

## **Engineering Graphics Hands-on Vise Project**

To promote hands-on learning at Kansas State University, a semester-long project was developed for the Engineering Graphics course. Although the initial charge was to include 3D printing into the re-developed course, the overall scope was expanded to include more hands-on learning activities. The new project requires students to work in groups to disassemble, measure, model, and reassemble desktop bench vises. Guided from previous research on dissection courses, this project helps promote hands-on learning in the classroom while integrating course content together.

Engineering Graphics develops visualization skills that are critical for technical communication. In this course, students learn hand drafting and a computer-aided design (CAD) program. In addition to the homework assignments and exams, this course typically includes a summary project. Most often, students are given a series of dimensioned drawings similar to ones shown in Figure 1, and asked to convert these two-dimensional drawings into an integrated CAD model as shown in Figure 2. At Kansas State University, recent projects have included a desktop steam engine, V8 automotive engine, unicycle, door with working locks, stirling engine, and a grandfather clock. These projects were geared towards enhancing students' CAD modeling skills, but not necessarily their understanding of how engineering objects are assembled and modeled. It was the opinion of the authors that this approach to learning Engineering Graphics could be improved, most significantly by implementing a more hands-on project distributed throughout the semester.

To brain-storm ideas, the authors started with a review of the literature for hands-on Engineering Graphics related projects. Research has shown that hands-on pedagogy with the use of physical objects can show an increase in student retention, critical thinking skills, and knowledge retention (Smith 2005, Pomalaza-Raez 2003, Singh 2014, and Clark 1998). A more specific project concept was developed in a mechanical dissection course taught at Tuskegee University. Here, first-year students study the function of a mechanical system by dismantling it in order to see how its specific function is realized (Aglan 1996). Similarly, Stanford University has also developed a mechanical dissection course to introduce students to understanding how everyday objects are designed (Sheppard 1992). While both of these courses focused on the engineering design process, the importance of clear, concise communication similar to the

purpose of Engineering Graphics was highlighted and emphasized in both. Another factor that led to the success of both of these courses was starting with objects that were familiar to the students and not conceptually overwhelming.

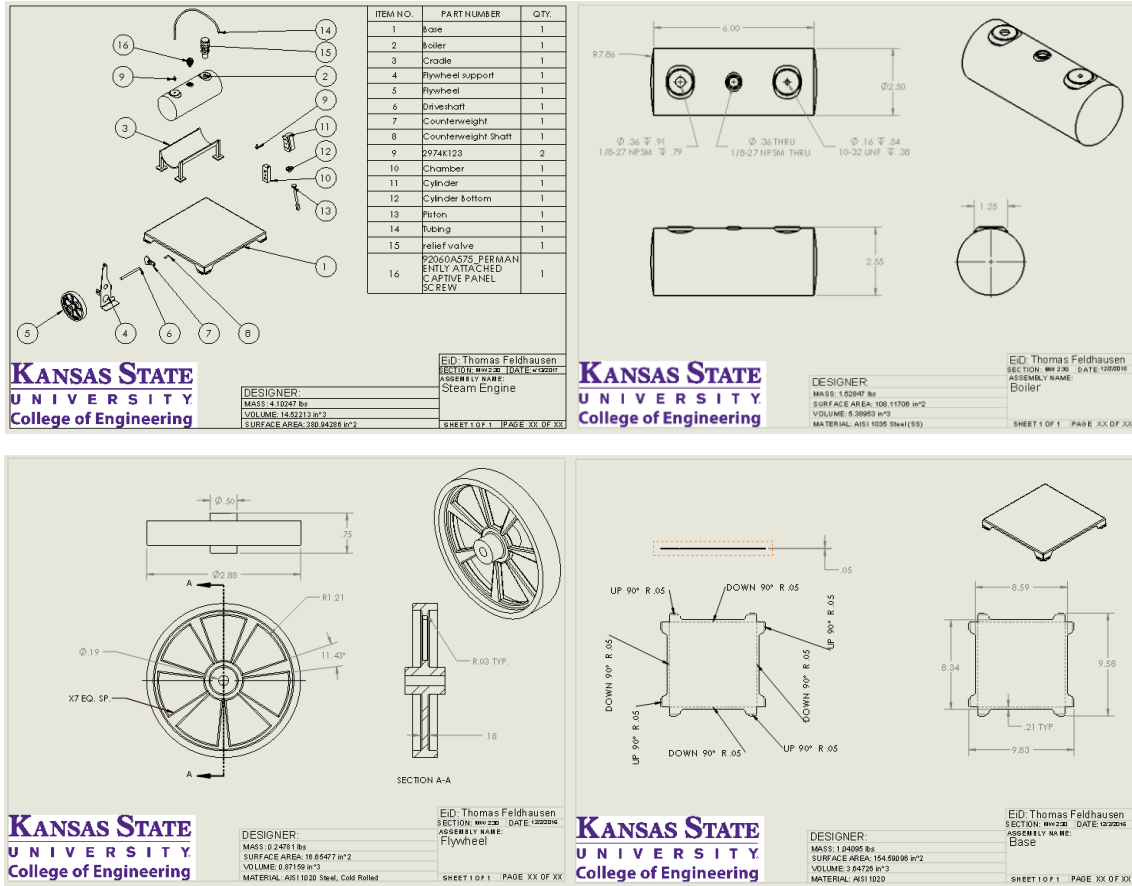


Figure 1: Traditional Engineering Graphics Drawings of a Steam Engine

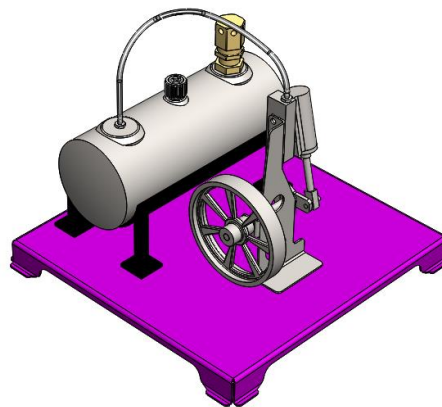
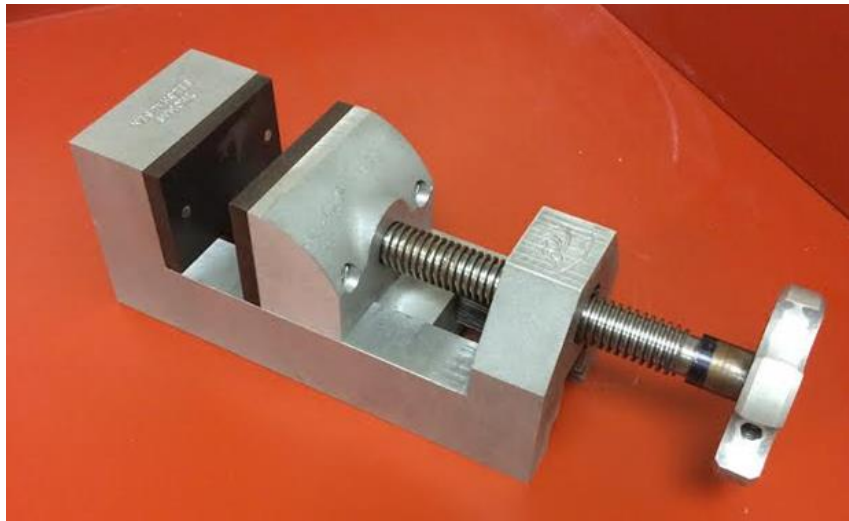


Figure 2: Traditional Engineering Graphics CAD Assembly of a Steam Engine

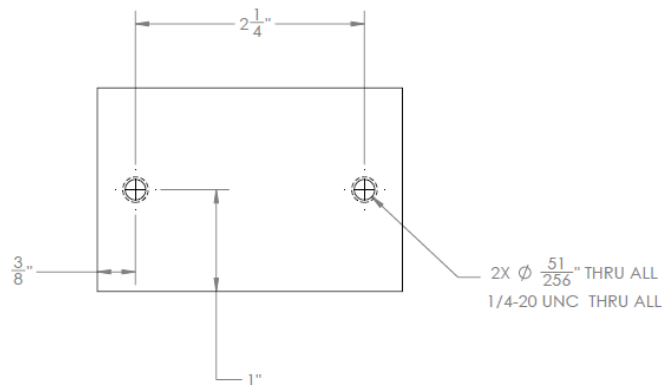
Guided by these principles, the physical object selected for our Engineering Graphics project was a desktop bench vise as shown in Figure 3. The vise selected is approximately twelve inches in length and weighs approximately 10 pounds. This object was a clear choice as it is simple, compact, and relatively inexpensive. Further, these vises are manufactured by students in the Kansas State University's Industrial Engineering Department in an introductory manufacturing processes course and are commonly seen throughout the Engineering College. This object will serve as the centerpiece of the Engineering Graphics project that will promote hands-on learning.



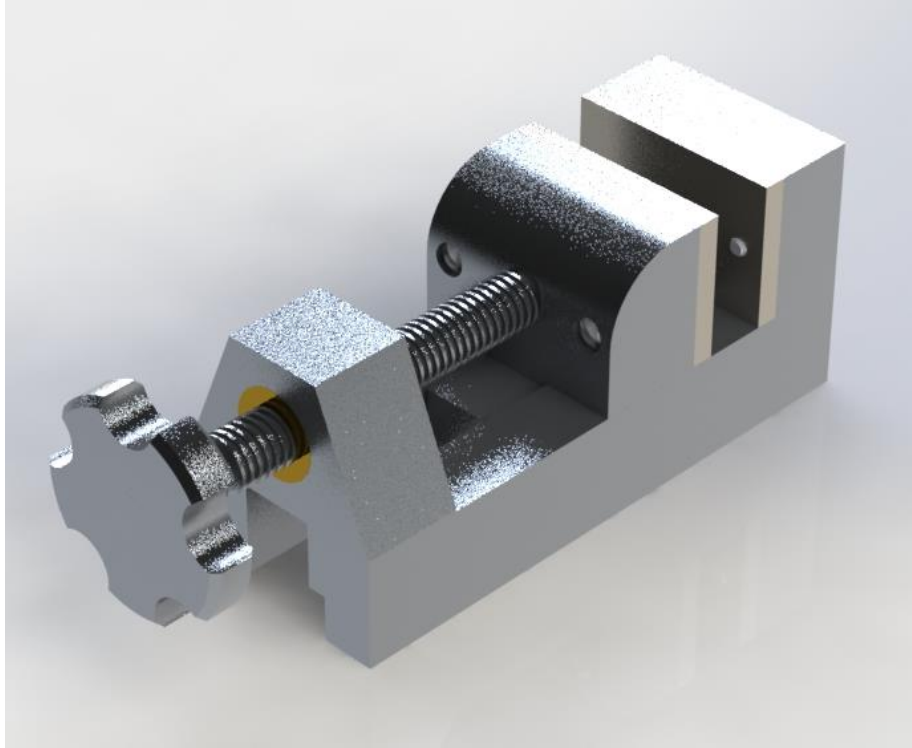
**Figure 3: Desktop Bench Vise**

Starting early in the semester, students will have their hands on the vise. As stated by Sheppard, “There is no substitute for rolling up your sleeves and digging in. I believe that we ‘see’ with our hands as well as with our eyes” (Sheppard 1992). To begin the project, students work in groups to disassemble and measure the physical dimensions of the vises. Having students disassemble the vises early in the semester helps them identify how the piece components work together as a whole. It also serves as reinforcement of on-going lessons regarding visualizing objects, but with meaningful and familiar parts. Each project work day, students are tasked with using calipers to measure a different piece of the vise. Students use these measurements to create CAD models of each component. Students also create hand-drawings of many of the vise components, again reinforcing the lessons taught throughout the course, particularly solidifying the connection between hand-drafting and CAD modeling.

The authors recognize that manufacturing processes are not perfect. Thus, each of the physical vises that the students measure is slightly different from the others. Students traditionally expect measurements to be round numbers (i.e.- 2"). Yet, they get slightly different measurements (i.e.- 1.998"). Furthermore, measurements are likely to differ each time a measurement is taken. Because it is virtually impossible to take a measurement from the center of a hole, students are encouraged to think critically about how dimensions should be measured. An example of seemingly simple dimensions that are not easy to measure are shown in Figure 4. Students must rely on their engineering intuition to determine the best path forward. Since students disassemble and reassemble the physical vises each time they measure a component, the device and its assembly becomes familiar to them.



**Figure 4: Difficult Dimensions to Measure**



**Figure 5: CAD Vise Assembly**

Upon completion of their CAD models, students can easily start identifying errors in their parts. Conflicts such as misalignments and interferences are readily identified when assembled as shown in Figure 5. As a result, students must determine the cause of the conflict and fix it. Although they may have precisely measured the location of each hole on a part, each part must properly align during assembly for the hole to function properly. This iteration process forces students to think critically about what they are doing as well as emphasizes the importance of taking proper measurements. Once the assembly is properly aligned, students are required to create a professional portfolio that contains not only a dimensioned drawing of each component, but also a description of how they measured and assembled the drawing.

This project was first implemented during the Fall 2016 semester. In the Spring 2017 semester it was tweaked to optimize the effectiveness. Now that the project has been fully developed and matured, a formal assessment plan will be developed. Comments regarding the vise project received from teaching evaluations have been generally positive. Many students comment that they enjoy seeing how CAD modeling relates to physical objects. Others comment on how frustrating and ambiguous the measuring process can be.

In conclusion, the development of the desktop bench vise project has helped enhance and promote hands-on learning for Kansas State University's Engineering Graphics course. Guided from previous research, students use their critical thinking abilities to disassemble and measure a physical object in order to produce a working 3D CAD model. The project emphasizes many concepts taught during the course and is well received by the students. For future work, a formal assessment plan will be developed by the authors to develop its effectiveness.

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