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VISUALIZING CONTINUITY BETWEEN 2D AND 3D GRAPHIC REPRESENTATIONS

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ABSTRACT
Understanding the principles of graphic language is necessary for visualizing, representing, communicating and generating new 3D space/form. The relationships between the basic elements of graphic language are defined by specific sets of rules that affect the information communicated about the 3D form. These principles are related concepts that are dynamic in nature and difficult to portray using words, diagrams and static pictures.
This paper explores issues regarding continuity between the representations of three-dimensional objects by means of two-dimensional diagrams. How the current pedagogical methods/media do not facilitate demonstrations of relationships between observer, object and representation, and how current attempts of using computer visualization do not leverage on the inherent characteristics of the computer environment.

Keywords: continuity, connections, visualization, information

1 INTRODUCTION

An idea must exist in the mind of the artist, engineer or designer before it can become a reality. The concept is developed on paper or a computer screen. It is then shared with others in the form of sketches, controlled line drawings, dimensioned drawings or computer generated images. These 2D representations are part of a structured language that communicates specific information about a 3D object or space. Proficiency in communicating through this language is essential to the success of any designer.
Parallel projections and perspective projections are representations that depict an instance; a relationship between four constant elements: The object, the observer, the picture plane and the projection lines. These elements are affected by two variables: observer's distance to the object / picture plane and the angles or positions between the elements. It is difficult and time consuming to demonstrate transformative concepts through the use of static mediums because the medium itself limits the explanation to "step by step" diagrams. The missing intermediate states create difficulties in understanding relationships. Many students are unable to make connections not "seen" during static or "interrupted" demonstrations and most importantly they do not understand how the projection systems are derived from the same fundamental principles.
In addition to the complexity in translating a static explanation into a dynamic concept, the students have to reconcile the differences we have created by teaching graphic language as two separate subjects: One that uses projection systems to represent

qualitative information and the other that uses the same conceptual elements to communicate and represent quantitative information.

These issues can be mitigated by a new methodology of instruction that emphasizes continuity between representational systems and by new technologies that can overcome the complexity of the written word and static images.

2 BACKGROUND

Graphic methods of representation as a form of communication are taught in the disciplines of Art, Design, Architecture and Engineering. Culturally we have assigned artistic connotations to perspective projections (one point, two point perspectives) and technical connotations to paraline projections (isometric, oblique). Engineers and product designers more commonly use isometric projections, while architects and interior space designers favor oblique projections due to the nature of the information needed to be conveyed. Linear perspective is more commonly used to depict “realistic” objects or environments. However, all graphic methods are the result of a specific relationship between the same elements: the observer, the picture plane, the projectors and the object. We can measure distances and angles if we want to communicate quantitative information, but to communicate qualitative features fine precision is not critical. Nevertheless, we are using the same elements and the same relationships.

As an instructor of foundation courses in multidisciplinary environments, I have had the opportunity to teach students who have different backgrounds and consequently, different approaches to which is the correct system and conventions to use in a given project. They consistently refer to drawing systems as unrelated concepts. The students also demonstrate a lack of understanding of the fundamental principles involved even after one or more drawing courses. Often times, they mix conventions (Figure 1), and are unable to discriminate between projections.

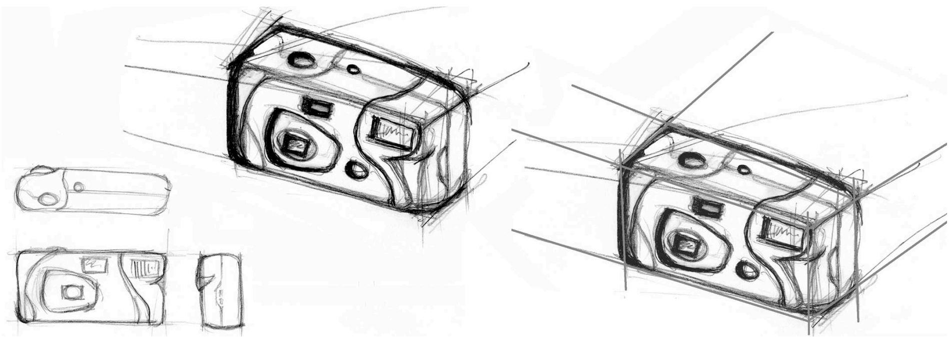

Figure 1. In this illustration the student used lines that are diverging, converging and parallel to each other in the same sketch. His intention was a 2-point perspective.

These problems become confounded when drawing is used as a design tool and design decisions are made on a given drawing projection with little control over the effects on the three dimensional form. These characteristics are not limited to the representational medium: computer generated drawings or hand constructed drawings (Figures 2 and 3).

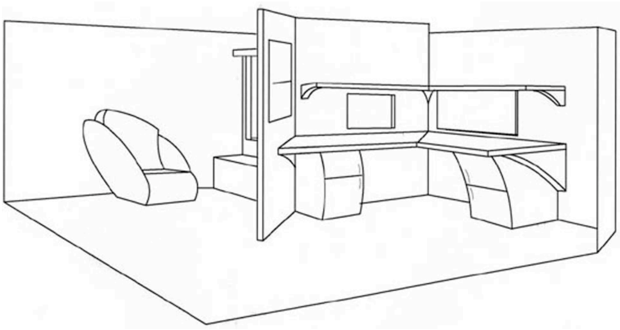

Figure 2. 2-point perspective view of a room

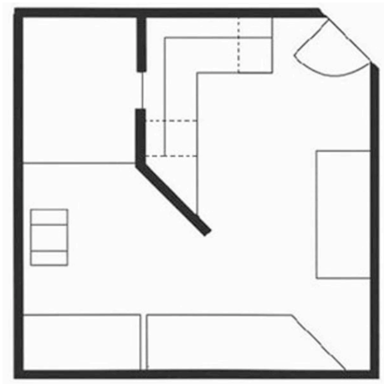

Figure 3. Plan view of the same room

These illustrations depict serious difficulties not only in communicating 3D form, but understanding it as well. The chair and the file cabinets are inconsistent between these two projections, which makes us question his understanding of the form itself. This is a common problem among students that translates into designs that reflect very limited exploration of 3D form.

The student is not the only one facing difficulties with the subject. Teaching it is just as complex. Live demonstrations are time consuming constructions and there are many skill levels within a class, so the pace of instruction is difficult to establish.

3 IN SEARCH OF ALTERNATIVES

3.1 Methods

If we, as educators, want the students to learn graphic language as a means to communicate information, maybe we need to teach it as such. Like with any language we need to understand the individual parts, how to organize those parts and re-arrange them in order to convey our ideas. We learn a language and become proficient when we understand the words, the rules and the effects on our communication when we break the rules. According to Dewey, learning occurs through the discovery of connections between something which we do and the consequences which result, so that the two become continuous [1].

So in graphic language the “parts” are: the object, the observer, the picture plane and the projection lines. The variables are: observer’s distance to the object / picture plane and the angles or positions between the "parts". If the emphasis is placed on the connections and the effects of our actions on the representation or drawing, then we can explain the transformation in a much clearer way. For example, the rules of an orthographic projection are: the distance of the observer to plane of projection is infinite, the projectors are perpendicular to the picture plane and the edges of the object are parallel to the picture plane (Figure 4). If the action is to move the observer to a finite position, the projection becomes a one-point perspective as the projection lines converge towards the observer's eye. If the action is to rotate the object so that the principal edges and surfaces of the object are inclined to the picture plane, the projection becomes an isometric view. This kind of demonstration provides an opportunity for students to "see" connections and possibly understand how they can control the variables on the representation of the object. It can also help them make appropriate choices according to the type of information they want to convey.

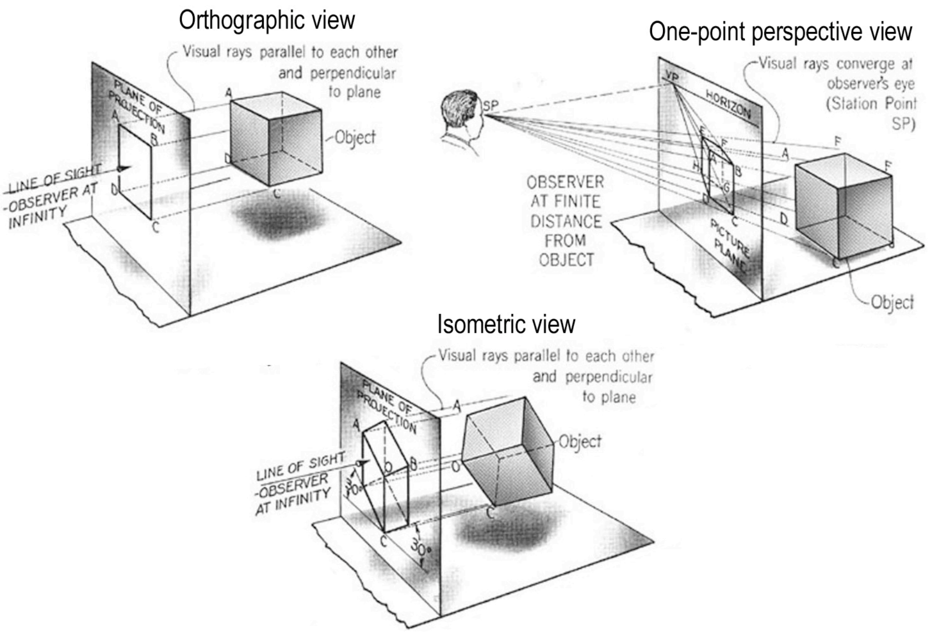

Figure 4. Projection views Source: Gielsecke, Et al. Technical Drawing [2]

This "scenario" cannot easily be depicted through traditional mediums such as books, hand made sketches or live demonstrations. Figure 5 is an attempt at demonstrating these relationships by a design student who understands the concept clearly. Communicating these relationships through sketches presents many difficulties such as how to depict the observer and the picture plane, how to depict the relationships between elements. The answers involve many different "disconnected" drawings.

An appropriate medium would allow the student to work at it's own pace, focusing attention on a particular relationship and most importantly it would allow the user to make changes to the "scenario" and see how an action directly affects it. Augmented visuals can answer such questions as what are the perceptual changes on the object/space when the observer changes position, when he/she gets closer, or farther away, or when the object rotates. The computer environment is ideally suited to demonstrate continuity and to clarify relationships. It is said that computer visualization not only changes how we see phenomena, but also how we think about them. The computer restructures the problem so that the human visual and perception systems may more easily process it. [3]

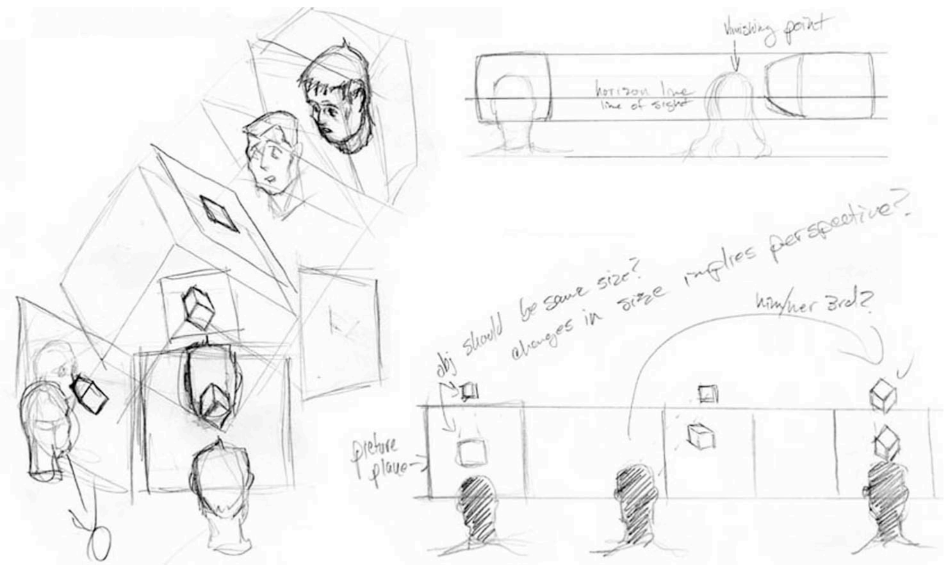

Figure 5. Visualization sketches by a sophomore design student

3.2. Digital material available for instruction

Computers are being used to visualize physical phenomena. Biologists for example, used to depend on the microscope and dissection to examine an organism. Today, they gain understanding by using a supercomputer to visualize and animate dynamic processes. Students observe complex biological patterns as they develop. These complex concepts are extremely difficult to portray using words, equations, graphs or static pictures. [3] These technologies are available to students in fields such as physical sciences, mathematics and medicine. In design we use these tools to communicate our design concepts on a regular basis. Unfortunately, we don’t use their potential to teach complex concepts such as graphic language. The visual “interactive” explanations available to us are part of multimedia CD-ROMs that supplement drawing textbooks. The following discussion looks at issues regarding continuity on interactive media from two popular contrasting publications: Design Drawing by Francis Ching and Introduction to 3D Visualization by Anne Frances Wysocki. Both publications allow some level of interaction, but neither one provides the user with the opportunity to become an active participant on the demonstrations and transformations. Figure 7 and 8 are images from “Introduction to 3D Visualization” [4], a book primarily targeting “technical” users. The basic elements of graphic language (picture plane, projection lines, observer and object) are not emphasized in the visualizations the CD-ROM provides. The definition of the isometric projection (Figure 6) is based on visualizing a diagonal line through the object, as if you were looking down on it. There is no reference to observer’s position (infinite) and the diagonal is a projection line but is not defined as such. Figure 7 is an animated explanation of “The Glass Box” method. This visualization is effective in clarifying associations between each orthographic view of an object, but it falls short in explaining how it relates to all other views. The "walls" of the box are really projection planes, and the lines within are projection lines. The technical "precision" associated with these projections is not discussed.

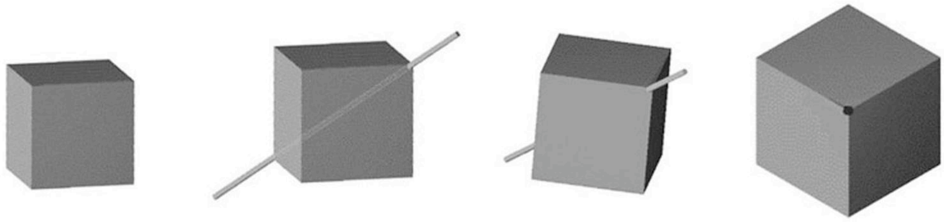

Figure 6. Animated definition of an isometric cube. Source: Wysocki [4]

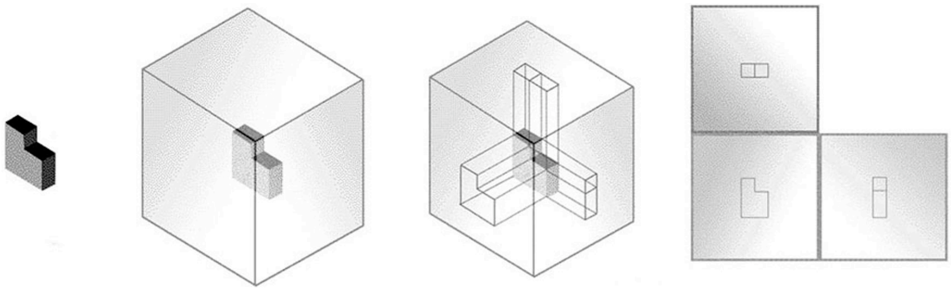

Figure 7. Animated definition of orthographic projections. Source: Wysocki [4]

Figures 8 and 9 are visualization from Ching's "Design Drawing". [5] His explanations of the same representational systems are clear; he defines the two projections based on the same elements so it becomes easier to search for relationships.

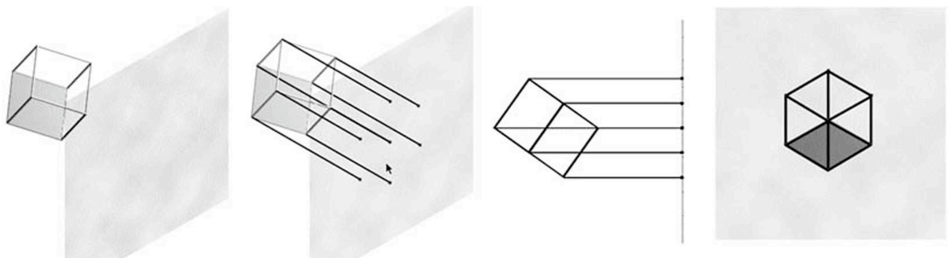

Figure 8. Animated definition of an isometric cube. Source: Ching [5]

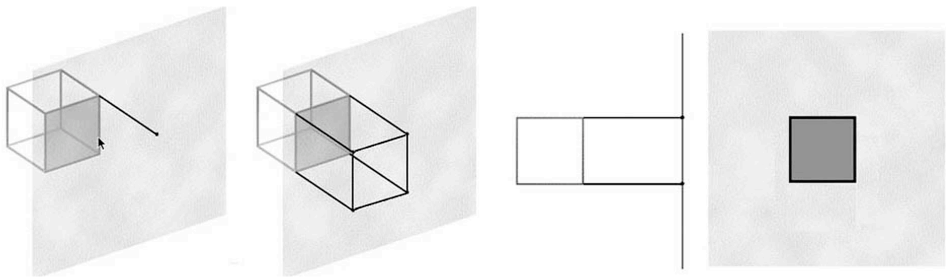

Figure 9. Animated definition of orthographic projections. Source: Ching [5]

Figure 10 depicts the relationships Ching is trying to demonstrate between the object, the picture plane, projection lines and observer. He takes advantage of multiple views and connects the representational system to a photograph to clarify the relationship between the diagram and what we see. In his demonstrations the user is a passive participant. The interactivity is limited to the navigation controls. [5]

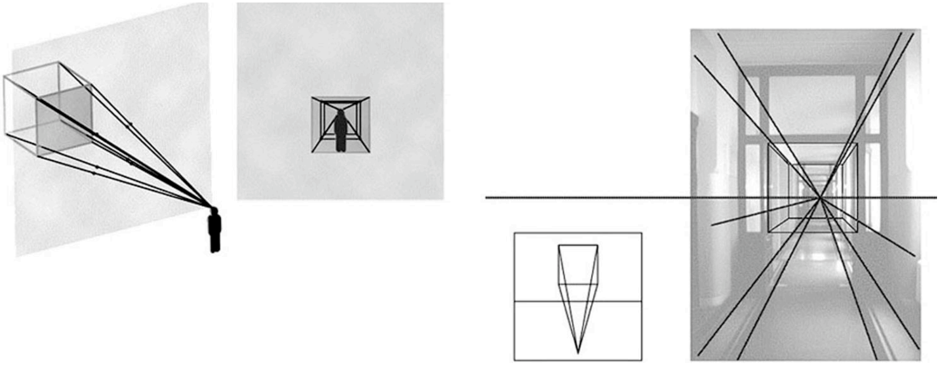

Figure 10. Animated definition of one point perspective. Source: Ching [5]

Alternative visualizations systems are dynamic manipulation programs commonly used to teach mathematics, such as The Geometer Sketchpad. Sketchpad is an immersive environment where students are active participants able to construct an object and then explore its mathematical properties by dragging the object with the mouse. All mathematical relationships are preserved, allowing students to generate their own conclusions.

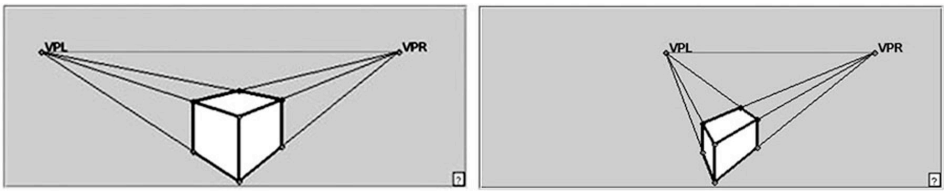

Figure 11. Interactive demonstration of a 2-point perspective-Source: The Geometer Sketchpad [6]

5 CONCLUSIONS

There is a need for new methodologies of instruction that emphasize in continuity between graphic representational systems. There is a need to develop a body of research in which existing high-end computer-graphics and visualization systems can be adapted to demonstrate these relationships. Immersive environments that provide real-time interaction may assist the student in creating dynamic mental images that will allow them to generate their own conclusions and recognize inconsistencies.

5.1. Further study

Initial study has raised questions regarding current methodology as well as questions regarding the tools we give students for understanding principles of graphic language.

The application of the proposed pedagogical method and visualization tools in design education may have an effect on the individual's ability to orient, compare and manipulate 3D form mentally, to place himself as the observer in an environment and relate the mental image with its graphical representation.

I intend to carry this research further to develop a prototype that can be used for testing in multidisciplinary environments at The Ohio State University. With faculty collaboration from the school of Art, Architecture, Engineering and Design, along with the support of the Advanced Computer Center of Arts and Design, we can provide a context for research in visualization technologies.

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