

Creation of a Women's Machining Course at Rowan University

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Retention of female students in mechanical engineering programs remains one of the greatest challenges to engineering educators today. In the year 2000, only 14% of mechanical engineering bachelor's degrees were awarded to women.¹ Possible reasons that are often cited include lack of female role models, perception of engineering as a man's profession and subtle differences in education and conditioning at early educational levels.

One likely explanation that is often overlooked is the relative lack of comfort many women feel around mechanical equipment, especially machine tools. Since much of traditional mechanical engineering involves the design and prototyping of mechanical equipment, this lack of comfort may manifest itself in the decision by women not to pursue mechanical engineering as a career.²³ In contrast, many young men are raised in an environment where familiarity with tools and machinery is expected. In a design-intensive environment such as Rowan, a lack of prototyping experience greatly diminishes a student's educational experience. It is through prototyping, or "seeing what works," that students become mature designers.

One Possible Solution: A Women's Machining Course

It was to help combat this artificial gender divide that we embarked upon the Women's Machining Course at Rowan University. Two of our former female senior ME students approached one of us (Constans) and stated that, despite four intense years of mechanical engineering instruction, they still felt uncomfortable in the machine shop. During course projects involving prototyping they noticed that most of the machining was performed by their male counterparts. This is consistent with our own observations; in a typical team project situation a male student will almost invariably volunteer to do the fabrication, leaving the female students to do the computational or written portions of the project. It was disheartening to learn that two of our senior students thought that they had missed out on one of the Rowan hallmarks, and we quickly resolved to remedy the situation as best we could.

The solution arrived at through discussions with our female students was to conduct a Women's Machining Course. The course was held on Tuesday evenings from 5 to 7 p.m. during the Spring semester of 2001. As the name implies, only women were allowed to participate in the course; this is pedagogically consistent with the findings of Kim,⁴ Tidball,⁵ Kim and Alvarez⁶ and others that single-gender instruction can have a positive impact on women's intellectual growth and self-confidence. To ensure a good turnout we enlisted the help of the local chapter of

the Society of Women Engineers (SWE). For a fee of \$20 to cover materials, any woman in the College of Engineering could participate. To keep administrative effort to a minimum, the course was offered on a voluntary, no-credit basis.

The turnout for the course was surprisingly high. Since we left the course open to all majors and all classes, we had a significant number of Chemical, Civil and Electrical Engineering students in addition to Mechanical Engineers. We also had the participation of two female faculty members (ME and ChE) as well as our Dean of Engineering. Approximately 15 students enrolled in the course; of those, a little over half completed the course. Those who dropped the course cited their school workload as the primary reason. Given the voluntary nature of the course and the fact that it lasted the entire semester, we were quite pleased with the rate of retention.

The Project: a Simple Engine Model

In choosing a project we needed something simple enough for beginning machinists yet challenging enough to hold the students' interest. Also, we wanted something that the students could take with them as mementos of the course. The design we arrived at, shown in Figure 1, is a simple, two-cylinder engine model. Dimensions of the engine block are shown in Figure 2. The engine block is made of plexiglas, so that one can easily see the inner workings. The pistons are made of brass round stock, polished to a high shine. The connecting rods are made of aluminum and the cranks are made of acetal (an engineering plastic). All shafting consists of stock steel dowel pins. The base is made of walnut wood, sanded and oiled to a smooth finish. Overall, the design is attractive enough to serve as a paperweight on an engineer's desk.

The tooling required for fabrication was quite simple; rectilinear parts (the engine block, wood base, connecting rods) were made on manual milling machines, axisymmetric parts (pistons, cranks) were turned on small lathes. One positive feature of the project was that it introduced the students to a wide variety of machining practices (milling, fly-cutting, boring, drilling, turning, facing, etc.) while requiring minimal tooling and stock.

Assessment and Lessons Learned

So far, feedback from the Women's Machining Course has been overwhelmingly positive. We recently distributed a survey to the course participants; nine students completed the survey. The goal of the survey was to determine whether

1. The course increased the students' confidence in their own fabrication skills.
2. The course increased the students' confidence in their own capacity for engineering design.
3. The skills learned in the course were applied to other, more traditional engineering courses.

The results of the survey are encouraging. Eight of the nine women felt increased confidence in their fabrication skills and six of nine felt increased confidence in their design abilities. All nine of the women reported that they had used the skills learned in the course in their other engineering courses at least occasionally. This is consistent with our own observations in the

classroom: students who have completed the course often take a leading role in projects involving fabrication work.

Interestingly, the women were somewhat divided as to whether the course should be integrated to include men. Six of nine expressed a preference for keeping the course segregated, while the other three desired integration. Obviously, nine students is much too small a sample for statistical significance; we intend to distribute the same survey at the end of each semester in the years to come.

As to informal feedback, the students truly appeared to enjoy “getting their hands dirty” once a week. Interestingly, many of the women also used the Machining Course time as an opportunity for networking; hopefully, the contacts made during the course will be helpful during the students’ careers as engineers.

One less positive aspect was the time required to complete the project. Despite the excellent prototyping facilities at Rowan and the enthusiastic students, the course lasted the entire semester, with the final class held during Finals Week: a total of 14 two-hour sessions. This was a considerable investment in time for the students and faculty, especially considering the voluntary nature of the class. Future projects will be simpler in scope, perhaps lasting only half the semester.

One final encouraging note: there appears to be considerable demand by our female engineering students to repeat the project in future semesters. Eight of the nine students expressed interest in attending a more advanced “Rapid Prototyping” course during the Fall 2003 semester, while some students who dropped out of the course in mid-semester have requested time and support to complete their projects at later times. Judging by the experiences of female engineering students at Rowan University, gender-segregated courses in mechanical prototyping appears to be a large, unmet need. We believe that a course like this is easily transferable to other universities, and would be one small step in improving gender parity in engineering education.

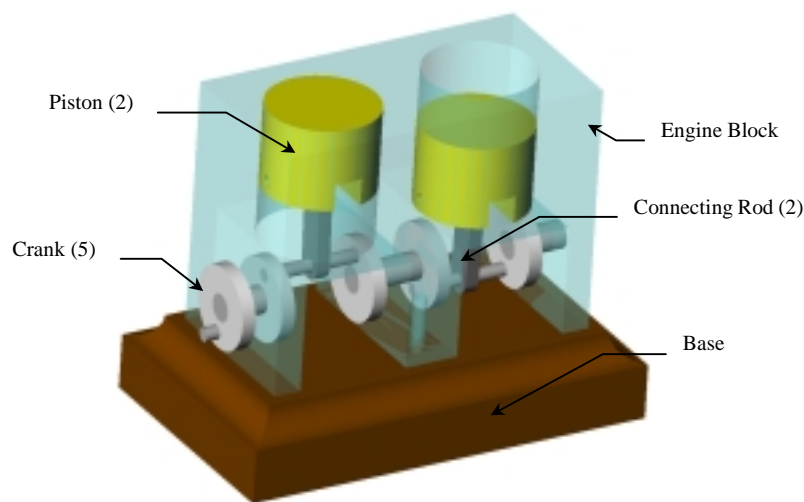


Figure 1: Engine Model

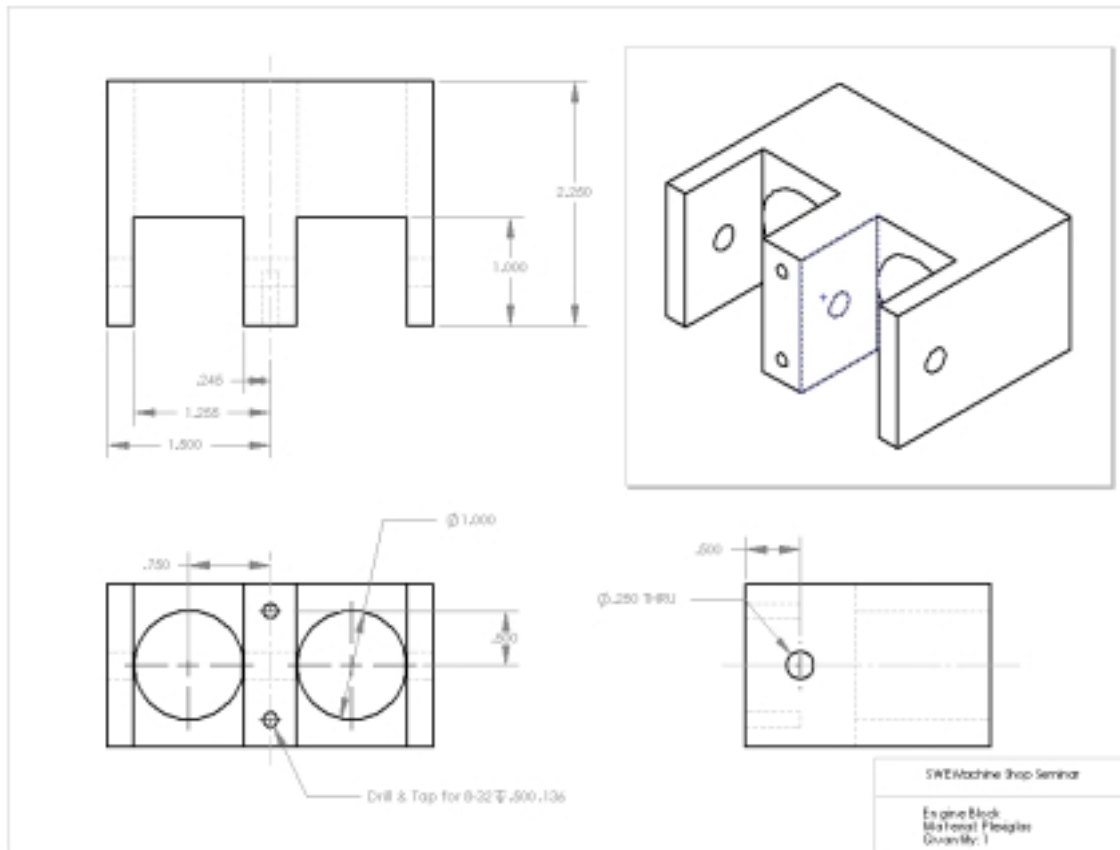


Figure 2: Dimensions of Engine Block

- ¹ American Society for Engineering Education Prism, September 2001, p. 14.
- ² McIlwee, J.S. and Robinson, J.G. 1992 "Women in engineering: Gender, power and workplace culture" Albany: SUNY Press.
- ³ Seymore, Elaine. 1995 "The Loss of Women from Science, Mathematics, and Engineering Undergraduate Majors: An Explanatory Account" *Science Education* **79**(4): pp. 437-473.
- ⁴ Kim, Mikyong. 1996 "The Effectiveness of Women-Only Colleges for Intellectual Development of Women Students" *Annual Meeting of the American Educational Research Association*, April 8-12, 1996, New York.
- ⁵ Tidball, M.E. 1980 "Women's Colleges and Women Achievers Revisited" *Signs* **5**, pp. 504-517.
- ⁶ Kim, M. and Alvarez, R. 1995 "Women-Only Colleges: Some Unanticipated Consequences" *Journal of Higher Education* **66**(6).