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Investigating Use of Glass Box & Rotating Bowl to Teach Orthographic Views

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ABSTRACT

Orthographic projection drawings are the primary communication media of engineers, architects and other designers. While learning how to create this type of drawing, students often struggle in correctly placing the individual views of the object within the orthographic layout so that the drawing can convey its full meaning. In this study a visual aid based on a bowl was added to a unit on orthographic drawing to find whether students found this alternative visual aid helpful. It was found that many students in this investigation responded positively to the bowl visual aid with some reporting it more helpful than the hinged glass box visual aid. It was also found that many of the students who found this alternative visual aid helpful predominantly shared two common spatial visualization deficiencies that were easy to Identify with simple spatial visualization pre-tests.

I) INTRODUCTION

Engineers and other designers must communicate with each other and with those who will create their designs. The engineering print is the means of communication that designers use to communicate with each other as well as with the welders, machinists, carpenters and many other professionals that help create new products. One of the challenges that designers face in the process of communicating with production workers is that their product is three-dimensional 3D in nature, while the drawing representing it is two-dimensional 2D for a successful communication of ideas between these two groups, it is essential that the designer creates drawings that conform to engineering standards [1] Drawing to a set of standards enables others to correctly read the print so they are able to interpret the information conveyed by the drawing with maximum clarity and minimal confusion [2].In order to completely describe a 3D object through 2D drawings, the orthographic projection technique was developed to show all the needed information in an organized manner. This most commonly used type of engineering drawing consists of multiple 2D views of the object in a specified arrangement. The necessary views of an object are placed in positions relative to each other to allow the reader to transfer information from one view to another. Figure 1 is an example of a third angle and first angle orthographic projection drawing. Each dimension of the object is given only in one view so that the reader must look to the other views for other information about this object. The use of this orthographic projection view alignment allows the reader to transfer information from one view to another view.

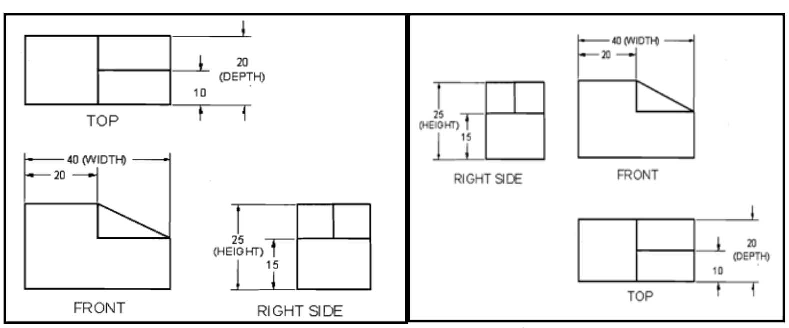

FIGURE1.1 3rd angle and 1st angle projection of orthographic view

I.I ORTHOGRAPHIC DRAWINGS

In technical drawing, there are two types of orthographic drawings that are commonly used: first and third angle orthographic projections. Third angle projection is most widely used in the United States while first angle projection is commonly used in Europe [3]. Figure 1 is an example of third angle projection and first angle projection. The important difference between these two techniques in respect to this study is the placement of the various views of the object on the paper in relation to the most detailed primary view known as the front view. In third angle projection, the top view of the object is placed above the front view, while in the first angle projection the top view of the object would be placed below the front view. Similarly, in third angle projection, the right side view of the object is placed to the right of the front view, while in the first angle projection the right side view of the object would be placed to the left of the front view. These distinctions become important when explaining the idea of rotating a part because if students visualize this rotation without an organizational structure provided by some type of visual aid, students could place views in locations that fit the definition of a first angle projection instead of the desired third angle projection and vice versa. While learning the conventions of orthographic projections, visual aids can be instrumental in helping students make the connection between visualizing the object and placing the appropriate view of that object in the correct location and orientation. Figure 2 is a picture of a widely used glass box visual aid that contains the object to be drawn. Students draw lines on the individual panes of glass that correspond to the actual lines of the object that are visible when viewing it through that pane of glass [4]. When this box visual aid is unfolded and laid flat, the lines of each view drawn on the sides of the box are in the correct position of a view in a third angle orthographic drawing.

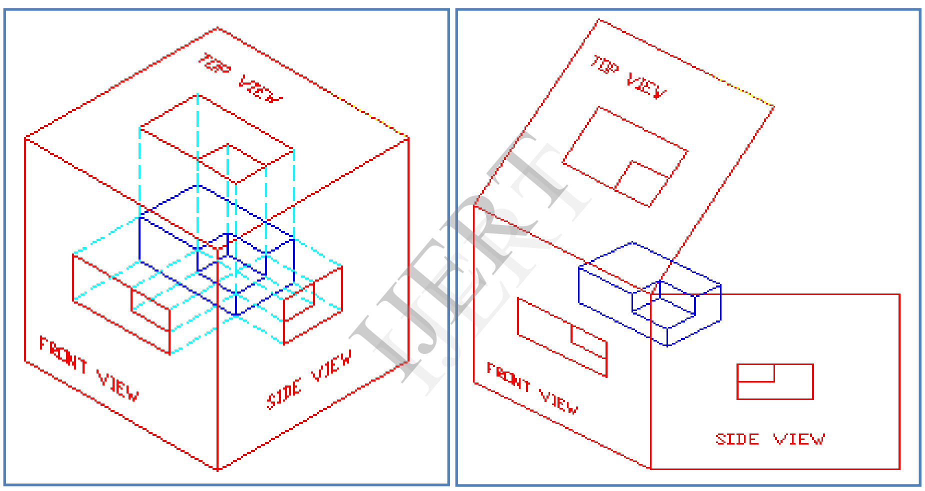

FIGURE 2 Glass box methods

While the explanation of view placement using box visual aid is sufficient for most students, classroom observations by the author have indicated that some students still do not understand orthographic projection view placement through the use of this concept alone. Although most textbooks rely solely on the box visual aid to demonstrate correct alignment of the views, one textbook [5] included an alternative explanation of how to visualize the layout of an object in third angle orthographic drawing. This explanation consists of a series of illustrations in which a hand progressively rotates an object toward the reader's viewing plane. Each illustration in the series is progressively more rotated than the previous illustration. The final illustration in each sequence is rotated 90 degrees from the object's original orientation to the correct location and orientation for an orthographic projection layout.

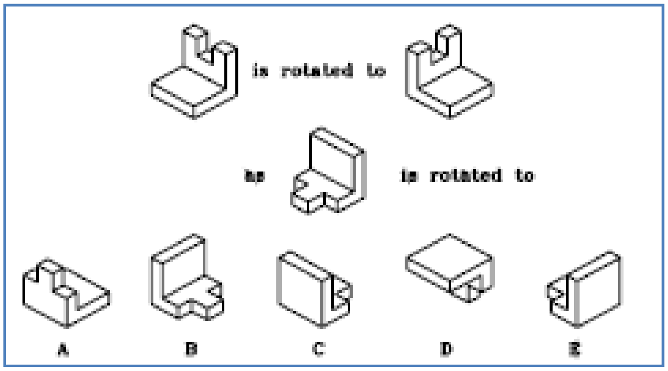

FIGURE 3 Orthographic views by rotating object

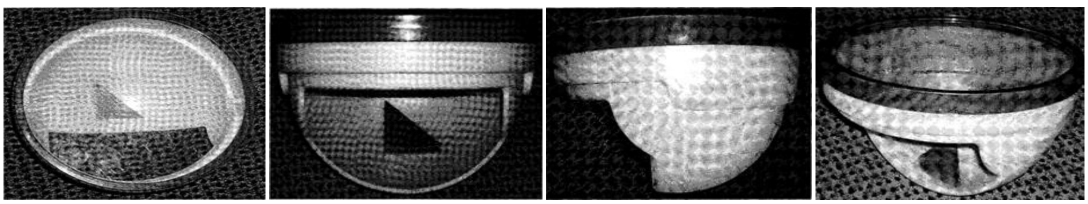

FIGURE 4 Rotating Bowl Method

In this investigation, the author has enhanced the rotation method shown in figure 3 by creating the bowl visual aid. The bowl visual aid provides a physical framework to help students remember which direction to mentally rotate the object in order to produce correct views for a third angle orthographic layout. In figure 4 the rotation of the object using the bowl visual aid is shown from the side of the visual aid in order to explain the way the object should slide along the sides of the bowl. Figure 5 is an illustration of the view placement provided by the bowl visual aid when looking down perpendicular to the top surface of the bowl. The resulting view placement conforms to third angle projection standards as shown in figure.

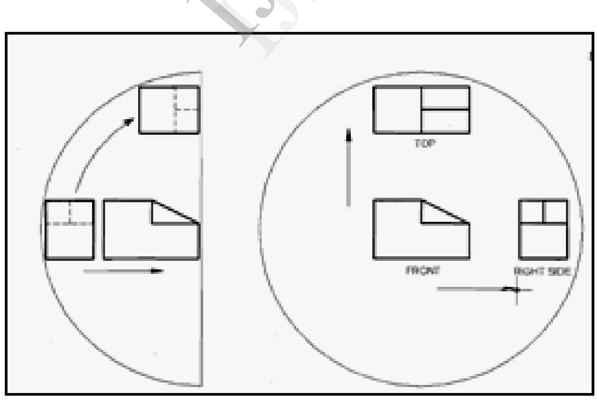

FIGURE 4 Rotating Bowl Method

I.II JUSTIFICATION

Since orthographic projection is a difficult concept for students to grasp, new teaching aids could prove helpful to better explain relationships between the views of an orthographic projection layout. While tried and true methods are enough to help most students understand view placement in orthographic projection drawings, alternative teaching methods may be identified that are better able to capitalize on students' spatial abilities when learning to create orthographic drawings. Since there is limited information on alternative teaching methods for explaining orthographic view placement, research should be done to investigate the effectiveness of an alternative visual aid and to identify the profile of students who may find this alternative visual aid more helpful than the box visual aid when learning to create orthographic drawings.

I.III ASSUMPTIONS OF THE STUDY

It was assumed that all students in the class were motivated to learn, and thus all students were receptive to learning the visualization techniques demonstrated by the instructor. It was assumed that the students participating in this study would perform at their personal best for each of the spatial visualization assessments administered throughout this experiment. This study assumed that the students' knowledge of orthographic projection was primarily formed by the direct instruction of the classroom teacher. This assumption was also made because it was impossible to control the content of the advice that students received from sources other than the classroom instructor.

I.IV VARIOUS TESTS

Intelligence and cognition, spatial abilities
Predictors of initial ability, Gender
Previous experience, Age, Mathematical ability, testing spatial abilities

I.V COMPARISON OF VISUAL AIDS

Most textbook sources used in introductory drafting courses explain the placement of Views in an orthographic drawing through the use of the box visual aid. This author was able to gain a greater understanding of the orthographic drawing itself by simply manipulating the object to make it correspond with the orthographic drawing. In both cases the bowl explanation was offered to help compare orthographic drawings to completed objects, not to explain how to draw the orthographic drawings correctly. This investigation was conducted to determine whether a visual aid in the shape of a bowl could be a helpful alternative to the traditional box visual aid used in the drafting and design environment to help students learn to create orthographic drawings. In comparing the two visual aids used in this experiment, one difference is apparent. The two visual aids seem to rely on either the student's ability to mentally unfold an object as in the hinged glass box visual aid, or to mentally rotate an object as in the case of the bowl visual aid. It is this author's opinion that the box visual aid relies on the ability of the student to mentally unfold an imaginary box, an area of spatial abilities that has a female advantage. Because females demonstrate an advantage in folding and unfolding objects [6] this author would logically expect to find a female preference for the box visual aid when learning orthographic view placement. The bowl visual aid however, relies on the students' ability to mentally rotate an object, an area of spatial abilities that has a strong male advantage. The male advantage in making mental rotations could lead to the logical expectation that males would find the bowl visual aid more effective in explaining orthographic view placement.

I.VI RESEARCH METHOD

The research method used in this study is based on the one-group pre-test/posttest research model. In this study, the one group was made up of first year engineering students' .Students in all sections received equal instruction on how to create correct orthographic layouts. This research model was selected to partially address the potential differences in the makeup of the three sections of the course due to external factors beyond the control of the author and also due in part to the small number of participants within each of the three course sections. These two factors would have made it difficult, if not impossible, to create a true control group to which results could be compared. Equal treatments were also used to reduce the Possibility of skewed data collected through the use of unequal samples.

PRE-TEST NAME	SPATIAL ABILITY ASSESSED	% OF TOTAL SCORE
Mental Rotation	Rotational abilities	33
Folding abilities	Folding abilities	33
Surface identification	3D to 2D Transformations	11
Single view Isolation	3D to 2D Transformations	11
Ortho/Iso Matching	3D to 2D Transformations	11

Table 1 Pre-tests developed to assess the spatial ability levels of students.

I.VII DATA ANALYSIS

In order to separate the participants into groups according to which visual aid they found to be more helpful, a score differential was created by comparing each student's responses to the first 3 questions of the student feedback survey. The questions were as follows:

1. How helpful was the bowl method in explaining view placement in orthographic drawings?
2. How helpful was the box method in explaining view placement in orthographic drawings?
3. Please tell me why you chose box, bowl, both or neither?

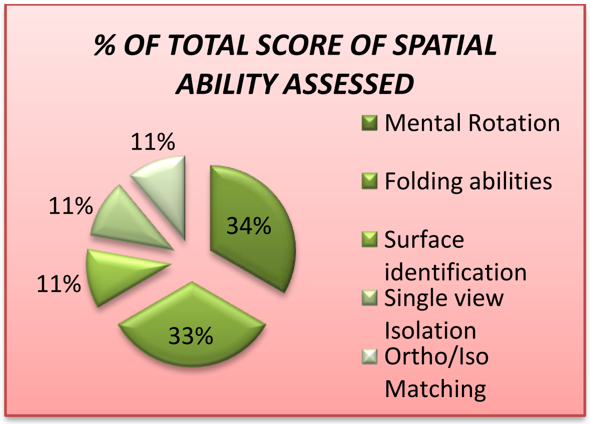

FIGURE 5 Pie-chart for Table No.1

II. CONCLUSIONS

In drawing conclusions from this investigation, based on the responses obtained from students through the student feedback survey, it was found that in a drafting course there are students who find the bowl visual aid more helpful than the box visual aid when learning to create orthographic drawings. Further student comments on this same student feedback survey revealed that students thought the best way to teach the orthographic drawing unit is to use both visual aids. There were various reasons given by the students for recommending both visual aids, but by far the most common was some variation of, "all students learn differently." it would seem as though students feel it is best to offer multiple explanations even if they personally don't need them. Students' comments indicated that they recognized the bowl visual aid as a better approach for some of their peers. All evidence indicates that it would be beneficial to add the bowl visual aid to instruction during the orthographic drawing unit of an introductory level drafting course.

III. REFERENCES

[1] Coover, 1966; French & vierck, 1978.
[2] Brown, 1972; hornung, 1957; Madsen,
[3] Folkestad, Schertz, shumaker, stark & turpin 2002
[4] Ryan, 2002
[5] Sundberg, 1972
[6] Spencer, dygdon and Novak, 1995
[7] Kimura, 1999