

# USING MODELS TO TEACH AND LEARN ENGINEERING

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## ABSTRACT

One of the biggest problems engineering students are facing is visualization. In fact, visualization skills have been found to correlate highly with successes in engineering, and mathematics in general. In order to help students to develop this skill and make teaching and learning more productive and interesting, a new teaching strategy based on using models has been developed. Experience in using the models shows that:

- 1) Students are able to learn the topic in the most effective and easiest way.
- 2) Students are fully engaged in the learning process.
- 3) Students can gain the knowledge and obtain the skills developed in this "hand on" approach in learning that affects students' ability to absorb knowledge in subsequent courses where good visualization skills are required.
- 4) Using the models makes students feel that engineering is an interesting field to study. The benefits for teachers are:
  - 1) very little (or no) preparation time
  - 2) less lecture time
  - 3) easy to explain the topic
  - 4) test results are incomparable to teaching from a textbook.

Keywords: STEM, Conference Proceedings Student Retention, Teaching Quality

## INTRODUCTION

One of the biggest problems engineering students are facing in the classroom is visualization. In fact, according to a study published by Shawn Strong from Southwest Missouri State University and Roger A. Smith from Iowa State University *Visualization skills have been found to correlate highly with successes in engineering, and mathematics in general.* (Strong & Smith, 2001). Another study by Beverly G. Baartmans and Sheryl A. Sorby shows that: *“Three-dimensional visualization skills are critically important for success in engineering careers”* (Baartmans & Sorby, 1996). In the study by Howard Turner and Francelina Neto, California State Polytechnic University, they stated that: *“Engineering students at California State Polytechnic University Pomona often have difficulties in visualizing concepts in 3D.”* (Turner & Neto, 2002).

The list of studies can go on and on and most of professionals in engineering graphics have come to an acceptance that spatial visualization skills can be improved through experience by exposing students to appropriate learning environment. The question now is: What kind of environment and teaching tools

need in order to achieve this goal of improving the visualization skills and subsequently students' success in Engineering?

Teaching any topic in engineering graphics from a textbook is a traditional, and in many cases, boring and difficult for the students to understand. In order to make teaching and learning more productive and interesting, a new and innovative teaching strategy has been developed based on using models. Models have been registered and used in the classroom. The results are impressive and some schools in the area have followed suit in this teachings strategy, seeing the benefits of using the models in teaching engineering compared to teaching from a textbook. There are an increasing number of schools that now have these teaching aids in their classrooms and are using them to date.

Based on the student feedback from classes at Western Michigan University and other schools that have been using the models, this strategy of using models in teaching engineering is working exceptionally well.

**THIRD ANGLE ORTHOGRAPHIC PROJECTION MODEL**

Helps students to understand the concept of Orthographic presentation and the Layout of the standard orthographic views.



**Fig. 1: Principles in creating two basic views (Top and Front), using 3<sup>rd</sup> angle orthographic method.**



**Fig. 2: Using a projection box in the 3<sup>rd</sup> quadrant to see the object projected from different sides.**

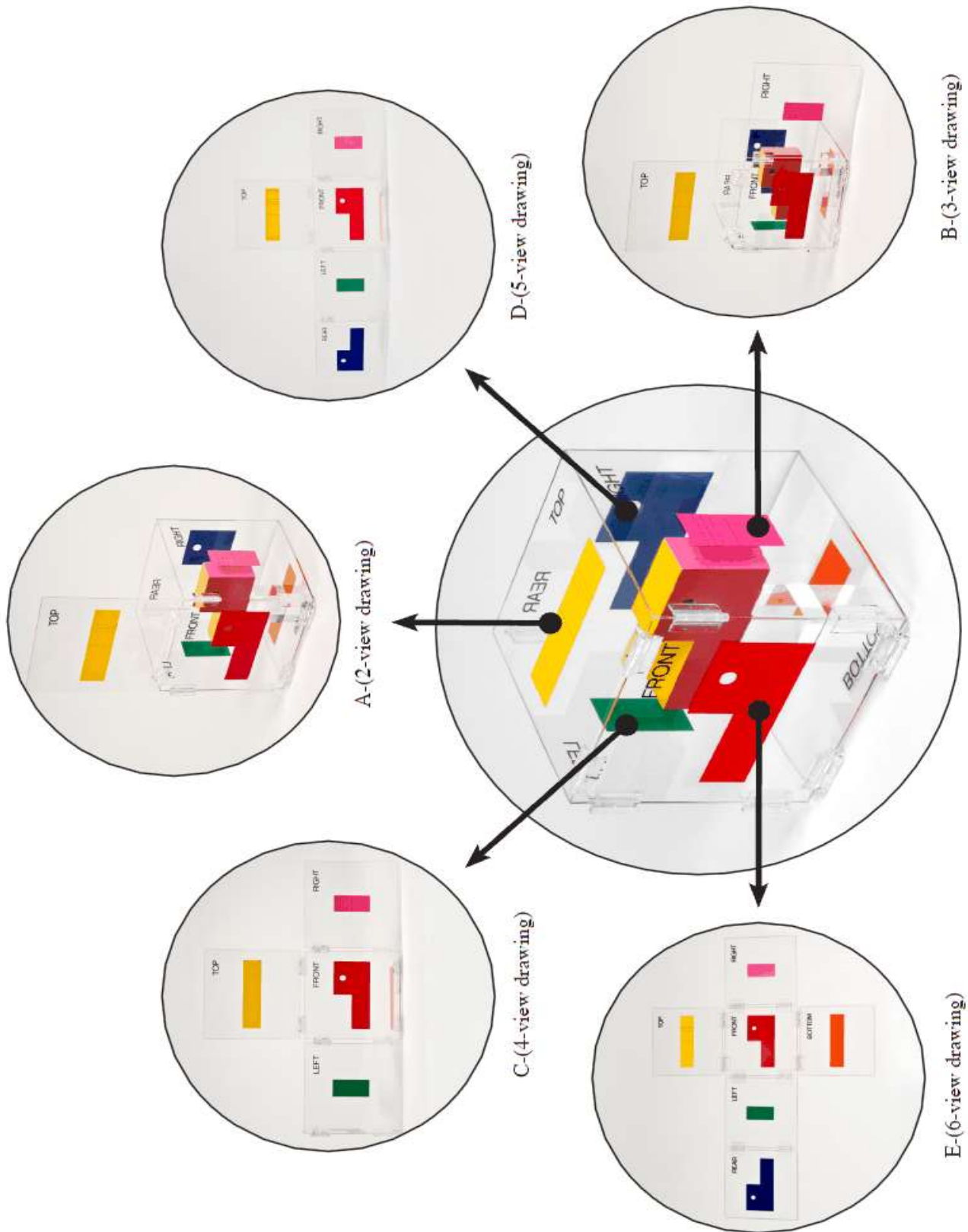
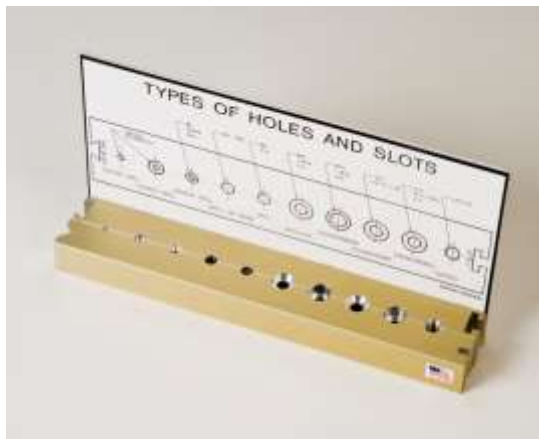
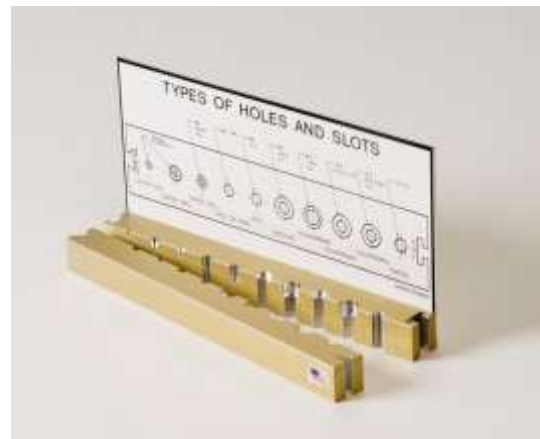


Fig. 3: Multiview Drawings

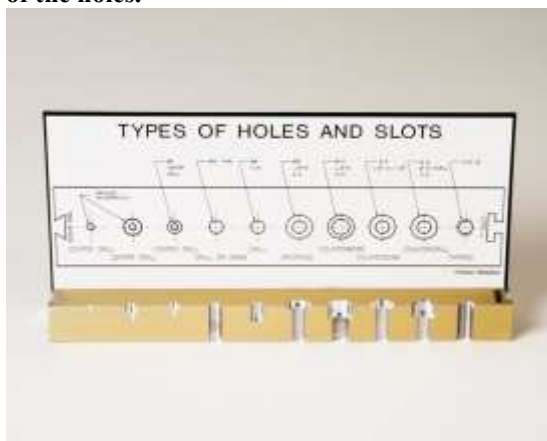
**TYPES OF HOLES AND SLOTS MODEL**



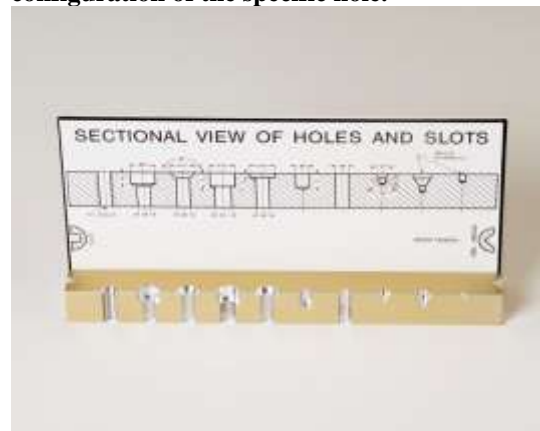
**Fig. 5:** The model shows the views of different holes and ANSI (American National Standards Institute) symbols used to identify the parameters of the holes.



**Fig. 6:** The model can be split to make a connection between the symbols used and the configuration of the specific hole.



**Fig. 7:** The model can be used to explain the process of making the holes and the tools needed in machining them.



**Fig. 8:** The back of the model illustrates the sectional views of each hole with all dimensions needed for manufacturing.

**TYPES OF SECTIONS MODEL**

Visualization, as a problem, is most evident in students' incapability of clearly seeing the interior features of parts. This set of models helps students to reveal the interior features of parts and understand the concept of creating full, half, offset, broken out, revolved, removed, aligned, assembly and auxiliary section views.

Each type of section is presented on a separate easel that can be taken out of the display case and be shown using a document camera or distributed to students individually to see and touch the features and surfaces. This set explains sections in the most effective, attractive and memorable way that makes learning this topic interesting and likable in classrooms.

This multipurpose set can also be used to explain specific features, such as a keyway and a set screw in a broken out section, different materials used in an assembly section, and principles of aligned and auxiliary sections. Each of the samples can be used in graphics classes as an assignment to take measurements and create a 3D solid model, and also in manufacturing process planning classes to make a manufacturing plan and select tools.



Fig. 9: Types of Sections Model

**TYPES OF JOINTS AND THEIR PREPARATIONS MODEL**



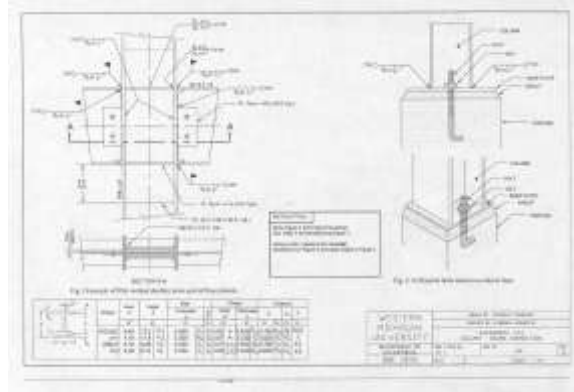
Fig. 10: Types of Joints and their Preparations Model

In most textbooks, this topic is explained using several, sometimes up to over 30 drawings, which are difficult to be visualized and subsequently memorized as three dimensional shapes.

This model shows different types of joints in a unique and very clear manner that makes learning this topic very effective and enjoyable. By using this model, students are cleverly engaged in learning the joints by moving the plates and playing with the options that could be created by positioning and repositioning the plates at different angles. Each pair of plates shows different types of joint and all possible

ways of their preparations. Plates can be taken out of the case and given to a group or an individual student to manipulate and at the same time, learn this topic in the most efficient way.

**STRUCTURAL STEEL/CONSTRUCTION MODEL**



The Column and Beams connection is the base in steel construction and the multistory buildings industry. Learning this critically important construction topic from a drawing is a low productive learning process that, in most cases, makes it impossible for students to understand all the elements and details that make this connection (please see the drawing above).

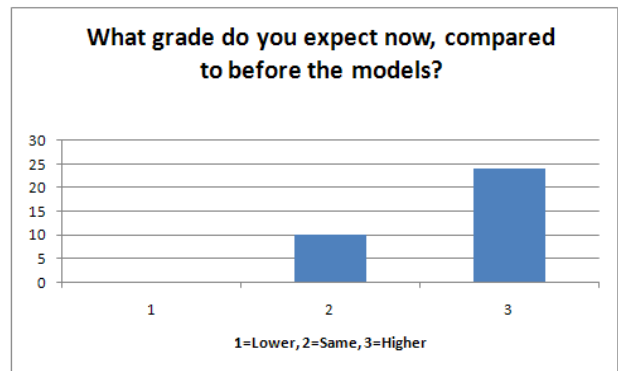
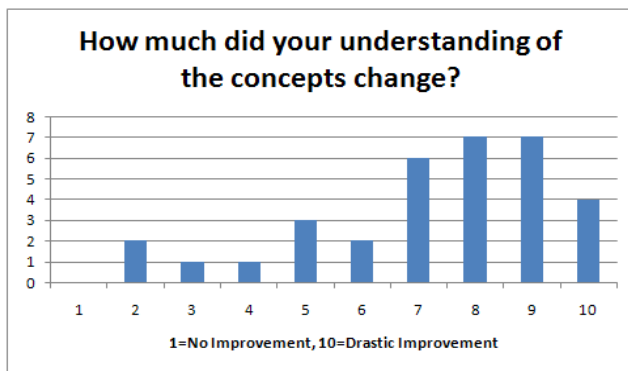
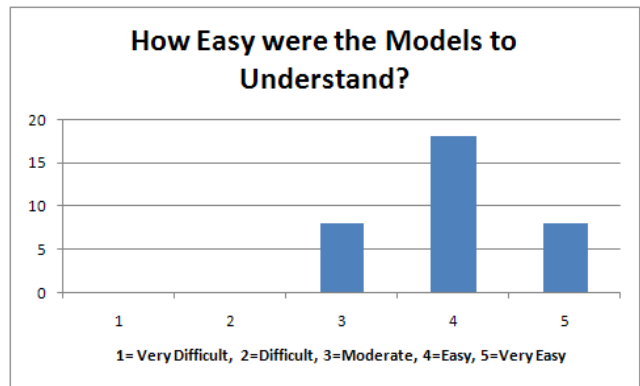
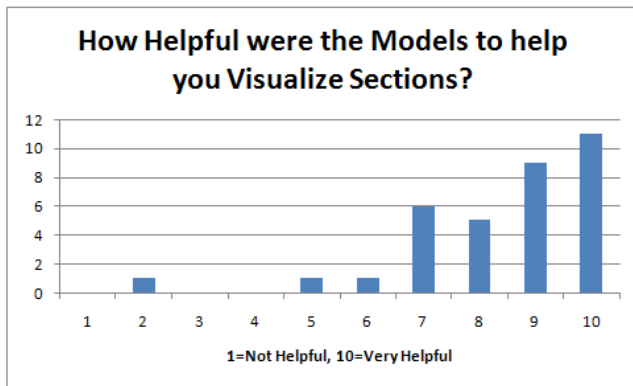
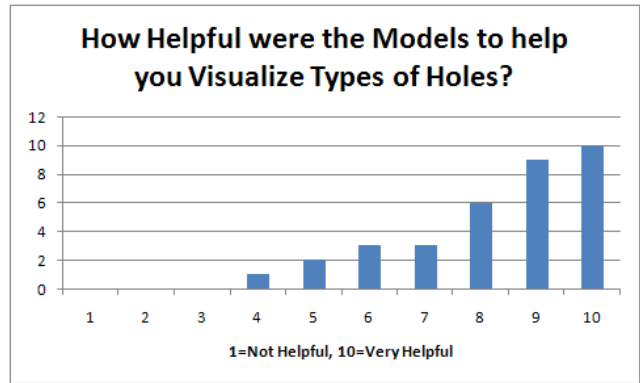
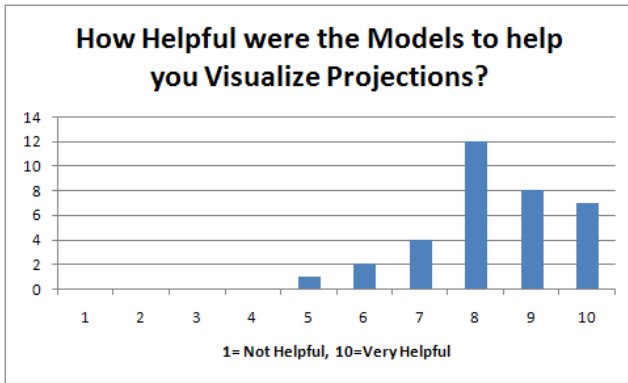
**Fig. 11: Structural Steel/Construction**

This model represents a real life structural steel sample of the column and beams connection with all the elements in a miniature size suitable for classroom learning. The sequence in building a multistory building that starts with creating a concrete base with anchor bolts holding the base plate that is welded to the column. This process is shown on the model in a chronological order, and in an easy to see and memorable way. Beams are connected to the column with shear plates and bolts, plus are welded in two areas at the top and bottom flange. Preparation of the bottom flange is shown on half of the flange and weld applied on the other half. The Central part of the model shows all of the elements, such as stiffener and doubler plates and, specific type of weld that makes this connection stronger.

**STUDENT SURVEYS REGARDING USE OF MODELS AND VISUALIZATION SKILLS**

The distribution of the data for each question shows that there was significant improvement in the student understanding of the concepts. Students found the models easy to understand, they felt that the models

helped them visualize the projections, types of holes and the sections. The students felt that their grades improved from what they would have been without the use of these models.



After using the models, the survey was given to students by their instructors at different schools during the period of approximately 2 years (2007 – 2009).

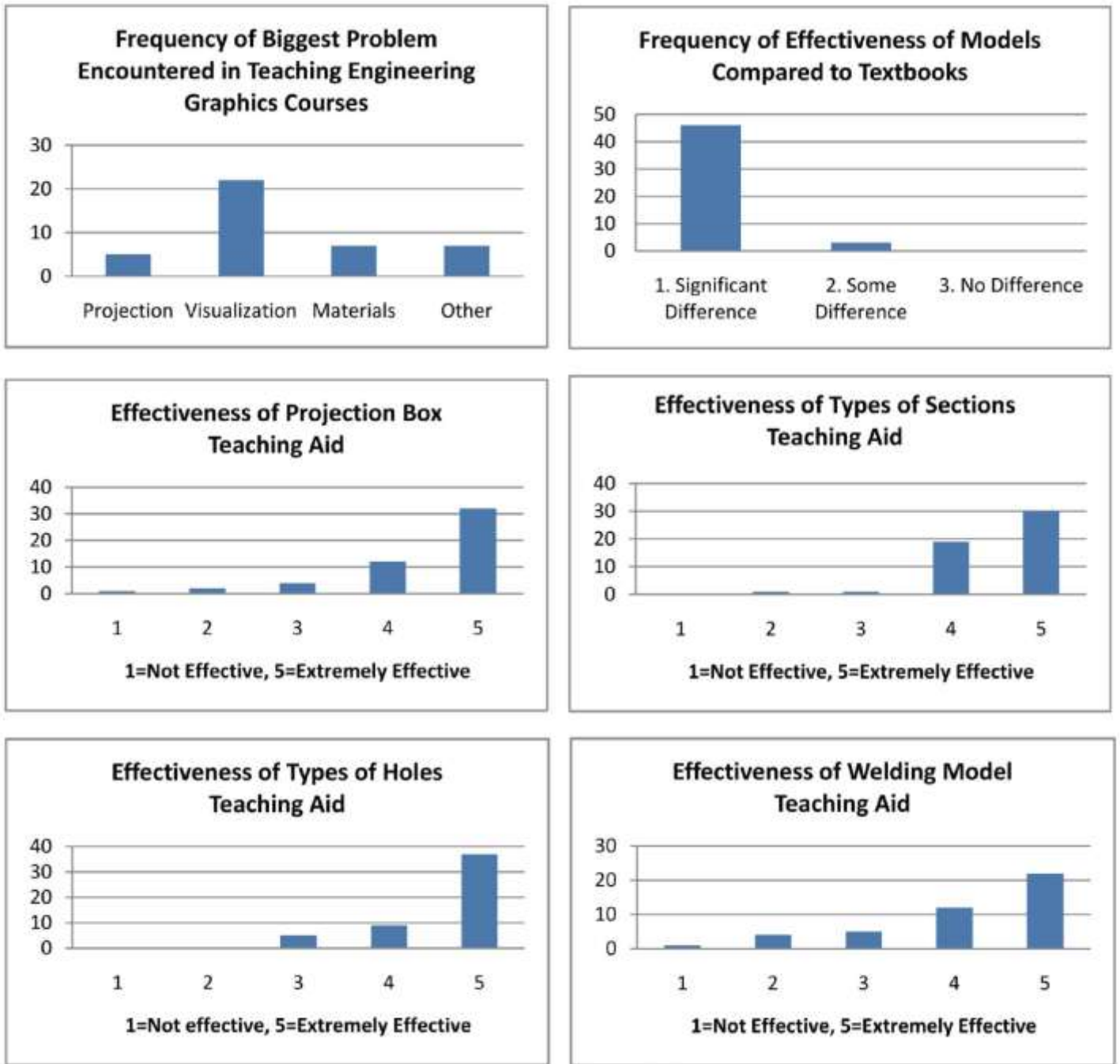


Fig. 12 Teachers Survey Data



## **CONCLUSION**

Students in the United States are more and more opting to stay out of the engineering field because of the level of difficulty and strain it places on them. With these models, there will be a great impact on the effectiveness and efficiency of students learning engineering and will help foster a better image of engineering on the incoming generations of students. The fact is that students like this very attractive way of learning engineering because by using the models they learn the topic in the most effective and easiest way. The models also increase students' confidence in handling subsequent subjects and they believe that they can be successful in the field of engineering.

### **Recommendations:**

1) Most of the instructors teaching Engineering Graphics and Manufacturing courses that I have talked to agree on the conclusion that although there are other ways of teaching 2D Modeling, there is no substitute for physical models, which are the best way for students to learn how to transfer the object into a 2D drawing. The models are also a very effective teaching material for manufacturing courses where students can see the correlation between engineering graphic topics, such as Surface finish or Welding symbols, and their application on the models.

2) The other very important component of using models in classrooms is that by using models in the STEM field, the Interactive Teaching Technique is applied, which increases students' interest and effectiveness in learning engineering.

3) Introducing and using the models at an earlier stage such as at the high school or even middle school level will attract and make students more likely to enter the field of engineering. The feedback received from students, teachers, and others from the industry tells us that this innovative teaching method is effective and likeable by all users, and is beneficial to students, teachers and all those in the industry to be used. This is my contribution to our national effort to get more adolescents into the engineering pipeline and consequently keep our economy strong and our nation safe.

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