

Summer Technology & Engineering Preview at Stout (STEPS) for Girls

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Abstract

This paper presents the successes of the Summer Technology & Engineering Preview at Stout for Girls (“STEPS for Girls”). In 1997, the University of Wisconsin-Stout (UW-Stout), in partnership with the Society of Manufacturing Engineering Education Foundation (SME-EF), initiated an outreach program for girls entering the seventh grade. “STEPS for Girls” is a one-week introduction to the world of manufacturing. The girls manufacture radio-controlled model airplanes from raw materials. The components are fabricated in various laboratory activities using real production equipment. Each girl has an opportunity to fly her airplane with the assistance of skilled radio-controlled aircraft pilots. “STEPS for Girls” campers gain direct hands-on experience in math, physics, chemistry, packaging, computer aided design, rapid prototyping, computer aided manufacturing, CNC machining, metals casting, plastics processing, robotics, web-page development, and printing.

“When I was accepted into the “STEPS for Girls” program for one week last summer.”

1997 camper, when asked in a newspaper interview about the most memorable thing she had ever done.

Industry, University, and SME-EF support have been key to the success of this program. The camp has been free to all campers due to the generous donations of industry and university sponsors. The seventh grade outreach program, which has recently completed its sixth camping summer, now has over 900 female graduates from the UW-Stout camp. In addition, there are several hundred other female graduates from branch camps established by SME in Minnesota and Michigan.

Evidence will be presented detailing the outstanding experiences of “STEPS for Girls” graduates and the influence this program has had on their high school course and career directions. Evaluation of the program is conducted centrally by SME-EF. Our first graduates are now high school seniors. Surveys of their college plans will give us our first indication of the impact of the program. Results of the evaluation will be shared. In addition, the paper will present the informal surveys of camp participants taken during their week of activities. UW-Stout anticipates there will be an influx of female students into engineering programs in our region over the next decade as a direct result of the science, math and technology confidence the “STEPS for Girls” campers gain during their summer week long camp.

The paper will conclude with a summary of UW-Stout's plans for a new tenth grade "STEPS for Girls" program, and will provide information regarding how other campuses may develop a "STEPS for Girls" camp. Beginning in 2004, an Advanced "STEPS for Girls" camp will be conducted at UW-Stout. Campers will manufacture radio-controlled model cars, from designing the body on the computer, to machining a body form on a computer controlled mill, to extruding plastic sheet from which they will thermoform the body, and fabricating an electronic sensor controlled timer for each car, as well as experiencing several other manufacturing activities, including a visit to the Ford Ranger assembly plant in St. Paul, MN.

"STEPS for Girls" – History and Rationale

A Manufacturing Engineering program at UW-Stout began officially in the fall of 1994. The enrollment of female students has averaged between 10 and 15%, and that of minority students has been even lower since the programs inception. It is felt that the most effective means of changing this situation is a long term one: to expose girls and all children of color to the opportunities for careers in engineering before they make limiting curriculum decisions in middle school and high school.

"We were initially nervous about attending and thinking the camp would be boring, by the end of the week we wanted to be duct-taped to our beds so we could stay longer. "STEPS for Girls" expanded your mind and your self-esteem. It was flattering to be accepted from all the seventh grade girls in Wisconsin."

Two 1997 campers

Several organizations document the participation rate of women in science, technology, and engineering professions or recommend interventions of innovative programs that encourage girls to enter undergraduate science, technology and engineering studies. While women make up 46% of the U.S. labor force in 1997, women make up only 8% of the overall engineering workforce.¹ Since much emphasis is placed on salary equity issues, national reports have recently been emphasizing women earning at 76% of equivalent male earnings.² This low figure is a cumulative average across all fields of employment. 1997 median salaries of engineers with less than five years of experience are identical at \$40,000, indicating salary equity at the beginning engineering levels.¹ Young women exhibit less confidence in their math skills than young men.³ Girls also indicate they like math and science subjects less than do boys.⁴ A low rate of participation of women and minorities in engineering careers is well established. In addition, there presently are 268,000 unfilled technology positions in the United States.⁵ By the year 2010 these unfilled positions are projected to grow to 1.6 million.⁵ "Innovative programs for girls and young women provide opportunities for them to interact with women in science and technical fields".³ In addition, girls benefit from programs that build on their strengths and encourage them to explore meaningful possibilities for their futures⁴.

Society is denied the services of talented young women in technology fields, who, were it not for gender or cultural biases, have the potential to become excellent engineers. Without interventions similar in spirit to those represented by the "STEPS for Girls" program, most young female students might make critical high school curriculum choices that would limit their ability to enter, participate in, and succeed in an engineering program in college. Therefore, it is essential to reach these potential students early with solid information about the excitement of an engineering career and what it takes to achieve and succeed in one. The "STEPS for Girls" program was designed for that purpose.

As a result of these concerns, the concept of a summer engineering and technology camp for girls entering the seventh grade was developed. The first camp was conducted in the summer of 1997 to expose women to the opportunities available in technical careers early enough to influence their choices of math, science, and technical courses in middle and high school. The ultimate goal is to increase the participation of women in these career fields. The College of Technology, Engineering, and Management (CTEM) at the University of Wisconsin-Stout publishes an annual “STEPS for Girls” report.^{6,7} Much of the information provided in this paper is summarized in more detail in this report.

“STEPS for Girls” Activities

The activities of the camp were developed to achieve an appropriate balance between technical and recreational activities and to conform as closely as possible to UW-Stout’s “hands-on, minds-on” philosophy in a small group setting. Selected activities focused around manufacturing concepts, involving both processes and production systems. No more than two consecutive hours were scheduled for any technical activity to avoid surpassing the attention span of the youthful audience. Instructors were tasked to develop activities that were not only instructive and interesting but also fun. As many women role models as possible from both technical and administrative contexts were presented to the campers.

“My daughter attended the “STEPS for Girls” program two summers ago in 1999. She has gained so much from it I can't put it into words. Her self-confidence has skyrocketed to the moon. Her grades have followed. Old grades were 2.5 - 2.7 range. Since the program, 3.7-4.0. Yes, straight A's a couple times. Our entire family attributes the change to the “STEPS for Girls” Program. She is a real leader and go-getter the last couple years. She always tells us that "she found out that she wasn't dumb" at the camp. No other changes in her life. She has surrounded herself with great friends and consistently gets high remarks from her instructors in school. Truly an amazing life change for her.”

Father of 1999 camper

The campers were given an experience as close to college life as could be provided. Upon arrival the campers were organized into four teams of ten, each team identified by a distinctively colored T-shirt (red, blue, yellow, and green). This serves to provide the experience of participation in diverse social groups and organizations. They also lived together in a dormitory for their week of camp attendance, ate meals in the Merle Price Commons cafeteria, attended classes in college classrooms and labs, and were taught by real college professors.

From arrival of the campers on Sunday afternoon until departure on Friday afternoon, there were 52.5 hours of scheduled time other than routine meals. The following shows the balance among the various types of activities:

- Technical Activities 20.0 hours
- Developmental Activities 18.0 hours
- Recreational Activities 14.5 hours

Technical activities were designed around the manufacture of a radio-controlled model airplane. The aircraft was final assembled in the Transportation Lab after other lab activities produced parts as “subcontractors”, or analyses and information as “consultants”. Several of the activities in the production of the airplane are described as follows:

Subcontractors:

Foundry	Casting aluminum nose weight
Plastics	Thermoforming clear plastic cockpit canopy
Packaging	Automated fabrication of fuselage and tail components

Consultants:

Physics	Theory of flight
Chemistry	How an internal combustion engine works, analysis of flight fuels using gas chromatography
CADD	Manipulation and modification of a 3-D computer rendering of the airplane, development of a plan drawing of the airplane
Mathematics	Analysis of weight and balance

A detailed set of schedules for a typical week can be obtained upon request to the CTEM Dean's Office at UW-Stout.

In addition to the activities surrounding the manufacture and assembly of the airplane, the campers also published a daily newsletter and developed a weeklong website detailing some of their experiences. The website can be viewed at <http://www.uwstout.edu/ctem/steps/>. This website provides an interesting view of the excitement experienced during the week in many of the technical, developmental and recreational activities.

The following pictures are provided as a means of documenting some of the experiences the "STEPS for Girls" campers have. The captions are provided from the website created by the 2002 campers.



Figure 1. Chelsie is looking at molten metal in a container where we soon put our Styrofoam nosecones. The nosecones were packed into sand, and then the metal was poured on top of it. The metal melted the Styrofoam away, causing it to mold into the nosecone shape. Melanie is reading the temperature of the metal. It turned out to be about 1525 degrees.



Figure 2. The Green Team in a chemistry class. We learned how to tell ink apart and also learned about gas and fire and did many experiments (explosions).



Figure 3. Today we went to a ropes program. We climbed a tower and a rock wall. This is Jodi climbing up the hardest side of the rock wall. She was the first person to make it up to the top today!



Figure 5. This is a picture of Kelsey & Alyssa working on their planes.



Figure 4. Yia is using a router. She was making creases on a fuselage. Look at her go!



Figure 6. The Blue Group poses for a picture.

As you can see from the preceding pictures, the “STEPS for Girls” campers are very actively involved in the “hands-on, minds-on” activities. These activities truly do follow the UW-Stout philosophy and provide the young women with many take-home mementos of their camp experience.

“Thank you, thank you, thank you for the awesome week you provided my daughter, Holly! What a wonderful experience! Holly is all excited talking about all she learned, sharing principles that were discussed, and giving reasons for why things were done in a certain way. I appreciate all the effort that was given to provide such a wonderful experience.”

Parent of 2002 Camper

“STEPS for Girls” Evaluation Results

“If I could do it again, I would!”

2002 Camper

Since the 2000 camp, the participants consenting to a pre-camp and post-camp perceptions survey⁷ are surveyed about their perceptions. This survey captures the campers’ perceptions of themselves in math, science, or technology related fields and their interests in taking math and science courses. The campers were asked to relate to three statements on a five point Likert scale varying from strongly disagree to strongly agree. The percentages reporting that they strongly agreed with the statement indicates the campers have already elevated their perceptions of themselves in these fields as they leave the camp at the end of the week. Using a paired t-test, the following general results demonstrate significantly increased perceptions.

	<u>Pre-camp</u>	<u>Post-camp</u>
<i>It is okay for me to work in the field of Science</i>	60%	70%
<i>It is okay for me to work in the field of Math</i>	62%	68%
<i>It is okay for me to work in the field of Engineering</i>	59%	72%

The campers were also asked about their science and math interests and class choices at school. Responses to the following two questions were rated on a nine point Likert scale varying from zero interest to very interested:

	<u>Pre-camp</u>	<u>Post-camp</u>
<i>How interested are you in taking math classes at school?</i>	7.10	7.43
<i>How interested are you in taking science classes at school?</i>	6.90	7.60

Both of these post-camp ratings demonstrate a significant ($p < .001$) increase in science and math interests after participation in a “STEPS for Girls” camp.

During the summer 2002 camps, three questions were included on the in-camp surveys to provide a quick snapshot of the immediate impact of the camp and a means of comparison with previous camps.⁷ The questions concerned the awareness of and the aspirations toward engineering and scientific careers. Typical results are as follows.

<u>Question</u>		<u>Initial Questionnaire</u>	<u>Final Questionnaire</u>
<i>I plan to go to college.</i>	Yes	97.4%	97.0%
	Not Sure	2.6%	1.5%
	No	0	1.5%
<i>I know what kind of work a scientist or engineer performs.</i>	Yes	37.2%	82.4%
	Not Sure	60.2%	16.3%
	No	2.6%	1.3%
<i>I would like to be an engineer or scientist someday.</i>	Yes	14.1%	25.0%
	Not Sure	57.7%	57.4%
	No	28.2%	17.6%

From the recently available SME Summative Report, several key indicators are also worth noting.⁸ These results are cumulative for the years 2000 to 2002 and come from a total of 424 valid responses. In a pre- and post-test of the STEPS campers, campers indicate an increase of 7.3 to 7.6 for their perception of their self-esteem, an increase of 7.4 to 7.7 for their perception of their self-efficacy, and an increase of 6.7 to 7.0 for their perception of their interest in math and science.

The camp attracts a sample of girls with solid college aspirations. The camp almost triples the percentage of girls who report that they fully understand the nature of an engineering or science career and eliminates most doubt of their familiarity with the area. The percentage of girls seriously considering engineering or science as a career possibility almost doubles, and the number of those who had initially ruled it out is greatly reduced.

A key component of the original UW-Stout “STEPS for Girls” evaluation concept was a tenth grade survey to determine how the camp affected middle and high school course choices, experiences, and career aspirations. This concept remains a feature of the SME-EF evaluation plan. The first tenth grade survey of the UW-Stout “STEPS for Girls” camp was administered to alumni of “STEPS for Girls” 1997 and to a control group made up of their contemporaries who applied to the camp but were not admitted. The major finding of the survey appears to be that “STEPS for Girls” alumni are taking elective math and science courses at a higher rate than those in the control group. This fact serves to validate the effectiveness of “STEPS for Girls” in achieving its important intermediate objective of providing inspiration to girls to adequately prepare for engineering, science, and technical careers.

“Not only was “STEPS for Girls” fun, but it also gave me a different perspective on engineering. I didn’t think that engineering could be this much fun or this interesting. It made me think about getting a job in the engineering field some day.... I am glad that you gave us a chance to learn. You opened up a new world for us.”

2002 Camper

In addition to these survey results, there are numerous examples of convincing evidence that “STEPS for Girls” camps are a success. Throughout this paper, there are anecdotal statements inserted into the text boxes indicating the direct impact the STEPS experience has had on a young woman. Two of the 1997 campers, who had then just completed 8th grade, have enrolled in UW system universities and are majoring in chemistry and applied science. These two individuals report that their STEPS experience influenced their career path into the science majors they ultimately have enrolled in. Applications to UW-Stout indicate two 1997 STEPS campers have selected manufacturing engineering as their major, two 1997 STEPS campers have selected engineering technology as their major and two 1997 STEPS campers have selected applied science as their major. Probably even more convincing is the fact that one of the 2002 female freshman in the manufacturing engineering program was convinced to enter this program by her younger sister, a 1998 STEPS camper. All of these examples provide direct evidence that the STEPS camp is having a significant influence on several of the campers’ career choices.

Future Directions for “STEPS for Girls”

Because of the high quality, popularity, and success of the UW-Stout “STEPS for Girls” program, the Society of Manufacturing Engineers Education Foundation (SME-EF), its initial sponsor, began a campaign to replicate the program nationwide. Its efforts at fundraising

resulted in the initiation of three camps in Minnesota in 2000, two camps in Michigan in 2002 with more to follow in 2003, and a number of sites in Illinois in 2003.

The Minnesota camps, which obtained three-year funding from the Bush Foundation, provided the model for future replication in additional states. Two seventh grade camps, at the University of St. Thomas in St. Paul and Alexandria Technical College in Alexandria, were developed as precise copies of the UW-Stout “STEPS for Girls” camp. An Advanced “STEPS for Girls” camp at the University of Minnesota (U of M) was designed to accommodate tenth grade alumni of the seventh grade camps and had a different engineering focus. Until seventh grade alumni were available from the Minnesota camps, alumni of the UW-Stout camp had been invited in each of the first three years, and an average of 50 of them (31% of their original camp enrollment and of U of M capacity of 160 campers) has enrolled annually. This enrollment indicates a significantly high level of sustained interest and aspirations for engineering as a career.

Unfortunately, budget problems at the University of Minnesota have caused its Institute of Technology to eliminate the Women in Technology office that had been the planning and coordination agency for its Advanced “STEPS for Girls” camp. As a result, the Advanced “STEPS for Girls” camp at the University of Minnesota has been discontinued. Without it, the SME-EF concept of providing continuous contact with and opportunity for “STEPS for Girls” alumni with sustained interest could have been seriously damaged in this region. However, SME-EF has granted UW-Stout the opportunity to continue the camp on its campus beginning in the summer of 2004. Planning and fundraising has begun to support the initiation of this camp.

Advanced “STEPS for Girls” Concept:

The seventh grade “STEPS for Girls” camps are designed to give the campers an appreciation for the creativity of engineers in designing manufacturing systems, processes, and tooling that will allow inexperienced youngsters to manufacture a relatively complicated product in a short period of time. They are not involved in engineering design, but are encouraged to observe the results of the engineers’ ingenuity. Because of their relative youth, the activities of the campers are evenly divided between technical and recreational.

The relative maturity and previous experience of the 10th graders in Advanced “STEPS for Girls” will allow them to tackle more complicated problems, spend more time in technical activities, and obtain a modest design experience. As is the case in the seventh grade camp, the Advanced “STEPS for Girls” campers will bring home with them a sophisticated working product or products that they manufactured themselves from raw materials.

It is proposed that the primary product of the UW-Stout Advanced “STEPS for Girls” camp would be a radio-controlled model car. All technical activities would be focused on the production of the car and be organized as follows:

- | | |
|------------|--|
| Math: | Designing a vehicle to accommodate people of various sizes. |
| Physics: | Aerodynamics of a car body with wind tunnel tests and analysis of the drag coefficient of each camper’s body design. |
| Chemistry: | Polymer science. |

CAD:	Design of the car body by which several stock car body shapes are electronically modified according to the desires of the individual camper using solid modeling.
CAM:	Basic instruction on CAM. CAM interpretation of CAD files of stock car bodies followed by machining of a form of each stock car body shape from machining wax or wood. Campers design the process, selecting the correct tools to be used on two Partner CNC mills.
Plastics:	Using the forms developed in CAM, thermoforming a stock car body for each camper from a clear plastic sheet. Injection molding hub caps and wheels.
Electronics:	Instruction on electronic sensors. Fabricating an electronic timer that will start after a sensor crosses a starting line and stop at the finish line.
Production Operations:	Each camper will be assigned a unique SKU number and a sheet of bar-coded decals to place on every part manufactured in order to provide inventory control.
Metal Forming:	Fabricating sensor bracket with progressive die.
Graphic Arts:	Designing and printing decals and bar code labels.
Assembly:	Painting and decorating car body. Final assembly.

It is estimated that the activities listed would take up 26 hours of the campers' time. In addition, one afternoon would be spent in a very pertinent tour of the Ford Ranger plant in St. Paul, MN followed by dinner and shopping at the Mall of America. The next morning would be spent in competitions of the cars in drag races, obstacle courses, and a course designed to exercise the timing system. Seventh grade campers would be invited to observe the competitions as incentive for enrollment in the advanced camp.

Recreational activities such as Teen Night, swimming at the community recreation park, participation in the UW-Stout low and high ropes courses, and bowling in the UW-Stout Recreation Center would be scheduled in the evenings.

“STEPS for Girls” Support

In each of the six years that “STEPS for Girls” has been presented at UW-Stout, the campers have attended tuition-free. In the past, the program has received 550 applications for the 160 spaces available each summer. Because sustaining funding for a continuous program has been increasingly more difficult in the current economic state, a maximum of \$300 tuition will be requested from each camper for the first time in the summer of 2003. This amount represents half of the cost per camper.

The remainder of the cost will continue to be defrayed by donations from various organizations, industries and foundations. Very consistent support has been received from the following organizations:

- Society of Manufacturing Engineers Education Foundation
- 3M
- AnnMarie Foundation of Phillips Plastics
- Banta Corporation
- West Group Publishing
- Xcel Energy
- Northwest Chapter of the American Society of Training and Development
- Stout University Foundation
- Uvex (donation of 200 safety glasses)
- Midwest Wireless (donation of services and use of cellular phones for counselor communications)
- Northwest Airlines (donation of 200 souvenir pilot's wings)

“STEPS for Girls” Replication Opportunities

SME-EF has been successful in replicating the “STEPS for Girls” program in a number of additional states. The STEPS staff at UW-Stout assists in the process of introducing new camps. A CD-ROM developed at UW-Stout, detailing the tooling necessary to manufacture airplanes and the procedures used to execute a program of this nature, makes this assistance easier. At least one year of planning, coordinating, and tool-up is needed in order to present a camp in a satisfactory manner.

Any institution considering the initiation of a “STEPS for Girls” program should contact one or both of the following individuals for assistance and advice:

Lynn Borg
Youth Programs Coordinator
SME Education Foundation
(313) 271-1500 ext. 1713
borglyn@sme.org

Pete Heimdahl
College of Technology, Engineering and Management
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Conclusions

In conclusion, University of Wisconsin-Stout's College of Technology, Engineering and Management created a summer experience for young girls, called the Summer Technology & Engineering Preview at Stout for Girls ("STEPS for Girls"). The intent is to expose the girls to the fields of science, engineering, and technology. These young girls are entering the seventh grade. This exposure to these fields of study is intended to influence their choices of math, science, and technical courses in middle and high school. The ultimate goal is to increase the participation of women in these career fields. Results indicate a considerable shift in STEPS campers' perceptions of their self-esteem and interest in math and science. This shift in perceptions indicates the girls understand they can become technology experts without losing their femininity, and they understand they can share their knowledge with others in a helping environment.⁹ Early recruiting results demonstrate the entry of STEPS campers to college programs in science, technology, and engineering throughout the region of UW-Stout. Plans are now in place to develop an advanced "STEPS for Girls" for 10th grade girls.

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Biographical Information

DANNY J. BEE is an Assistant Professor of Manufacturing Engineering since 1995 and the former Program Director for Manufacturing Engineering at the University of Wisconsin-Stout. He earned a B.S. in Mechanical Engineering at the University of Wisconsin-Madison and a M.S. in Manufacturing Systems Engineering at the University of Wisconsin-Madison. He has design/manufacturing experience in the aerospace and computer industries. In addition, he worked as a Quality Specialist in the Janesville/Beloit, WI region at Blackhawk Technical College. He is currently a Ph.D. student in mechanical engineering at Michigan Technological University working in the area of environmentally responsible design and manufacturing.

BRENDA S. PUCK is a lecturer in the Technology Department at the University of Wisconsin-Stout. She teaches a variety of courses in support of the Technology Education and Engineering Technology programs. She received her M.S. in Technology Education from the University of Wisconsin-Stout. She has been on the “STEPS for Girls” faculty since the programs inception and will become the “STEPS for Girls” Camp Executive Director in the future.

DR. PETER D. HEIMDAHL is the “STEPS for Girls” Camp Executive Director and Associate Dean of the College of Technology, Engineering, and Management. He joined the UW-Stout faculty in 1992 after retiring from the U. S. Army in the rank of Brigadier General. Sixteen years of his military career were spent on the faculty of the United States Military Academy, West Point, New York, where he ultimately held the position of Professor and Head of the Department of Mechanics and later the Department of Civil and Mechanical Engineering. Dr. Heimdahl’s undergraduate degree is from the United States Military Academy. He completed his M.S. and Ph.D. in Theoretical and Applied Mechanics at the University of Illinois.