the process of using computer programs to extrude melted plastic in a pattern. This is done in layers to create complex 3D shapes. The material used was ABS (Acrylonitrile Butadiene Styrene), which has low cost and good mechanical properties. However, the finished surface on the part was rough. Acetone vapor was, therefore, used for post processing the finished part so as to create a smooth surface to prevent bubbles and seed particles sticking to the surface during the experiment. Flow model objects can be rapidly produced with the 3D printing machines at the University as can be seen in Figure 4. 3D printed objects are inserted into the Flowcoach system for flow visualization and analysis. The flow models can also be interchanged easily allowing the experiment to be done efficiently and quickly.

Literature Search

Excellence in STEM subjects is crucial for every nation to be competitive in science. The United States strongly depends on STEM subjects to maintain its position but the federal government has failed to adequately resolve the crises in education which will require significant changes in our education system to improve learning opportunities. There is so much room for innovation when it comes to teaching methods. Some schools have begun to introduce inquiry-based-learning programs for engineering

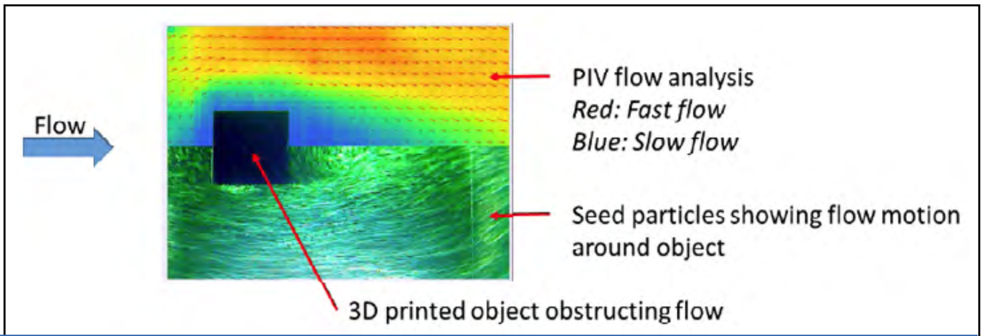

Figure 2. Typical PIV Results

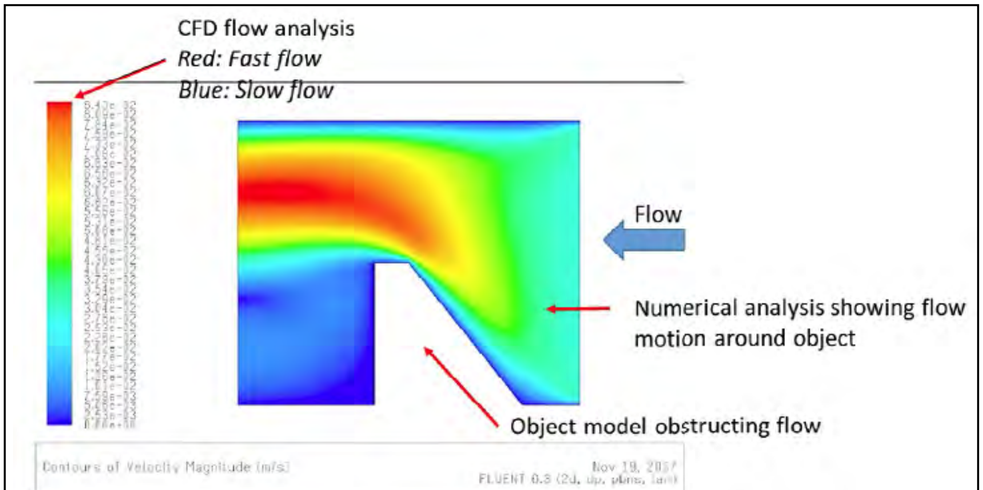

Figure 3. Typical CFD Results

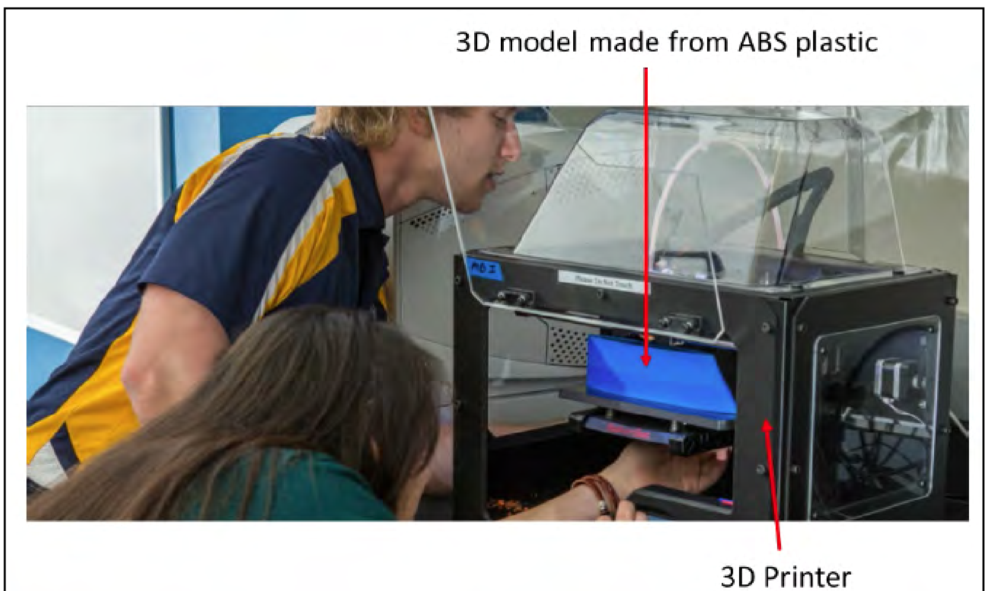

Figure 4. A 3D Printer at the University

subjects. Through hands-on, real world projects, students can become engaged and excited as they learn how their classroom skills can be applied to everyday life as stated by Machi (2009). This was the inspiration for the project described in this paper. This hands-on approach is often called activities and problem based learning to increase in student motivation, in cooperative learning skills, and critical thinking.

Successful STEM education is only possible if the students are motivated and understand the importance. According to Hossain et.al (2012) the US is behind in STEM education compared to some other countries and this may be due to students failing to realize the importance and potential of STEM at the high school level. The paper indicated that as the technology advanced, a growing need for STEM field occurred and the United States lacked the manpower in this field to meet the demand. Nevertheless, Gonzales et.al. (2012) claimed that U.S. students actually weren't performing poorly and stated that science and engineering enrollments grew by 35% over the last decade, but it also added that there were concerns in the US STEM education system such as teacher quality and meeting domestic demand. The US also faced a shortage of up to 70,000 engineers in 2010, and one major contributing factor to the low number of students receiving degrees in engineering is the two decades of steady decline in the number of students enrolling in engineering disciplines as stated by Eniola-Adefeso (2009). So it is clear that we must emphasize the importance of students' motivation in STEM subjects and motivate students to pursue STEM careers at the high school level or even earlier.

STEM education is very important and it must be paid attention to because the US can only turn its economy around, including eliminating the massive trade deficit, largely through science and technology-based industries. Science and technology based innovation is impossible without a workforce educated in science, technology, engineering and math. But so as to improve STEM education, the learning environment must first be improved. Schools teach STEM facts rather than STEM skills. The courses are designed such that the students master the particular subject matter of the course rather than develop generic skills such as the ability to analyze and to solve problems, to comprehend complex situations, to think critically, to be creative, to be adaptable, to be able to work with others and learn and re-learn over a lifetime according to Atkinson et.al. (2010). Unfortunately, STEM workers also lacked fundamental knowledge as stated in the report of National Research Council (2012) and the decline of the position of US in global economy due to this reason was concluded.

Overall, concluding from the reports mentioned above, the main factor that should be focused on is raising student awareness in the importance of STEM in order to reach the desired level of success in science and technology. Even though the awareness has been raised in the past years, there are still aspects such as motivation of students or meeting the domestic demand, that need to be addressed. A solution can be introducing K-12 students to fields of engineering in high school, improving their knowledge about the subject by collaborations between colleges and high schools as suggested by the National Research Council (2012).

High school and University collaborations have been a popular strategy throughout the United States. Compared to working separately collaboration results in more energy, ideas and creative potential. Brookhart et.al (1992) showed this fact in their article by reviewing collaborative projects in the United States.

Liebermen (1991) also discussed the forming of these collaborations through her experiences. She indicated that problems usually occur in the formation process. These problems include unpredictable reaction from both sides. For example, universities usually keep themselves aloof from the high schools, creating a negative image or skeptical viewpoints of high schools where they think these collaborations are not possible. The workplace cultures of high schools and universities are different. The most important difference is the impact of the educator in the system. While in the universities, professors usually have the right to criticize and change the education system, high school teachers' opinions may not be taken seriously. Loadman et.al (1992) drew attention to these differences in their publication by comparing the cultures and claimed that collaborations may have mixed results. They also stated that understanding these differences can prevent the unexpected results of high school and university collaborations. The collaborations will have highly successful outcomes once the differences are resolved, as suggested by the publications. It is, therefore, important that these collaborations are encouraged further.

Myers (2020) examined the outreach through literature review with a student-centered approach and concluded that outreach has positive academic, personal and social outcomes for the students. He also highlighted students' previous beliefs interact with the outreach experiences and a potential conflict may initiate forming own ideas and opinions for students. Researchers document additional reasons for conducting outreach programs in K-12 settings. These include introducing students to engineering professions, teaching engineering concepts (Nadelson et.al., 2011), familiarizing them engineering analysis (Hunley et.al., 2010), and providing insights into what universities student do and study (Bonjour et.al., 2016). Programs also introduce students to campus resources and are used to recruit local students to the university (Bonjour et.al., 2016). Sahlin (2019) questioned the high school – university collaborations with an institutional perspective by examining three examples and found the outcomes of these collaborations are mainly related to collective participation as well as responsibility. Other factors affecting these outcomes include trust and improved culture among participants.

While these outreach programs are often run by university faculty, studies document the advantages of using graduate and undergraduate students as curriculum developers and classroom presenters. In this capacity students can serve "engaged role models" (Jeffers et.al., 2004). Descriptions of outreach programs that have utilized graduate students instructors have outlined the benefits of participation. These programs provide valuable teaching experience of younger children who often have dissimilar backgrounds. The instructors have opportunities to improve communication and teamwork skills, and their participation has led to scholarship opportunities in the form of conference presentations and subsequent publication (Moskal et.al., 2007). Another set of researchers emphasized the active participation of graduate students in their program stating that "Most Fellows thrive when they independently develop and present new curricular units, not contribute solely as a background technician or teacher's aide" (Degrazia et.al., 2000).

Furco (1996) claimed in his article the focus and beneficiary of the program must be determined from the start to distinguish it from the other programs. The positive effects increase if the outreach is part of a course as concluded by Astin et.al. (2000), where data from 22,236 college undergraduates were used. Typically outreach programs involve hand-on activities that require K-12 students to engage in guided inquiry [16]. For example, one outreach program provided middle school students access to software used to design bridges. Students were engaged in a competition to improve the design of a bridge so that it could withstand the required loads (Symans, 2000). Another outreach program provided middle school students' insight to biomedical engineering as the students built a biomimetic device that represented how muscles contract. The students conducted an experiment with the device and they gathered data with the intent of learning how engineers approach problems (Hunley et.al., 2010). A recent publication (Nair et.al., 2016) indicated that using an educational PIV system similar to Flowcoach but for endovascular device testing in an active learning-based curriculum improved student understanding of biofluid mechanics where the students deployed an endovascular stent into an anatomical model of a cerebral aneurysm and measured intra-aneurysmal flow velocities with this system.

There is evidence in published literature that educational PIV systems have been successfully used by Universities. For example, a paper by Stern et.al. (2012) demonstrated that hands-on integrated Computational Fluid Dynamics (CFD) educational interface and educational PIV laboratory was an effective means of training students in modern experimental methods and simulation technology while simultaneously increasing their understanding of fluid physics and classroom lectures. Medina et.al. (2011, 2012) also used educational PIV tools to supplement the traditional teaching methods. Brower (2011) and Grant et.al. (2010) utilized the educational PIV technology for outreach through University and local high school collaboration by teaching flow concepts such as separation, drag, and lift showing examples of the various phenomena using computational and physical models. Okcay et.al. (2008) described components of educational PIV in detail and provided examples of how it can be used to enhance undergraduate and graduate laboratory experience. Cousin et.al. (2015) combined educational PIV and a finite element analysis and simulation software, COMSOL, to study fluid flow in microfluidic valves.

Objectives

From an educational perspective, outreach activities create a different learning environment from those present in regular classes. The objectives of this exercise can be divided into two groups since there are two groups of students involved in the program. The first group is the undergraduate students from the University. The second group is the High School students. The undergraduate students volunteered to be part of the program even though there were no extra credits but because they saw the intrinsic value of the activity and signed up just for these reasons.

a. Undergraduate Students:

i. Gain valuable and diverse experiences outside their University environment,
ii. Empowering the students to effect positive change and serve as citizen-leaders in a global community,
iii. Improve their presentations skills and responding to questions from the audience,
iv. Practice their organization skills including scheduling, preparing for the presentations, setting up the experiment, and manufacturing parts,
v. Teach new skills learning new technology such as PIV experimentation,
vi. Introduce to publishing their findings after critical data evaluation.
vii. Working in a team environment

b. High School Students:

i. Increase their interest in STEM,
ii. Learn about science through interactive exercises with fluid dynamics,
iii. Gain valuable and diverse experiences outside their High School environment,
iv. Expose the students to new technology such as PIV, CFD and 3D printing,
v. Working in a team environment
vi. Opportunity to ask questions to University students which includes technical as well as general student life

4. Student Leadership

Faculty at ERAU initiated the program. The undergraduate students were nominated for the Outreach training by the Faculty. The group consisted of five seniors students (four female, one male) at the time of this program. Even though the Faculty were the initial architect of this program the students took the lead in preparation and execution of the program with guidance and feedback from the Faculty. The purpose of this real life experience was to give the students the opportunity to develop leadership skills and roles in communities as well as in their future professions, as has been done in other programs (Fogg-Rogers et.al., 2017).

1. What is the definition of a fluid?
2. Which of the following ARE fluids (circle all that apply)?
    a. Water   b. Gas   c. Air   d. Rock
3. List the four main properties that define a fluid.
4. How do fluids affect the flight of airplanes?
5. Would a big truck or a sports car have better fuel efficiency? Why?
6. Why is flow visualization important for engineers?
7. What are three ways to model a fluid?
8. What is fluid dynamics is important in science?

Figure 5. Pre Quiz Questions

1. What is the definition of a fluid?
2. Which of the following ARE fluids (circle all that apply)?
    b. Water   b. Gas   c. Air   d. Rock
3. List the four main properties that define a fluid.
4. How do fluids affect the flight of airplanes?
5. Would a big truck or a sports car have better fuel efficiency? Why?
6. Why is flow visualization important for engineers?
7. What are three ways to model a fluid?
8. What is fluid dynamics is important in science?
9. Has this presentation increased your interest in science, technology, engineering, or math?
10. Has this presentation increased your interest in attending Embry-Riddle?

Figure 6. Post Quiz Questions

5. Materials and Procedures

A. Pre and Post Quizzes

Senior level engineering students from ERAU visited Prescott High School in Prescott Arizona. The high school students included 9th-11th grades. During the first visit a pre quiz, as can be seen in Figure 5, was administered to gauge where their level of understanding of fluid dynamics was.

The post quiz, as can be seen in Figure 6, had additional questions regarding their interest in STEM and ERAU.

Figure 7. Presentation

B. University Student Presentation

The quiz was followed by a twenty minute presentation on introduction to fluid dynamics as can be seen in Figure 7. This presentation deliberately did not include any details of flow lines, streamlines, or fluid flow over objects. This is because the students were, as part of the exercise, later asked to draw streamlines of flow over objects to

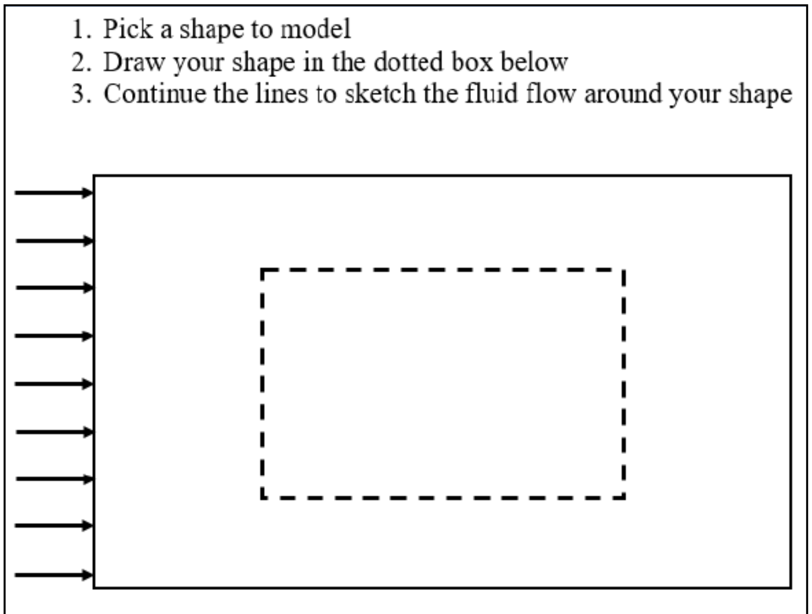

Figure 8. Shape Format

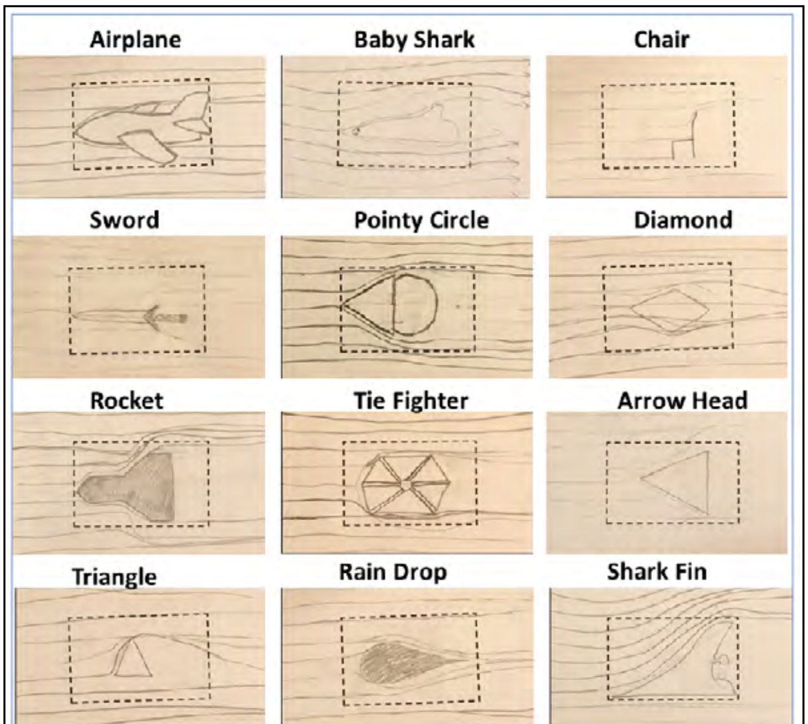

Figure 9. Student Objects and Their Predicted Flows

predict the flow behavior. At the end of the lecture the high school students were allowed to ask questions to the university student presenters.

C. Class Exercise

After the question and answer time 58 high-school students were divided into small groups. Each group was asked to draw a shape of their choice and draw what they believed would be the fluid flow around the object they chose. These drawings were collected by the University students so as to manufacture the objects and compare to the actual flow.

D. Student Project Descriptions

The students were given a format to draw the shapes as can be seen in Figure 8.

It was surprising to see such diverse shapes with no duplication, as can be seen in Figure 9, among the groups even though the groups worked independently. Full credit goes to high school students' ability to use their imagination when the opportunity presents itself.

E. 3D Printing of Shapes

The University students modeled the shapes chosen by the high school students using Solidworks Computer Aided Design (CAD) as can be seen in Figure 10.

The shapes were then manufactured using the 3D printers at the University as can be seen in Figure 11.

F. Flowcoach Testing

The University students set up the Flowcoach system, as seen in Figure 12, and flow around each shape was analyzed and compared to the initial flow sketches of the high school students. This was performed at the University before the second visit.

G. High School Demonstration

During the second visit another presentation, as can be seen in Figure 13, was given by the University students where the results were presented to the high school students to show them how accurate their initial drawings were.

A demonstration of the Flowcoach system also gave the students first-hand experience of performing experiments on the shapes they drew as can be seen in Figure 14.

A post-test identical to the pre-test were administered to the high-school students at the end of the exercise.

III. Analysis

The pre and post quiz test results on Fluid Mechanics knowledge can be seen in Appendix 1. The knowledge of 58 children was measured before and after the teaching method had been applied. The knowledge was measured on a scale from 0 to 8, with 8 indicating highest knowledge of fluid mechanics. As can be seen in Table 1, the initial baseline showed a mean score of 1.8 and after the teaching method had been used the average increases to 3.4.

The statistical analysis involved identifying a null hypothesis defined as:

1) Null Hypothesis: There is no difference between pre and post student knowledge
2) Alternative Hypothesis: There was a difference be tween pre and post student knowledge

A statistical Z test analysis was performed to decide whether or not to reject the null hypothesis as can be seen in Table 2. According to the statistical analysis the Null Hypothesis can be rejected as $|Z|$ is greater than the critical value. The results were also considered significant as $p < 0.05$. Therefore there was a difference between pre and post student knowledge.

The pre and post response results for change in interest in STEM and University as a result of this exercise can be seen in Appendix 2. A summary of the increase interest in STEM and the University can be seen in Table 3.

IV. Results And Discussion

Pedagogical collaboration between the high school and the university had great benefits to the school and the students. Both the high school and university students showed great interest in this interaction. For example, it

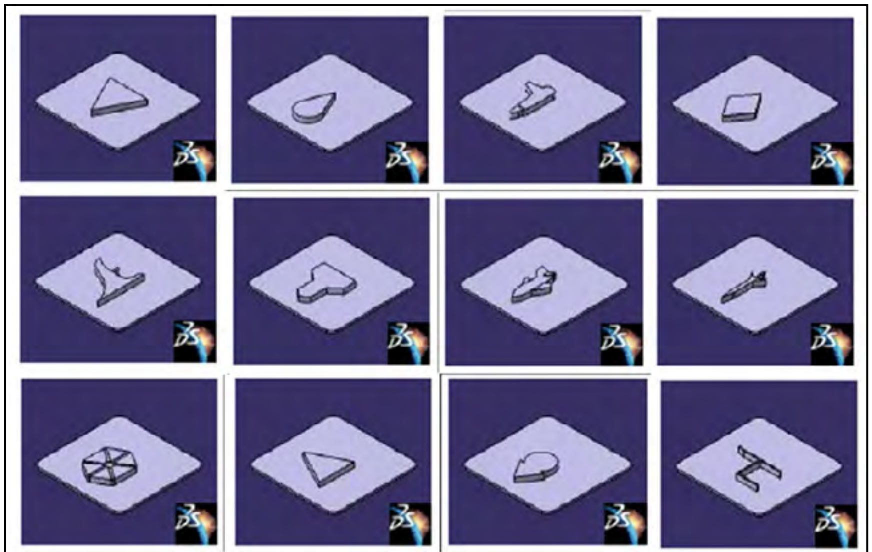

Figure 10. CAD Drawings of Models

Figure 11. 3D Printed Parts

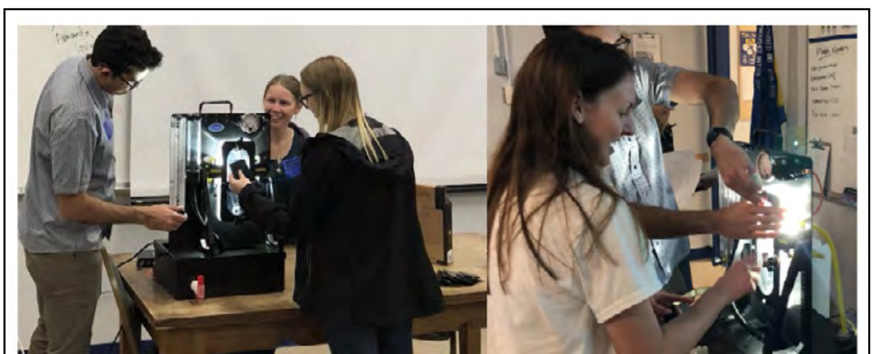

Figure 12. Flowcoach Testing

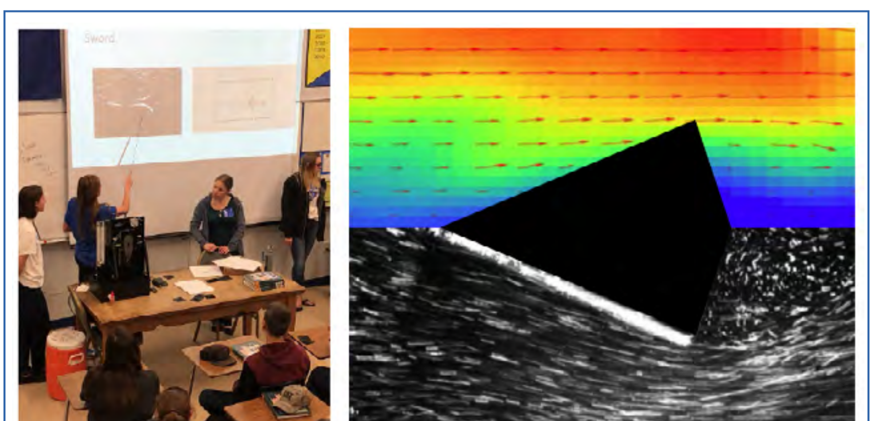

Figure 13. Presenting the Results

Figure 14. Student Hands-On Testing

was interesting to see that the questions at the end of the presentation were not limited to the lecture or science but also to university life in general. It was clear that Mechanical Engineering Department at the University should do more reaching out to students in person at local high school events which may also be a part of the recruitment process. The University and the high school must work together to build long-term interest and commitment.

Experiment based learning has a lasting effect on students because it involves not just their intellect but also their senses and their personalities. The excitement and

	Pre	Post
Mean	1.83	3.36
Standard Error	0.18	0.23
Median	2.00	3.00
Mode	1.00	4.00
Standard Deviation	1.35	1.76
Sample Variance	1.83	3.11
Kurtosis	4.12	0.00
Skewness	1.78	0.30
Minimum	0.00	0.00
Maximum	7.00	8.00
Confidence Level (95.0%)	0.36	0.46

Table 1. Pre and Post Quiz Descriptive Statistics

Z-Test: Two Sample for Means		
	Pre Quiz	Post Quiz
Mean	1.83	3.36
Known Variance	1.83	3.11
Observations	58	58
Z	-5.26	
P(Z<=z) one-tail	0.000000073	
z Critical one-tail	1.64	
P(Z<=z) two-tail	0.000000146	
z Critical two-tail	1.96	

Table 2. Z-Test for Pre and Post Quiz Results

Number of Students						
Total	Increased Interest In					
	STEM	UNIVERSITY	STEM Only	UNIVERSITY Only	BOTH	NEITHER
58	38	31	10	3	28	17

Table 3. Pre and Post Quiz Increased Interest

interest can clearly be seen in Figure 14 from the behavior of the students and their faces while they were interacting with the experiment. This type of learning fits very well into courses in STEM.

Most of these students came to the first presentation with little or no knowledge of fluid dynamics. The first presentation focused on the overall concept of fluid dynamics with real world examples. The second presentation, which took place several weeks later, focused more on engineering examples, PIV and experiments. The second presentation did not include the fluid dynamics concepts again because they were covered in the first presentation.

The improved results in the second quiz shows that the student did retain some of the information from the first one even though it was several weeks earlier.

More than half of the students showed an increased interest in STEM. This is likely due to students being exposed to tools and applications, such as Flowcoach and PIV technology, they would not have previously been exposed to in a public high school setting.

Another important benefit of the University and high school student interaction was that the students were interested to learn more about the University.

In addition to quizzes, students were put into groups to estimate the streamlines over an object of their choice. The actual streamlines from Flowcoach and students' predicted streamline sketches are shown in Figure 15. The Flowcoach results, shown in Figure 15, are a single image of the flow which gives an indication of the fluid flow. However, the students were allowed to interactively experiment with Flowcoach and see the dynamic motion of the flow as the water past their objects.

The students observed that their predictions were close to the actual flow. None of them, however, included recirculation regions behind the objects on their sketches. This was something they observed when they performed the experiment. The students were also able to slow down the flow and see the effect on their streamlines.

The areas of the education technique that worked the best included the real world situations related to fluids that were presented along with the hands on interactive Flowcoach experimentation. Based on the comparison between the pre-quiz and post-quiz scores the results showed that the high school students did learn from the lectures and Flowcoach demonstration. The students learned the most about fluids when applied in a real-world problem like how airplanes fly and how to make a car more aerodynamic. This was because for young students who have not been previously introduced to fluid dynamics, it was easier to remember and understand information when it related to something else they were very familiar with. Based on the streamlines sketches, the students had intuition for streamlines. However, it was not surprising that they lacked knowledge of other physical fluid flow characteristics such as circulation and separation points. Experiencing this new knowledge through hands on experimentation showed through their enthusiasm and excitement.

The feedback from the University students during the after event interview was also very positive and they all agreed that for them the outreach exercise satisfied all their outlined objectives they set out to accomplish such as gaining valuable and diverse experiences outside their University environment, practicing their presentations skills, responding to questions from the audience, serving as citizen-leaders, practicing their organization skills including scheduling, preparing for the presentations, setting up the experiment, manufacturing parts, learning new technology such as PIV experimentation, publishing their findings after critical data evaluation, and working in a team environment. They could only achieve these by participating in this activity.

V. Conclusion

It was clear from the results that the outreach exercise successfully achieved the objectives. The high school students had the opportunity to access state of the art technology and performed hands on interactive learning which greatly enhanced their depth of understanding of fluid mechanics. This exercise increased their interest both in STEM and the University. At the same time the university students had the opportunity to develop their teamwork and communication skills building awareness of professional and ethical responsibilities. The broader benefits included building partnerships between the university and local high schools and enhancing university engagement in community issues.

We can conclude that more faculty members should implement outreach which should be embedded in the institutional culture. Outreach requires shared vision,

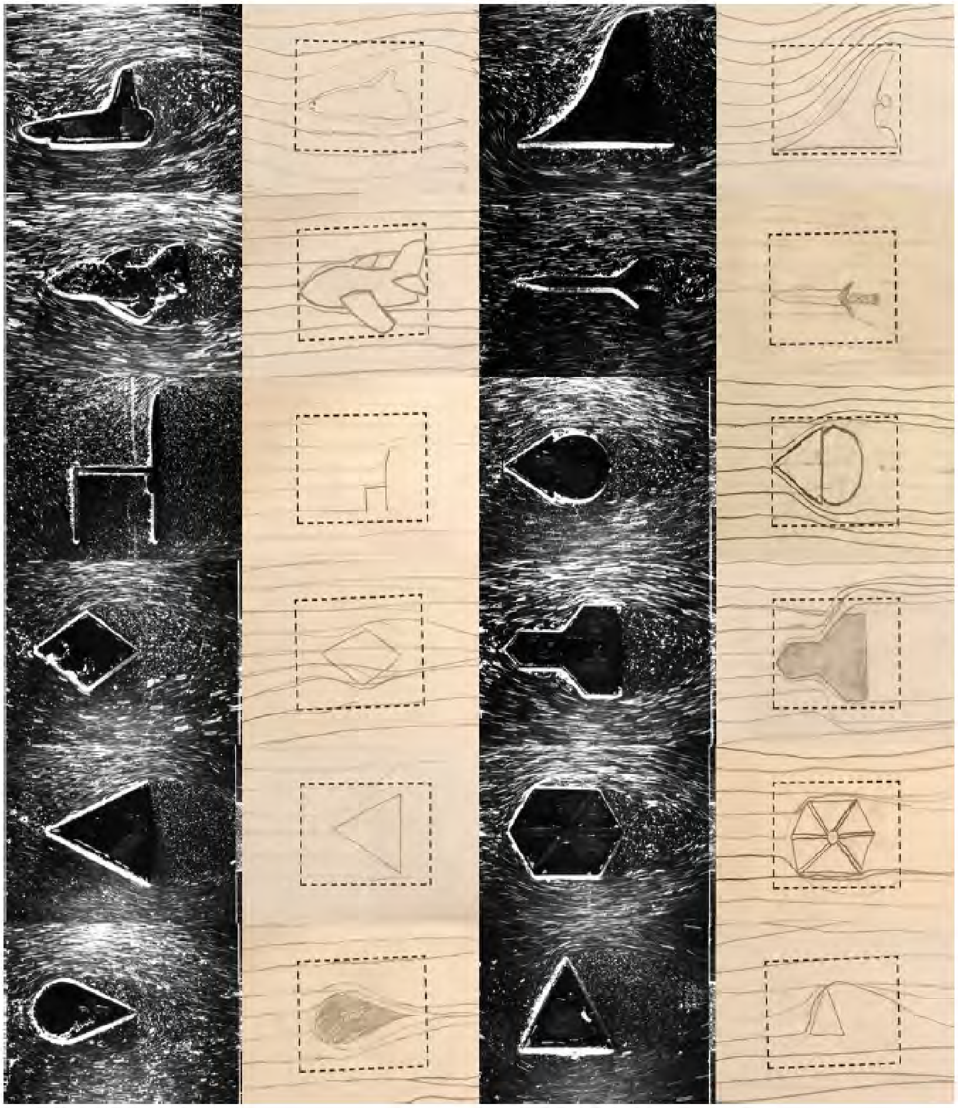

Figure 15. Actual (Flowcoach) versus Predicted (pencil sketch) Flow Streamlines

creativity and more importantly resources. It is, therefore, very difficult to sustain this collaboration between local high schools and universities by the individual efforts of isolated faculty who are tremendously committed to experiential learning.

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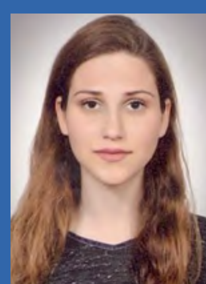
Deniz Akyazi is a Senior Mechanical Engineering student at Bogazici University in Turkey. Her interests include computational fluid dynamics, plasmas and their applications in biomedical engineering. Currently planning to pursue a Masters degree in Mechanical Engineering.



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APPENDIX 1. Pre and Post Quiz Results – Fluid Mechanics Knowledge

Student	Correct Answers		Change
	Pre Quiz	Post Quiz	
1	1	4	3
2	1	3	2
3	0	4	4
4	2	5	3
5	1	2	1
6	2	2	0
7	1	4	3
8	3	5	2
9	0	4	4
10	1	2	1
11	2	4	2
12	2	3	1
13	1	2	1
14	1	2	1
15	1	1	0
16	1	2	1
17	5	5	0
18	1	2	1
19	4	5	1
20	2	6	4
21	6	8	2
22	0	2	2
23	2	4	2
24	2	2	0
25	1	2	1
26	2	4	2
27	2	3	1
28	1	2	1
29	0	3	3

Student	Correct Answers		Change
	Pre Quiz	Post Quiz	
30	2	4	2
31	4	5	1
32	2	7	5
33	1	5	4
34	2	0	-2
35	2	5	3
36	2	6	4
37	2	4	2
38	3	4	1
39	1	1	0
40	2	3	1
41	2	3	1
42	1	0	-1
43	1	3	2
44	3	4	1
45	1	4	3
46	3	5	2
47	1	1	0
48	1	3	2
49	1	3	2
50	1	0	-1
51	4	6	2
52	2	4	2
53	1	1	0
54	1	3	2
55	1	2	1
56	7	7	0
57	2	2	0
58	2	3	1

Key:
Highest possible score = 8
Lowest possible score = 0

APPENDIX 2. Pre and Post Quiz Results – Interest in STEM and the University

Student	STEM	UNIV.	Student	STEM	UNIV.
1	1	1	30	1	1
2	0	0	31	1	1
3	0	0	32	1	1
4	1	0	33	0	1
5	1	1	34	0	0
6	0	0	35	1	1
7	1	0	36	1	0
8	0	0	37	0	0
9	1	0	38	1	1
10	1	1	39	1	0
11	0	1	40	1	0
12	0	0	41	0	0
13	0	0	42	0	0
14	0	1	43	0	0
15	0	0	44	1	1
16	1	1	45	1	1
17	1	1	46	0	0
18	1	1	47	0	0
19	1	1	48	1	1
20	1	0	49	1	1
21	1	1	50	0	0
22	0	0	51	1	1
23	1	1	52	1	1
24	1	1	53	1	1
25	1	1	54	1	0
26	1	0	55	1	1
27	1	0	56	1	1
28	1	1	57	1	1
29	1	1	58	0	0

Key:
Increased Interest = 1
No Change = 0