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Detachable Rubik's Cube as an Innovative Learning Strategy in Drafting Courses

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***Abstract* – The main focus of this study was to innovate Detachable Rubik's cube as learning strategy in drafting course for drafting students, especially those in the lower years, who encountered difficulty in visualizing the views given in isometric drawing for orthographic drawing. The IPO (input-process- output) model provided the general structure and guide for the direction of this study. The study used the descriptive method, and the respondents were chosen through purposive sampling. The findings revealed that the developed Detachable Rubik's cube met the criteria of functionality, durability, aesthetic, convenience, safety, cost and effectiveness in terms of accuracy. In the overall aspects, the Detachable Rubik's cube was rated very acceptable by the respondents. This means that the Detachable Rubik's cube could be used as an innovative learning strategy in teaching orthographic drawing in drafting course. Based on the findings, it was recommended that the faculty handling drafting should be encouraged to and use the detachable Rubik's cube and develop similar device for the same purpose.**

***Keywords*– Isometric drawing, Orthographic drawing, Drafting.**

I. INTRODUCTION

Drafting is the integral communication of technical or engineering drawings and in the industrial arts. It is a sub-discipline that underlies all involved technical endeavors. There are two types of technical drawings based on graphical projection. One is used to create an image of a three-dimensional object onto a two-dimensional surface (Goetsch, 2000).The other one is a two-dimensional representation that uses orthographic projection to create an image where only two of the three dimensions of the object are seen present.

Orthographic drawing is the basic technical drawing standards. One of the most difficult topics for beginning drafting students to understand is the relationship between the views in orthographic projection. There are occasions where three-dimensional (3D) drawing may not provide enough information about an object to be constructed. Orthographic drawing, which is a multi-view two-dimensional (2D) drawing system, resolves this problem. Each view of an object (front, side and top) is drawn separately showing only two dimensions but is kept aligned and to the same scale.

According to Khabia (2012), explaining the concepts of engineering drawing to students has always been a challenging job for the professors. It is very difficult to explain the three dimensional concepts of orthographic projection, isometric projection, and perspective projection through conventional methods. Students with less visualization ability find great difficulty in understanding the three dimensional concepts necessary for understanding the object or subject.

Based on the researcher's personal experience and interviews with other faculty, it was established that in drafting classes, especially in grades 7 and 8, most of the students encountered difficulty in visualizing the concept of orthographic drawing even after direct instruction using the most common visual aid, the glass box visual aid. With this visual aid, students drew lines of the individual panes of glass that corresponded to the actual lines of the object visible when viewing it through that pane of glass (Sunberg, 1972).When this box visual aid was unfolded and laid flat, the lines of each view drawn on the sides of the box were in the correct position of a view in orthographic drawing.

Although the explanation of view placement using box visual aid was sufficient for most students, classroom observations by the researcher, however, had indicated that most of the students still did not understand orthographic projection view placement through the use of this concept alone. As mentioned earlier, grade 7 and grade 8 drafting students struggled on how to visualize the views (front, top and side) of the object, or isometric / mechanical drawing for an orthographic drawing. Becoming proficient on this aspect of orthographic projection would only be possible when a student would be capable of visualizing an object in his/her mind. The student must also be able to imagine what the 3D object would look like as a 2D drawing when rotated and viewed from various perspectives (Spencer, Dygdon and Novak, 1995). Khabia added further that students with this inability to visualize cannot be proficient and will have a limited knowledge in other areas of technical drafting. Research has found that a student's level of proficiency in spatial tasks is a strong indicator of likely success in engineering and in creating engineering drawing (Kana, Jean, Chung & Chung, 2004; Boersman, Hamlin & Sorby, 2004).

One alternative instructional device for orthographic drawing in a tri-color projection box was designed by Denist D. Harrison, B.S. (1969). Other device that is being used to present orthographic projection is the glass box. The glass box is designed using panes of glass where the box visual aids are unfolded and laid flat. The lines of each view drawn on the side of the box are in the correct position of a view in a third angle orthographic drawing. The device can only describe the three views; it cannot project the complicated hidden views.

Likewise, Brian Kurszewski (2007) enhanced the rotation method by creating the Bowl visual through AutoCAD software using computer to describe or represent the different views in orthographic projection. The only disadvantage here is that not all schools are provided with computer units for drafting courses. Orthographic drawing is the basic drawing standards which is found in the Curriculum Guide of Technical Drafting of the Department of Education (DepEd), the Training Regulation of the Technical Education and Skills Development Authority (TESDA) and the syllabus of BTVTED-Drafting Technology Course in the College of Education at Mindanao State University- Iligan Institute of Technology (MSU-IIT).

The problem in the drafting classroom, thus far, centered on the difficulty of students to understand and visualize the relationship between the views in orthographic projection using the traditional way of presenting manually its concept, be it through the three-dimensional or the two-dimensional drawings. On the other hand, the multimedia is an alternative way for the students to imagine the idea of orthographic views since they are projected on the computer monitor. But the problem here was the inadequacy of multimedia equipment in the school where the use of this new instructional equipment was hard to obtain.

In connection with the problems cited above, a research on innovating a detachable Rubik's cube as an innovative learning strategy could be the answer to the present need in drafting courses. A Rubik's cube is described as a 3D combinational puzzle commonly known as magic cube that children and adults manipulate for solving the structural problem of moving the parts independently without the entire mechanism falling apart. Envisioned in the innovation of a detachable Rubik's cube as an instructional tool could be that students would be able to correctly place views in orthographic drawing and could visualize the object in various views (front, side and top). They, then, would be able to create orthographic drawings by forming the Rubik's cube according to the given object with the corresponding colors representing the three principal planes: red for front view, yellow for side view, and white for top view. In application, the detachable Rubik's cube could form twenty-four or more objects based on the given isometric drawing to visualize views for orthographic drawing.

Along this concept, the study aimed to innovate a detachable Rubik's cube as a learning tool in drafting courses that could help the students visualize easily the object for orthographic drawing, not to mention, develop their critical thinking. This innovation would look like a Rubik's Cube composed of a Medium Density Fibreboard (MDF) forming a cube with a magnet inside wherein each cube could be detached. Every view would have a specific color as indicator of the front view, the side view, and the top view. This innovation, henceforth, named Detachable Rubik's cube, would not only be for drafting students, but for teachers as well who would use it for facilitating the discussion and demonstration of orthographic and isometric drawings.

1.Conceptual Framework of the Study

The Input-Process-Output (IPO) model provided the general structure and guide for the direction of this study. As a process, the IPO model is viewed as a series of boxes (processing elements) connected by inputs and outputs. Information or material objects flow through a series of task or activities based on a set of rules or description points (Harris & Taylor, 1997). Flow charts and process diagrams are often used to represent the process. What goes in is the input; what causes the change is the process; and what comes out is the output (Armstrong, 2001).

The inputs of the model are information, ideas, resources used and the bases in creating a project. It includes the project objectives, project background, and project budget to facilitate the implementation of the project. In this study, the following variables considered as inputs are product design and development.

The processes of the model are actions taken upon and how to process the input into a more useful form. It is in this stage where the manipulation of the input usually happens. It is also an activity, or series of activities, that converts an input to an output by implementing the project. Processes only exist to add value and to achieve outputs of the project. This includes the present activities and simulation of the Detachable Rubik's cube prototype

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for visualizing the object for orthographic drawing. The outputs of the model are the information flowing out in the project as results of the processing system. These are the results that provide linkages between the input (problem situation) and the intended outcomes. Additionally, outputs of the model are the direct evidence of the project and are typically tangible and countable. Outputs are the intended and unintended results and consequences of the activities, and tend to be categorized into short, medium, and longer-term results. The output considers the simulation of the prototype.

The Product Acceptability Evaluation part of the model is to evaluate the functionality, durability, aesthetic, convenience, safety, cost, and effectiveness in terms of accuracy of the product. The product can form twenty-four or more different basic objects that can help the students visualize the views of the objects. It can be detachable in every cube of the Rubik's cube mock-up and can be formed through magnet inside the cube. The effectiveness of the product is seen when it can help the students visualize easily the views of the objects for their orthographic drawing. The product is tangible, and anyone can create it at cheaper cost of materials.

Orthographic drawing must be fully understood to visualize the views of given objects, isometric drawing, or mechanical drawing. It must be performed after discussion for hands-on learning and for better appreciation of the uses of the orthographic drawing, especially when working in the field.

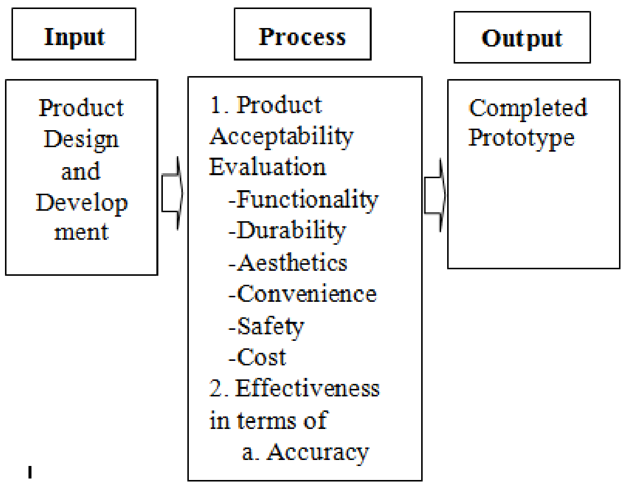

Fig.1. Schema of the Study.

2. Statement of the Problem

This study sought to find out the acceptability of the instructional material for teaching in Orthographic Drawing with the use of the Detachable Rubik's cube as an innovative strategy for drafting students. Specifically, it aimed to answer the following questions:

1. What design consideration is given to innovating the Detachable Rubik's cube as a teaching-learning device?
2. What are the processes and procedures in creating the Detachable Rubik's cube?
3. What are the respondents' perceived acceptability of the Detachable Rubik's cube in terms of the following:
   - functionality;
   - durability;
   - aesthetic;
   - convenience;
   - safety; and
   - cost?
4. What are the respondents' comments and suggestions on the effectiveness of the Detachable Rubik's cube in terms of accuracy to form into different objects for orthographic drawing?
5. What is the completed Detachable Rubik's cube?
6. Significance of the Study

This study would be beneficial to the following individuals and entities:

Students. One of the basic importance of the proposed study is that it could be a big help on the part of the students to help them visualize easily the different views of the object or isometric drawing or mechanical drawing for orthographic drawing discussions and activities.

Technicians/Teachers. This innovation can also be useful for delivering the concept on how to visualize the different views of the object, isometric drawing, or mechanical drawing for the orthographic drawing of Technical Drafting.

University Administration. This innovation would help the industrial education program meet the vision and goals for the standard implementation of works and activities.

Industry. Students with quality skills and competence would be able to contribute to the industry's developmental goals by providing quality and globally competitive services in technical industry.

Future researchers. They might find this study useful for further investigation that would result to an improved version of the finished product in terms of efficiency and effectiveness in the field of drafting and drawing.

3. Scope and Limitation of the Study

The respondents of the study were the first year BTVTED drafting students, the faculty in the College of Education of MSU-IIT, and the drafting experts based in Iligan City. The study was limited to drafting faculty and students and the learning strategy in drafting that would enhance students' ability in visualizing the object or isometric drawing for orthographic drawing in Drafting Technology.

Definition of Terms

Accessibility means that the device is made of movable parts that could be transformed into different forms for the orthographic drawing. Accuracy is the appropriateness in forming objects for orthographic drawing. Aesthetic tells that the device is color- coded with color that enhances the direction so that the possibility of damaging the inter links will be avoided.

Cost means that the device is made of low- cost and locally available materials. Convenience means that the device is handy and can easily be manipulated forming into different forms. Functionality means that the device is made of movable parts that can be transformed into different forms for the orthographic views.

Glass box visual aid is a tool 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 (Sunberg, 1972). Instructional materials are any collection of materials including animate and inanimate objects and human and non-human resources that a teacher may use in teaching and learning situations to help achieve desired learning objectives.

Rubik's Cube is a three-dimensional combination puzzle invented in 1974 by Hungarian sculptor and professor of architecture, Ernő Rubik. Originally called the Magic Cube,[3] the puzzle was licensed by Rubik to be sold by Ideal Toy Corp. Safety is a feature of the device that ensures that no small parts and sharp objects can injure the users because of its specific design and material used.

II. REVIEW OF RELATED LITERATURE AND STUDIES

This chapter presents ideas gleaned from related literature, studies and other sources that have similarities with the Detachable Rubik's cube as an innovative learning strategy in drafting courses. The information obtained from related literature and studies are the bases for the study, thus the information and the ideas gathered have strengthened the theoretical concept of this research.

Related Literature Throughout human history, people used pictures to convey ideas, express themselves, present information, etc. Basically, they used pictures to communicate. The problem that engineers, designers, builders, architects and others faced throughout history was they did not have a way of communicating ideas that everybody understood. This was a problem encountered by Gaspard Monge (1770-1850) when he started as an engineer in the French military. He devised a system that could be used to communicate an object to anyone across the world. This system was called orthographic projection and was quickly adopted by army engineers. However, France was at war and Monge's system was kept top secret. It was not until many years later that Monge was allowed to publish and teach his system. Shortly, this system spread across and revolutionized world industry. Orthographic projection (or orthogonal projection) is a means of representing a three-dimensional object in two dimensions.

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 (Brown, 1972; Hornung, 1957; Madsen, Folkestad, Schertz, Shumaker, Stark & Turpin, 2002). The standardized rules about view placement and other aspects of engineering drawings are so specific and widely used by peoples of various nationalities that Spencer, Dygdon and Novak (1995) referred to this means of communication through technical drawings as its own language, "the graphic language". When one first learned to read the written language, he progressed through it in a logical order. He learned the alphabet, then learned simple words. He could not learn the simple words until he knew the letters which formed them. Later, more complex words were added to his vocabulary and the process continued.

The same concept can be applied to learning the graphics language. The graphics language can be broken down to an "alphabet" of points, lines, and planes. Solid objects are made up of these features: points representing corners, lines representing edges, and planes representing surfaces. Technical drawings are understood to have one intended meaning (Goetsch, 2002). There are two types of technical drawings that are based on graphical projection. One of these is used to create an image of a three-dimensional object onto a two-dimensional surface (Goetsch, 2000). Two-dimensional representation uses orthographic projection to create where only two of the three dimensions of the object are seen. Orthographic projection is a way of drawing a 3D object from different directions.

The drawing is composed of a front, side, and plan views of the L-shaped object. The first drawing is the front view (drawn looking straight at the front of the L-shape), the second is a drawing of the L-shape seen from the side known as side view, and last of all is a drawing from above known as a plan view. Usually a front, side and plan views are drawn so that a person looking at the drawing can see all the important sides. Orthographic drawings are useful especially when a design has been developed to a stage whereby it is almost ready to manufacture. According to Fahiem, (2007), 3D reconstruction of objects from orthographic projections of engineering drawing has been very crucial research area since decades.

In the study of Passarella (2016), it was shown that design engineer in the early phase of building up another product is typically using a freehand sketching to communicate or illustrate the ideas in the form of orthographic projection. This orthographic projection is based on viewpoint. A translation from 2D drawing view point to 3D models is needed to help engineers to imagine the product preview in 3D. This procedure is tedious, so that automation is needed. The way to deal with this reproduction issue begin straightforwardly from 2D freehand portraying; by using the camera, the 2D drawing is captured and then transferred to a Personal Computer. Inside the computer, the image is processed with filtering to find the view point zones. The view point zone then separates to three zones, each zone consisting of the pixel coordinate. This coordinates are used in generating and processing of 3D Voxel Image according to the form of geometries. A case study is presented in order to emphasize and discuss the proposed method.

As stated by Dori (1996), 3D object reconstruction from 2D orthographic views has been a major research issue during the past two decades. Existing algorithms assume coordinate-based, noise-and error-free input without dimensioning annotation. The approach presented here assumes that the original input is a real-life engineering drawing, in which the 2D geometry of each orthographic view is annotated with dimensioning. Detected dimensions are translated into sets of constraints, one for each view, from which proper dimensioning is validated and 2D minimal graphs are obtained. The method combines elements from variational geometry, matrix algebra and graph theory to construct a composite network describing the structural and topological relations among the various entities that combine the 3D object.

According to Yue (2006), spatial visualization is a fundamental skill in technical graphics and engineering designs. From conventional multi-view drawing to modern solid modeling using computer-aided design, visualization skills have always been essential for representing three-dimensional objects and assemblies. Researchers have developed various types of tests to measure students' spatial visualization abilities, in which most pictorial views of three dimensional objects are represented by isometric drawings. Isometric drawings have many advantages such as being simple to draw, and equally representing the front, top, and side surfaces.

However, they are also susceptible to drawing mistakes in spite of their relatively simple construction. The typical styles of visualization tests are designed for engineering and technology students. Three formats for spatial visualization tests (developments, rotations, and isometric views) are compared through the students' performance at a community college. A popular spatial visualization test is used as example to show some mistakes in its isometric drawings. Recommendations are made to improve isometric drawing in spatial visualization tests. Strong spatial visualization skills are important to an engineer's ability to create and interpret technical drawings, which is critical in thinking, modeling, and problem solving processes. The ability to visualize in three dimensions is a cognitive skill that is linked to success in engineering. Spatial visualization skill and its correlation with students' success has received much attention in technical education. The ability to understand important topics in engineering drawing such as orthographic projection, isometric drawing, hidden views, and sectional views is very critical as it represents the fundamentals of engineering drawing education. However, research shows that some learners with poor spatial ability had trouble understanding basic fundamental concepts of engineering drawing. This study investigates the correlation between spatial visualization ability and academic success in a technical drawing course which has three sections: (i) hand drafting, (ii) two dimensional (2D) CAD drawing, and (iii) three dimensional (3D) CAD drawing. Students were pre-and post-tested using a standard mental rotation test to gauge spatial visualization ability and results are discussed for three sections of this course (Sedar, T., 2015).

In the study of Uria (2009), the test comprises the reading, interpretation and creation of industrial technical drawings, interpreting the different views (multi-view) of an object/piece represented in/shown by any technical drawing. However, engineering students show certain learning difficulties and a high failure rate in subjects such as Technical Drawing and Design. A problem solving model for visualization has first been designed and developed for all kind of industrial objects (Methodology for Part Visualization Problem Solving) within a constructivist framework. The Problem Solving model is the key to all technical knowledge and is an application of the scientific method. To develop this methodology, technical drawing textbooks, research and papers from all around the world have been used. In relation with this methodology, some teaching strategies have been developed. They may be applied by drawing up a programmed of specific task which takes into account the theoretical contents and procedures involved in part visualization as well as the students' main difficulties and deficiencies when faced with this kind of problem.

As has been shown by significant researches over the past several decades, there is much that can be done to encourage students' development in visualization ability. This capability to visualize, or "see" in three-dimensional space in the mind's eye is crucial in many areas of computer graphics, engineering design, and manufacturing technology, and is spreading across traditional boundaries in many industries. In conventional engineering graphics instruction, having students alternate between pictorial representations and orthographic views of an object or assembly is one method used to exercise and develop 2D/3D visualization skills. The success of this method of instruction is highly dependent on individual student ability, and often requires a significant amount of instructor mentoring. The authors have written several papers on the rationale for, and the development of, a computer-based tutorial that focuses on enhancing student capabilities with multi-view orthographic drawing. An important recent enhancement to the tutorial is the incorporation of an interactive Web-based drawing application that provides real-time assessment and performance feedback. Preliminary analysis of early versions of the application has been both encouraging and informative. The authors anticipate that continued testing and development of the application will provide a novel and effective educational aid (Connolly, 2005).

Bertoline (1990) developed an examination to determine a student's visualization capabilities. This examination has two versions, both developed to measure visualization ability, time to visualize, and reaction time. This test indicates the learner's ability to visualize complex three-dimensional objects from six principal views. Included are the results from a pilot study.

According to Prieto (2010), technical drawing improves a person's ability for spatial visualization. Visualization and inductive reasoning tests were applied at the beginning and end of a course in technical drawing in samples of the first year engineering students. In both studies it was observed that a moderate percentage of students improved their visualization test execution. The improvement was similar in men and women. There was no improvement on the inductive reasoning test. The results support the conclusion that the spatial visualization ability can be improved with training.

To analyze if learning technical drawing improves the spatial visualization aptitude, a visualization test was applied, at the beginning and at the end of a Technical Drawing course on a sample of first year engineering students. At the end of the Technical Drawing course, it was observed that more than one-third of the students increased their performance on the visualization tests. This improvement was statically significant and equal both for men and women. These results support the conclusion that spatial visualization is an aptitude that could be improved with training and, although teachers do not explicitly subscribe to this objective, technical drawing courses are an efficient way of doing this. It can be suggested that the change in spatial visualization aptitude may be considered as an efficiency indicator of the teaching-learning process (Adanez, 2004).

In the study of Gambari (2014), the potentials on interactive whiteboard (IWB) as one of the new technologies to meet the challenges of the 21st century are also discussed. The efficacy of IWB for teaching Isometric and Orthographic Projection concepts in technical drawing aspect of Basic Technology was determined using a pretest-posttest, non-equivalent, non-randomized quasi-experimental design. A 2x2x3 factorial design was employed. Ninety-four (49 males and 45 females) and (31 high, 51 medium and 12 low achievers) JSS-1 students from two secondary schools in Abuja Metropolis made-up the sample. The schools were randomly assigned to experimental and control groups. The experimental group was taught selected concepts of Isometric and Orthographic Projections using IWB and (Chalkboard) traditional method was used for the control group. A validated Basic Technology Achievement Test (BTAT) comprised of 25-item multiple choice object test was employed for data collection. The reliability coefficient of BTAT was 0.88 using Kuder-Richardson (KR-20). The hypotheses were tested using ANCOVA and Scheffe post-hoc analysis. Results revealed that the students taught with IWB performed better than the control group. Also, high achievers performed better than medium and low achievers, respectively. The IWB was found also to be gender friendly. Based on the findings, it was recommended that the use of IWB should be encouraged in Nigerian schools.

Classroom teachers have the challenge of balancing between passing along important knowledge with allowing their learners adequate time and opportunity to develop it into practical skills. Teachers recognize that at some point in a learner's academic and professional career, they will be recognized not just for what they know, but for the experience and practice they can demonstrate. Simulations seek to enhance students' learning by addressing the limitations of more traditional classroom techniques (Lean, 2006).

Hands-on activities in the classroom foster connections to real-world situations and increase learner engagement. This co-mingling of the classroom and the rest of the life is called hands-on learning. When students make connections between the concepts in the classroom and concepts in the real word, more parts of their brains are activated, and the knowledge gained is more easily transferred to long-term memory.

According to Dawson (2008), connectionism is a "hands-on" introduction to connectionist modeling through practical exercises in different types of connectionist architectures. Tangible interface for hands-on learning uses physical-tangible objects (pattern blocks). A computer recognizes the states of the user-handled objects in real time and it gives the users advice to execute learning tasks if necessary. In the study's approach, a pattern block is employed as a primitive piece. It helps the users to do direct manipulation in real environments, while displayed events in virtual environments help them to support the learning tasks (Yonemoto, 2006).

Related Studies Previous studies helped the researcher of this study in understanding the whole issues of the factors that affect the development of the spatial visualization skills of the drafting students.

The study of Nedom C. Munsen, B.S. (1969) entitled, "The effectiveness of the overhead projectuals and a transparent projection box in teaching orthographic projection," was to determine the effectiveness of overhead projectuals and transparent projection box on the ability of students to visualize orthographic views to determine the change in the student's ability to visualize the application of the orthographic principles in different units of engineering drawing. Consistent with the purpose of the study, the student population was divided into control and experimental groups. To determine the effectiveness of the experimental variables, each group was administered a pre-test, post-test and retest.

The study of Denist D. Harrison (1969) entitled, "The design, construction and use of a tri-color projection box to be used in the instruction of orthographic projection" was aimed to study the literature in the field of teaching drafting with special reference to the use of instructional aids in presenting orthographic projection. It concerned with the use of a projection box in teaching orthographic projection to an experimental group of students and to determine if an analysis of these data indicates a justification for the use of this type of an instructional aid in teaching orthographic projection.

Using 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 (Sunberg, 1972). 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.

A study of an alternative visual aid to teach orthographic drawing in introductory drafting course by Brian Kurszewski (2007), originally supplied to the researcher, himself, by K. Fozzler (through a personal communication in June 1996),was used when explaining the relationship between a completed part and an orthographic print to inspect that completed part. In this investigation, the researcher has enhanced the rotation method 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. Bowl visual aid, however, relies on the student's ability to mentally rotate an object, an area of spatial abilities that has a strong male advantage.

In relation to this, the present researcher innovated a Detachable Rubik's cube as an innovative learning strategy in drafting courses specifically for orthographic drawing. In manufacturing and design, a prototype or mock-up is a scale or full-size model of a design or device used for teaching, demonstration, design evaluation, promotion, and other purposes. A mock-up is a prototype if it provides at least part of the functionality of a system and enables testing of a design (Vieru, 2009).

Rubik's cube is one of the materials in creating prototype for orthographic drawing. There are many different hobbies nowadays for all different types of people. Most intellectual and brain-stretching hobbies are fairly modern and rely on technology. The Rubik's Cube has one thing that most modern hobbies and pastimes cannot challenge – a history and worldwide accolades that prove its impact on society all throughout its lifetime. Rubik's Cube is a 3D combination puzzle invented in 1974 by Hungarian sculptor and professor or architecture Erno Rubik (Fotheringham, 2007).

Another material used for a prototype Rubik's cube was a magnet. A magnet is a material or object that produces a magnetic field. This magnetic field is invisible but is responsible for the most notable property of a magnet: a force that pulls on other ferromagnetic materials, such as iron, and attracts or repels other magnets. The overall strength of a magnet is measured by its magnetic moment or, alternatively, the total magnetic flux it produces. The local strength of a magnetism in a material is measured by its magnetization. The similarities of the Detachable Rubik's cube to those of other instructional materials mentioned above show that they have the same strategies on how to visualize the views of the object for an orthographic drawing and the use of color indicators in any views.

The differences of the Detachable Rubik's cube to other instructional materials is that, it could be detached through the magnet inside the cube that could be deformed depending on the given object or isometric drawing. The student could easily visualize every view of the object at one glance, with the specific color indicator for the front, side and top views. In this manner, they would be able to draw an orthographic drawing, as well as, develop their critical thinking.

III. METHODOLOGY

This chapter presents the research design and methods used in the study. It also describes the research setting, research respondents, research instruments, sampling procedure, data-gathering procedure, statistical treatment of data and project development.

1. Research Design

This research study utilized a descriptive research method. Creswell (2003) maintained that descriptive research is an approach which the inquirer often makes knowledge claims based primarily on constructivist perspective (i.e., the multiple meanings of individual experience, meaning socially and historically constructed, with an intent of developing a theory or pattern) or advocacy/ participatory perspectives (i.e., political, issue-oriented, collaborative or change oriented), or both. It also

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uses strategies of inquiry such as narratives, phenomenologies, ethnographies, grounded theory studies, or case studies. The researcher collects open-ended emerging data with intent of developing themes from the data. In addition, descriptive research is used when the objective is to provide a systematic description that is as factual and accurate as possible. It provides the number of times something occurs, or frequency, lends itself to statistical calculations such as determining the average number of occurrences or central tendencies.
Research Setting

The study was conducted in the Department of Technology Teacher Education (DTTE), College of Education in MSU-IIT, Iligan City. Data analysis and presentation were carried out at the University of Science and Technology of Southern Philippines (USTP), Lapasan, Cagayan De Oro City.

Fig. 2 Map of Mindanao State University- Iligan Institute of Technology (MSU-IIT).

2. Respondents of the Study
The respondents of the study were composed of twenty-four selected students in the Bachelor of Technical – Vocational Teacher Education, major in Drafting Technology (BTVTED) and ten faculty experts who are handling drafting courses in Iligan City.

3.The Research Instrument
In the development of the instructional design, two important factors were considered: effectiveness of the instructional materials (Detachable Rubik's cube) and the prototype evaluation. A researcher-made instrument was constructed to evaluate the instructional materials. Together with this was the formulation of scoring Rubrics to determine the effectiveness of the instructional material and prototype evaluation.
The survey questionnaire was the main instrument in gathering the data. The questionnaire served to determine the respondents' perception of the Detachable Rubik's cube as an innovative learning strategy in drafting courses. The questionnaire was based on the functionality, durability, aesthetic, convenience, safety, cost and effectiveness in terms of accuracy of the Detachable Rubik's cube. To response the effectiveness of the instructional materials, the respondents should take worksheet to experience the effectiveness of the detachable Rubik's cube.

4. Validation of the Instrument
A researcher – made survey questionnaire for data collection was used. The researcher instrument was validated through faculty experts teaching drafting. As pointed out by O'Donnel and Duffy (2002, p. 1203) the design goals relate aspects of design (artefact) such as functionality, form, or in design development and consider aspects such as the time taken and cost of resources.

5. Statistical Statement
The study made use of descriptive statistics such as percentage, frequency count and weighted mean to describe the respondents' scores and responses. Inferential statistics (T- Test) was used for prototype evaluation.

Table 1 Scoring Guidelines

Mean Level	Descriptive Level
1.51-4.00	Very Acceptable
2.51 – 3.50	Acceptable
1.51 – 2.50	Fairly Acceptable
0.00 – 1.50	Not Acceptable

6. Sampling Procedure
The purposive sampling technique was used in this study. This type of nonscientific sampling is based on selecting the individuals as samples according to the purposes of the researcher of his/her controls. An individual is selected as part of the sample due to the evidence that he/she is a representative of the total population. A sample of twenty-four (24) BTVETED students from the Department of Technology Teacher Education and ten (10) faculty expert teaching drafting in Iligan City.
Data Gathering

Before the actual collection of data, a letter to the Dean of College of Education and the Department Chairman of the Department of Technology Teacher Education (DTTE) of MSU-IIT was sent requesting for the use of the school and its students to participate in the research. A written letter of consent to the respondents – the students, faculty, and other faculty experts in drafting of Iligan City – was also given informing them of the scope of the study and their participation in it. Conduct orientation about the detachable Rubik's cube, then the respondents do worksheet so that they can answer the survey questionnaire fairly.

7. Project Development for Detachable Rubik's Cube Prototype for Orthographic Drawing

7.1 Designing and Planning

The researcher considered the study as a necessity in the hands-on part of explaining about the Detachable Rubik's cube prototype. The product design was made of MDF with 1.5-inch size that could magnetically fit inside the cube. The Rubik's cube was broken apart into pieces to attach the two small magnets in the two opposite sides of the cube using adhesive to the magnet in every side of the cube. Then, the six pieces of cubes were assembled. The table below shows the materials and its operational function for the trainer model.

Table 2 Materials and Functions

Material	Function
Magnet (15mm x 4mm dia) Neodymium Magnet N52	To attach and detach in every cube of the Rubik's cube
MDF (Medium Density Fibreboard)	A wood material to be used as a cube
Adhesive	Something to stick fast the magnet to MDF
Vinyl Sticker	Fully waterproofs and toughens durability of the sticker. Used for color-coding in every side of the cube
Transparent Sticker	It has printed N(north) and S (south) to indicate the magnet

7.2. Supplies and Materials

The supplies and materials used for making the trainer model were available in the localities. The supplies were parts and components to be used in the production of the trainer model. Below is the table of the materials and its price for the trainer model.

Table 3. Bills of Materials

Quantity	Unit	Material Description	Unit Price (Php)	Total Price (Php)
768	Pcs.	Neodymium magnet N52 (15 dia mm x 4mm thickness)	₱11.30	₱ 8,678.40
1	Pcs.	MDF (3mm thickness)	₱ 270.00	₱ 270.00
20	Pcs.	Adhesive (Shoe Glue)	₱ 8.00	₱ 160.00
2	pack	Adhesive (glue stick)	₱ 25.00	₱ 25.00
75	Pcs.	Laser cutting at FabLAB	₱ 20.00	₱ 1,440.00
3	Pcs.	Vinyl Sticker (1 x 2 ft.)	₱ 45.00	₱ 270.00
1	Pcs.	Transparent Sticker (A4)	₱ 60.00	₱ 60.00
TOTAL			₱ 424.3	₱ 10,903.00

7.2.1 Mechanical Design

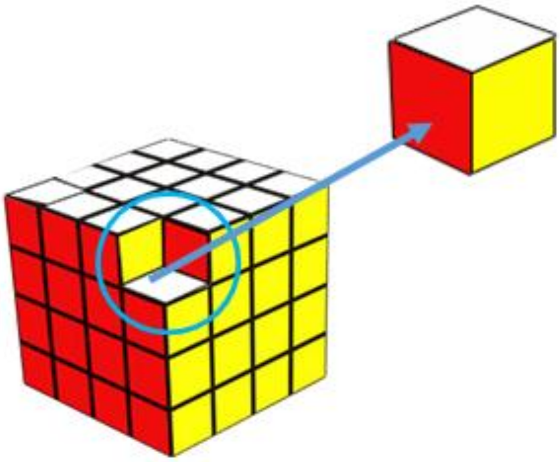

Fig. 2. Detachable Rubik's cube (Mechanical Design)
b. Perspective Design

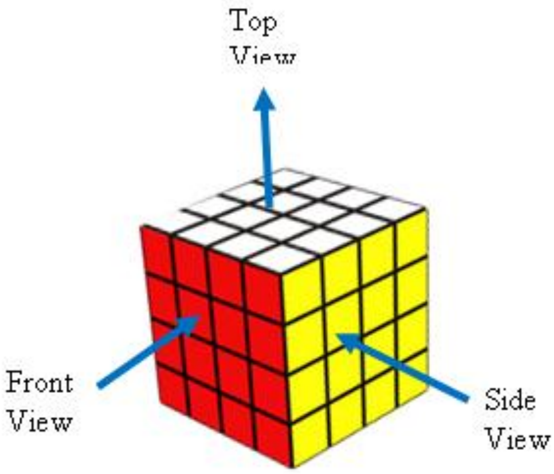

Fig.3. the instructional model view (Figure 3 shows the front, side and top views of the instructional model. As shown, every view has respective colors for easy visualization of each view.)

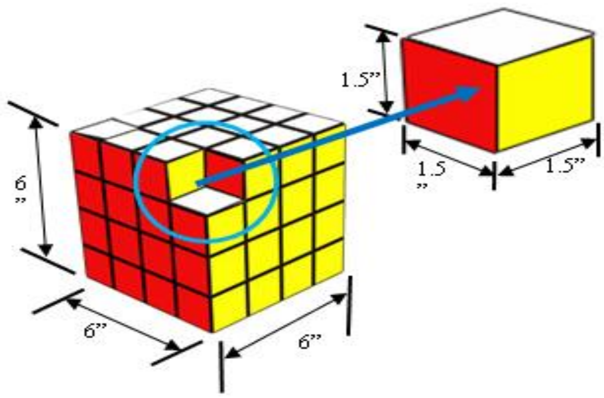

Fig. 4. Dimension of the Instructional Model (Figure 4 shows the dimensions of the instructional model.)

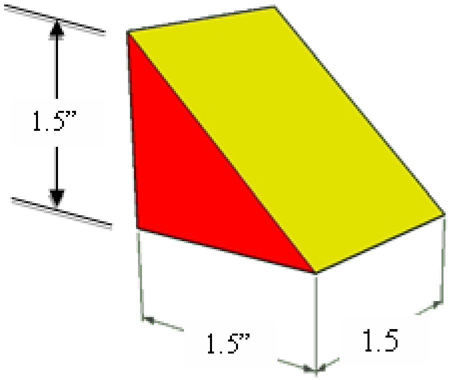

Fig. 5. Triangular Prism (Figure 5 displays other figure that the instructional model can demonstrate)

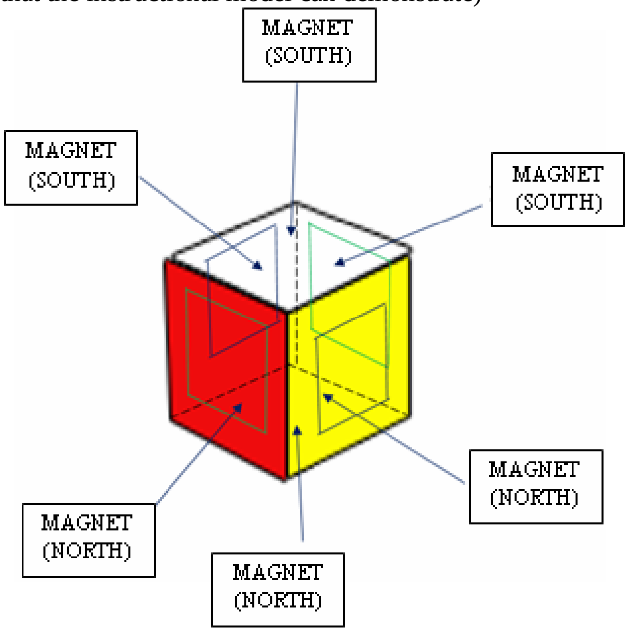

Fig. 6. The position of magnet in a cube (Figure show the position where the magnets are attached in every side of the cube)

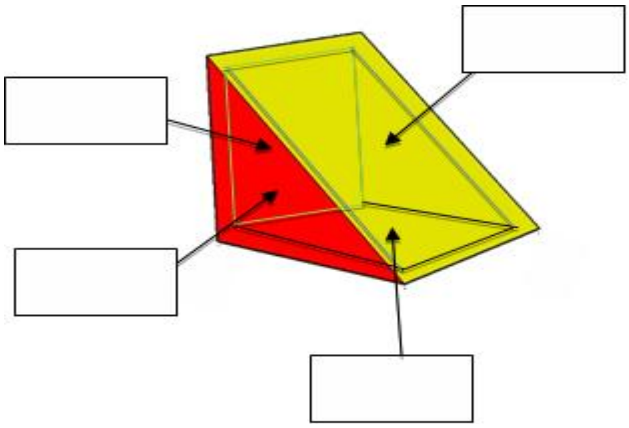

Fig. 7. The position of magnet in a triangular prism (Figure show the position where the magnets are attached in every side of the triangular prism)

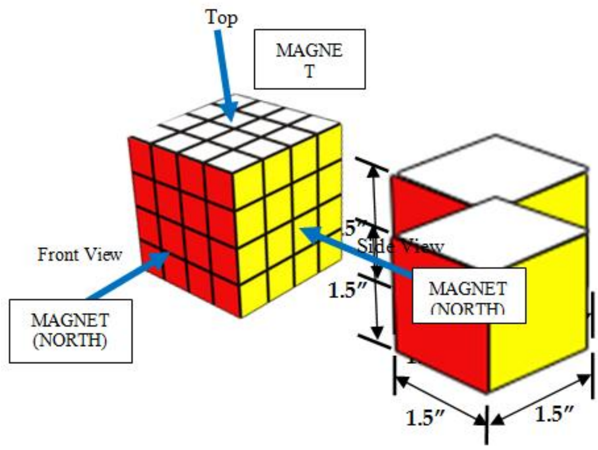

Fig. 8. The position of magnet as a whole Rubik's cube (Figure 8 shows the positions where the North and South magnets are attached in every side of the cube in the whole Rubik's cube.)

During assessment, the students were given an isometric drawing to visualize the three views; the top, the front and the side views for orthographic drawing. To make it easier for the students to visualize the views, they could detach every cube and formed them based on the given isometric drawing. Here, the object / isometric for the orthographic drawing could be easily visualized.

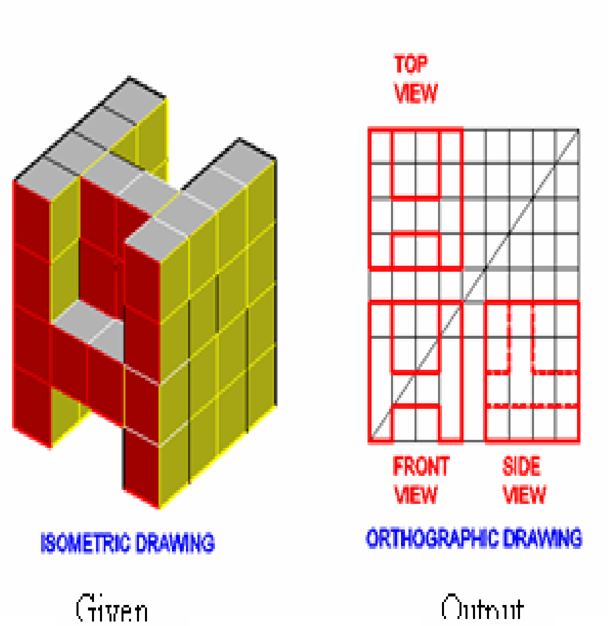

Fig. 9. The application of the Instructional Model (Figure 9 shows the application of the Detachable Rubik's cube as innovation for instructional tool in orthographic drawing.)

7.2.2 Procedure

The development of the Detachable Rubik's cube followed the procedure and processes enumerated below:

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Step 1. Consultation on the project design, its features and the materials to be used for the Detachable Rubik's cube with the expert at FabLab, MSU-IIT.
Step 2. Lay-out the desired design using Autodesk Fusion 360 for the visualization of the product, and then collect and gather the needed materials.
Step 3. Create a 3D view of the desired design to check the object result in the Autodesk Fusion 360.
Step 4. Prepare the MDF material for laser cutting.
Step 5. Cut the MDF with a laser cutter at a cutter speed of one minute per cube.
Step 6. Identify the different patterns for cubes. The Rubik's cube is made of MDF that is broken apart into six pieces.
Step 7. Assign numbers in every piece of MDF to indicate the sequence of placement of the pattern in the cube.
Step 8. Identify and assign which pattern to be marked as North and which pattern to be marked as South. The corresponding pattern determines what pole of the magnet is to be attached in each pattern.
Step 9. Prepare and identify the North Pole and South Pole of the magnet (3mm thickness and 15 diameter) and attach it to the corresponding pattern based on the indicator in the MDF. Use adhesive to attach the two small magnets in the two opposite sides of the cube.
Step 10. Assemble the six pieces of MDF to form a cube. Apply an adhesive (shoe glue) in every edge, then let it dry.
Step 11.Color code each pace of the cube using vinyl sticker in 1.5-inch dimension. Use red for front view, yellow for side view and white for top view.
Step 12. Mark the North (N) pace and the South (S) pace of the cube using transparent sticker for easy identification during attachment in forming the object view.

IV. PRESENTATION, ANALYSIS AND INTERPRETATION OF RESULTS

The presentation of the evaluation of the Detachable Rubik's cube as an innovative learning strategy in the drafting course by faculty and students of the department of Technology Teacher Education and faculty experts in Iligan city is discussed in this chapter. The presentation is discussed by parts.

Part A. What design consideration is given to innovating the detachable Rubik's cube as a teaching-learning device?

The product design was made of MDF (Medium Density Fibreboard) with 1.5-inch size that could magnetically fit inside the cube. The Rubik's cube was broken apart into pieces where the two small magnets were attached in the two opposite sides of the cube using adhesive. The same technique was used to attach the magnet in every side of the cube. Then, the six pieces of cubes were assembled. Every view of the cube had its respective color for easy visualization: red for the front view, yellow for the side view, and white for the top view. Aside from the cube, another object can be formed like the additional triangular prism. For application of the Detachable Rubik's cube, the students were given an isometric drawing to visualize the three views: the top, the front and the side views for orthographic drawing. To make it easier for the students to visualize the views, they could detach every cube and formed them based on the given isometric drawing.

Part B. What are the process and procedures in creating the Detachable Rubik's cube?

The development of the Detachable Rubik's cube followed the enumerated procedure and processes. The numbering of the figures in this presentation starts from numbers 1 to 26 to distinguish them from the figures illustrated in Mechanical and Perspective Designs in Chapter III of this study.

Step 1. Consultation on the project design, its features and the materials to be used for the detachable Rubik's cube with the expert at FabLab, MSU-IIT.

Fig. 10. Consultation with the Expert

Step 2. Lay-out the desired design using Autodesk Fusion 360 for the visualization of the product followed by the collection and gathering of the needed materials.

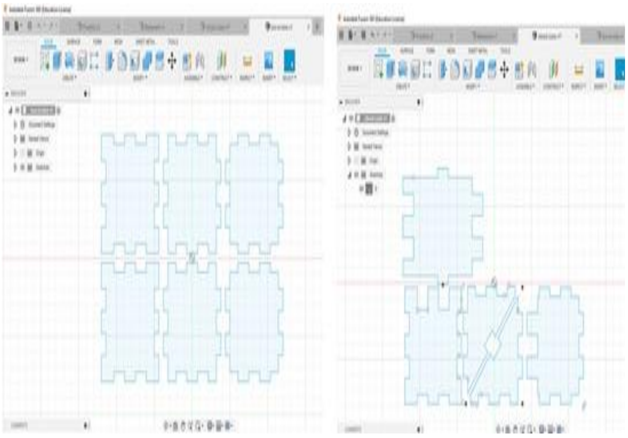

Fig. 11. Lay-out of the Design Pattern.

Step 3. Create 3D view of the desired design to visualize the object result in the Autodesk Fusion 360.

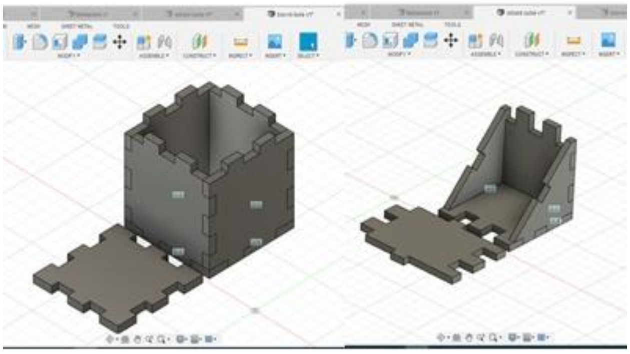

Fig.12. 3D View of the Desired Design

Step 4. Prepare the material for laser cutting.

Fig. 13. MDF Material Ready for Laser Cutting

Step 5. Cut the MDF with a laser cutter at a cutter speed of one (1) minute per cube.

Fig.14. Laser Cutting of the MDF Material.

Step 6. Identify the different patterns for cubes. The Rubik's cube is made of MDF that is broken apart into six pieces.

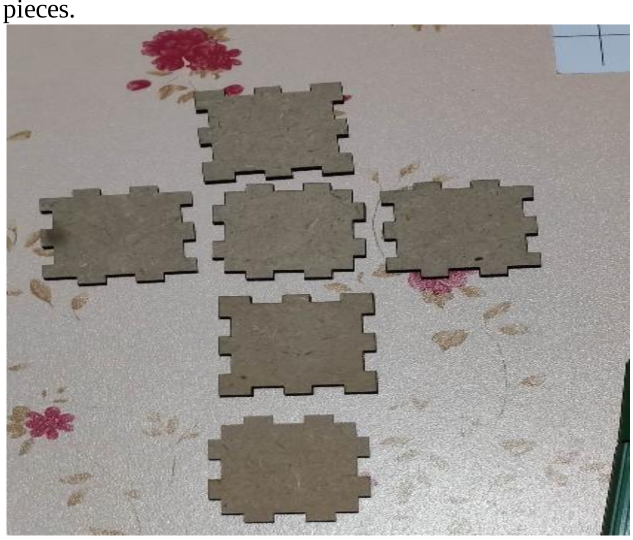

Fig. 15. The Cube Pattern.

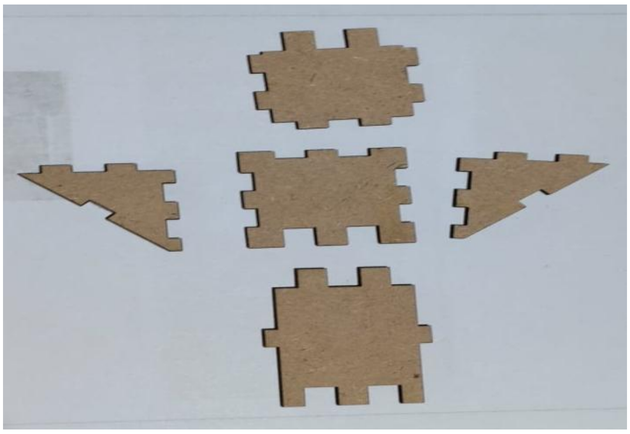

Fig. 16. The Triangular Prism Pattern

Step 7. Assign numbers in every piece of MDF to indicate the sequence of placement of the pattern in the cube.

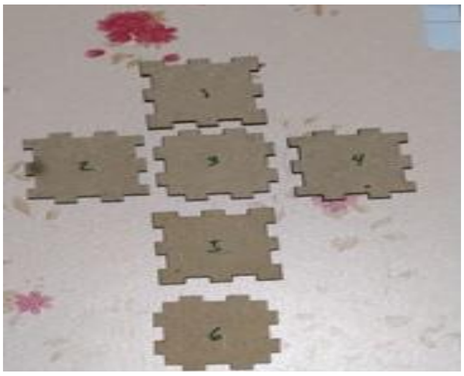

Fig. 17. The Assignment of Numbers in each Cube Pattern

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Fig. 18. The Assignment of Numbers in each Triangular Prism Pattern.

Step 8. Identify and assign which pattern to be marked as North and which pattern to be marked as South. The corresponding pattern determines what pole of the magnet to be attached in each pattern.

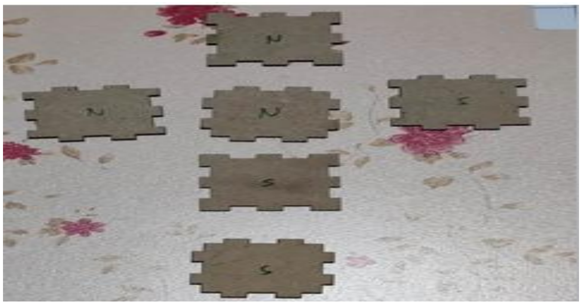

Fig. 19. The Assignment of Poles in Each Cube

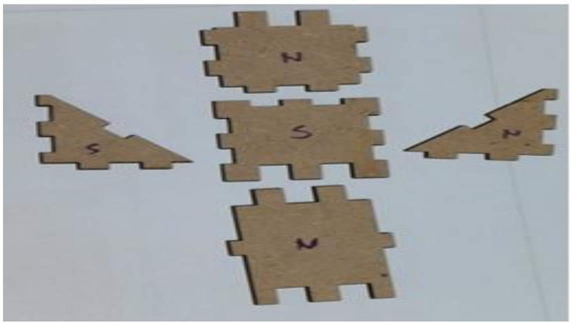

Fig. 20. The Assignment of Poles in each Triangular Prism.

Step 9. Prepare and identify the North Pole and South Pole of the magnet (3mm thickness and 15 diameter) and attach it to the corresponding pattern based on the indicator in the MDF as indicated procedure that follows.

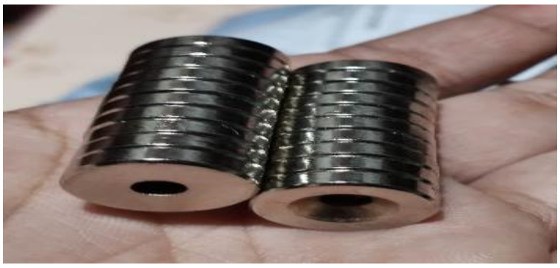

Fig. 21. The Magnets

Use adhesive to attach the two small magnets in the two opposite sides of the cube.

Fig. 22. Applying Adhesive to the Magnets

b. Put another adhesive (glue stick) around the magnet as additional support to prevent it from getting easily detached from the MDF.

Fig. 23. Applying Additional Adhesive to the Magnets

c. After putting adhesive in every piece of MDF, keep the resulting cubes apart to avoid attachment to each other.

Fig. 24. Keeping each Piece Apart of the Cube Pattern

Fig. 25. Keeping each Piece Apart of the Triangular Prism Pattern

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Step 10. Assemble the six pieces of MDF to form a cube.

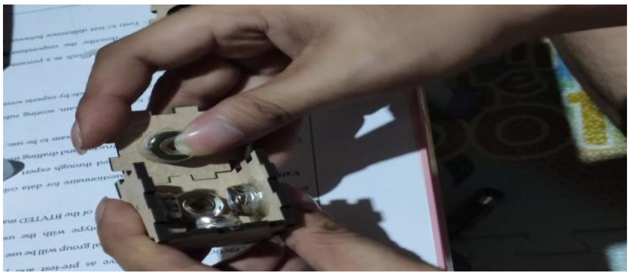

Fig. 26. Assembling the Pattern.

1. Apply an adhesive (shoe glue) in every edge then let it dry.

Fig. 27. Application of Adhesive at the Edge of the Cube Patterns

Fig. 28. Application of Adhesive at the Edge of the Triangular Prism Patterns.

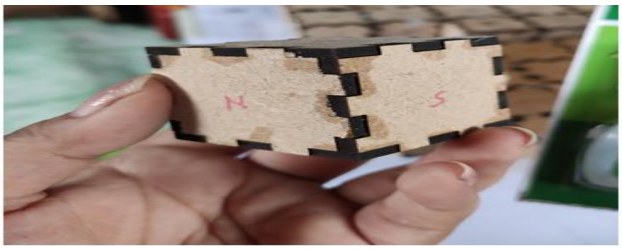

Fig. 29. The Completed Assembly of Cube .

Fig. 30. The Completed Assembly of Triangular Prism

Step 11. Color code each paces of the cube using vinyl sticker in 1.5-inch dimension.

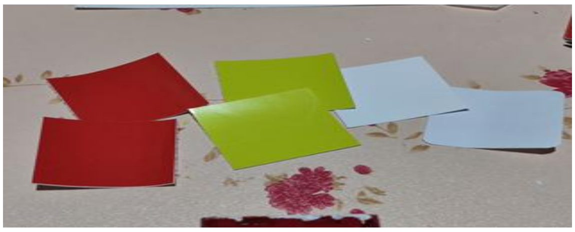

Fig. 31. The Colored Vinyl Stickers.

a. Place the vinyl sticker in every assigned views. Use red for front view, yellow for side view and white for top view.

Fig. 32. Placing of the Colored Vinyl Stickers in the Cube Pattern

Fig. 33. Placing of the Colored Vinyl Stickers in the Triangular Prism Pattern.

Trim the excess sticker in every side of the cube/ triangular prism.

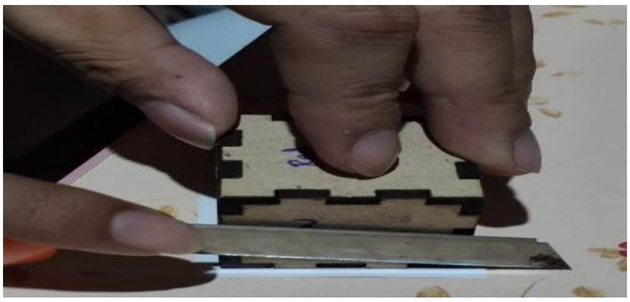

Fig.34. Trimming the Excess Sticker

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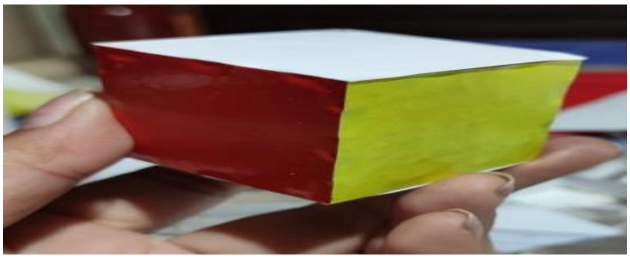

Fig. 35. The Completed Cube (Figure 35 shows the completed cube)

Fig. 36. The Completed Triangular Prism (Figure 36 shows the completed triangular prism)

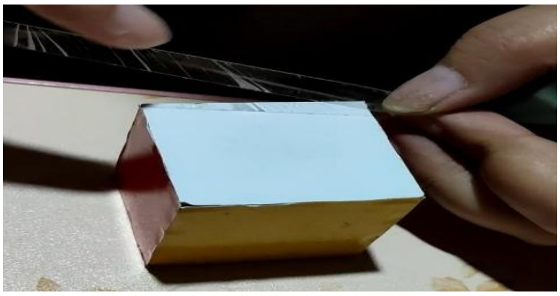

Fig. 37. Securing the Edges of the Cube Using Scotch Tape (Figure 37 shows how every edge of the cube is secured by applying clear scotch tape to avoid opening of the edges.)

Step 12. Mark the North (N) pace and the South (S) pace of the cube using transparent sticker for easy identification during attachment in forming the object view.

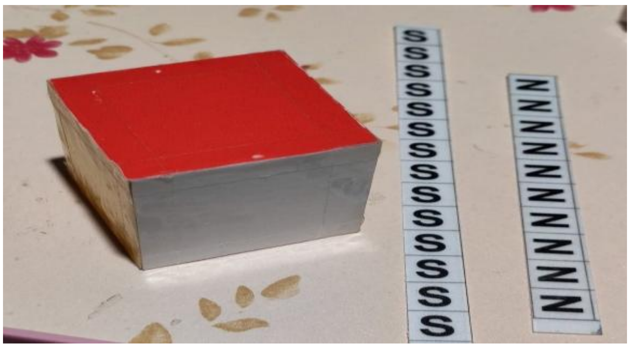

Fig. 38. Marking the Paces of the Cube

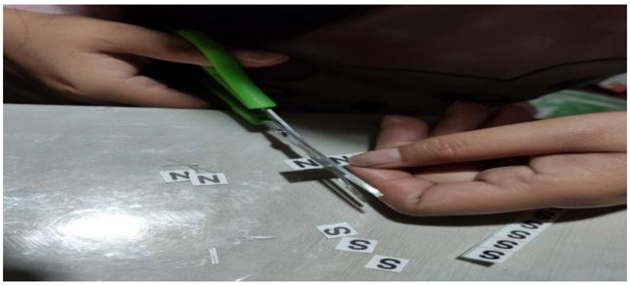

Fig. 39.Cutting the Stickers Marked North (N) and South (S).

b. Identify the North and South poles for labeling.

Fig. 40. Marking the Paces of the Cubes According to the Assigned Poles.

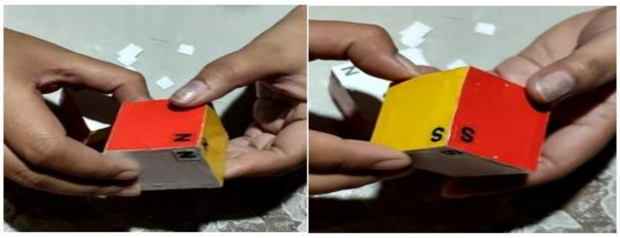

Fig. 41. Marking the Paces of the Cube (Figure 41 shows how the paces of the cube are marked.)

Fig. 42. The Finished Cube Patterns.

Part C. What are the respondent's perceived acceptability of the Detachable Rubik's cube in terms of the functionality, durability, aesthetic, convenience, safety and cost?

Table 4: Mean Level of Respondents' Perceived Acceptability of the Detachable Rubik's Cube

Indicators	Mean	Sd	Descriptive Level
Functionality			
1. It Can Form The Different Object For Orthographic Views (I.E., Front, Side, Top) By Movingly Detaching The Components.	3.88	0.327	Very Acceptable
2. Color-Coded Components Or Panes Give Easy Visualization Of The Different Orthographic Views.	3.94	0.239	Very Acceptable
3. Components Can Be Assembled And Disassembled.	4.00	0.000	Very Acceptable
Overall	3.94	0.189	Very Acceptable

Indicators	Mean	Sd	Descriptive Level
Durability			
1. It Is Made Of Good Quality Materials That Will Last Even With Constant Use.	3.79	0.410	Very Acceptable
2. The Components Can Be Assembled And Disassembled Without Possibility Of Damaging The Inter Links Or Connection.	3.85	0.360	Very Acceptable
Overall	3.82	0.385	Very Acceptable
Aesthetics			
1. The Device Is Presentable.	3.85	0.360	Very Acceptable
2. The Device Uses Color-Coded Panes Or Components That Enhance And Capture The Attention Of The Users Or Students.	3.88	0.327	Very Acceptable
Overall	3.87	0.343	Very Acceptable
Convenience			
1. It Can Be Manipulated Easily.	3.88	0.327	Very Acceptable
2. It Is Handy And Lightweight.	3.79	0.410	Very Acceptable
3. The Component Can Be Assembled And Disassembled Easily.	3.91	0.288	Very Acceptable
Overall	3.86	0.342	Very Acceptable
Safety			
The Device Is Made Of Wood And Magnet With No Small Parts And Sharp Edges That May Injure The Users.	3.76	0.431	Very Acceptable
Cost			
The Device Is Made Of Locally-Available And Affordable Materials.	3.74	0.448	Very Acceptable
Effectiveness In Terms Of Accuracy			
The Device Can Form The Different Objects Based On The Given Isometric Drawing.	3.94	0.239	Very Acceptable

Legend:

Mean Level	Descriptive Level
3.51 – 4.00	Very Acceptable
2.51 – 3.50	Acceptable
1.51 – 2.50	Fairly Acceptable
0.00 – 1.50	Not Acceptable

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Table 4 shows the mean level of respondents' perceived acceptability of the designed Detachable Rubik's cube. In terms of functionality, the Detachable Rubik's cube obtained an overall mean of 3.94 and standard deviation of 0.189 which has a verbal description of very acceptable. In particular, the raters strongly agreed that it could form the different objects for orthographic views (i.e., front, side, top) by moving or detaching the components. The color-coded components or panes gave easy visualization of the different orthographic views and the components.

In addition, it could be easily assembled and disassembled. This means that the functionality aspect of the Detachable Rubik's cube was very acceptable to the raters. Second, in terms of durability, the Detachable Rubik's cube was very acceptable for the raters as indicated by the overall mean of 3.82 and standard deviation of 0.385. They strongly agreed that it was made of good quality materials that would last even with constant use and assembling and disassembling of the components without possibility of damaging the inter links or connection. Third, with respect to the aesthetic value of the Detachable Rubik's cube, they rated it as very acceptable as indicated by the overall mean of 3.87 and standard deviation of 0.343.

They strongly agreed that the device was presentable and used color-coded panes or components that enhanced and captured the attention of the users or students. Next, in terms of convenience the raters said it was very acceptable as indicated by the overall mean of 3.86 and standard deviation of 0.342. They strongly agreed that manipulating the Detachable Rubik's cube and assembling and disassembling its components were both easy to do, not to mention, that it was handy and lightweight. In the criteria of safety, cost and effectiveness in terms of accuracy, the raters noted as very acceptable as indicated by the overall means of 3.76, 3.74 and 3.94, respectively and standard deviations of 0.431, 0.448 and 0.239, respectively. They strongly agreed that the device was made of wood and magnet with no small parts and sharp edges that might injure the users, that it was made of locally- available and affordable materials, and that it could form into the different objects based on the given isometric drawing.

Overall, in all aspects, the Detachable Rubik's Cube was very acceptable as rated by the respondents. Part D. What are the respondent's comments and suggestions on the effectiveness of the Detachable Rubik's cube in terms of accuracy to form into different objects for the orthographic drawing?
These are the responses of the respondents on the effectiveness of Detachable Rubik's cube:

- The detachable Rubik's cube is very useful.
- It is helpful to the teachers handling orthographic.
- I like detachable Rubik cube because it is useful to teacher.
- It's challenging and can easy to handle.
- Make use at greener Rubik's cube to make catch attention.
- improve cube corners
- Good for individual and groupings.
- Improve the surface to more durable.
- A user manual make prior to the prototype.
- Good for presentation in class for orthographic cube.
- Strong magnetic interaction can hinder the possibility.
- very innovative and very well presented
- I hope the next version can form holes and circles and any detailed
- It is handy and it can really help the student to visualize the object.
- I had difficulty with the magnet but it is fun and creative.
- It is indeed a nice idea. It would be a big help to the future drafters

Part E. What is the completed Detachable Rubik's cube?
The Detachable Rubik's cube has sixty-four cubes with 1.5 inches for one complete cube with six inches size. Each view is color-coded with the front view colored red, side view colored yellow and top view colored white. Together with this is an additional eight triangular prism.

Fig. 43 .The Completed Detachable Rubik's Cube

Fig. 44. The Completed additional eight triangular prism

V. SUMMARY, CONCLUSION AND RECOMMENDATION

This chapter presents the summary of the study and its findings based on the results of the evaluation made by the respondents who participated in the study. This chapter also includes the conclusion and recommendation arrived from results of this study.
Summary

The main objective of this study was to innovate a detachable Rubik's cube as a learning strategy in drafting course. Specifically, it sought to answer the following questions: (1) What design consideration is given to innovating the Detachable Rubik's cube as a teaching learning device? (2) What are the process and procedures in creating the Detachable Rubik's cube? (3) What are the respondent's perceived acceptability of the detachable Rubik's cube in terms of a.) functionality, b.) durability, c.) aesthetic, d.) convenience, e.) safety, and f.) cost? (4) What are the respondent's comments and suggestions on the effectiveness of the Detachable Rubik's cube in terms of accuracy to form into different objects for orthographic drawing? and (5) What is the completed Detachable Rubik's cube?

The development of the Detachable Rubik's cube was evaluated by twenty-four BTVTED students of DTTE, MSU-IIT and ten faculty experts handling drafting course in Iligan City. The quantitative ratings and the qualitative comments and suggestions of the respondents were considered carefully in the development of the Detachable Rubik's cube as an innovative learning strategy in drafting course.

Findings

From the results of the evaluation, the major findings of this study are drawn.

1. The Detachable Rubik's cube could form different objects by moving its detachable components for orthographic views (i.e., front, side, top).
2. The Detachable Rubik's cube had color-coded components or panes that enable users to visualize easily the different views (i.e., front, side, top) for orthographic drawing.
3. Its components could be easily assembled and disassembled.
4. The Detachable Rubik's cube were made of good quality materials that would last even with constant use.
5. The components could be assembled and disassembled without the possibility of damaging the inter links or connections.
6. The Detachable Rubik's cube was presentable with color-coded panes or components that enhanced and captured the attention of the users or students.
7. The Detachable Rubik's cube could be easily manipulated, its components easily assembled and disassembled, and handy and lightweight.
8. The Detachable Rubik's cube was made of MDF and magnet with no small parts and sharp edges that might injure the users.
9. The Detachable Rubik's cube could form different object based on the given isometric drawing for orthographic drawing.

VI. CONCLUSION

The following conclusions are arrived at based from the findings of this study.

The developed Detachable Rubik's cube has met the criteria of functionality, durability, aesthetic, convenience, safety, cost and effectiveness in term of accuracy. On the over all aspects, the Detachable Rubik's cube is very acceptable as rated by the respondents. Thus, it can be used as an innovative learning strategy in teaching orthographic drawing and isometric drawing in the drafting course. With the Detachable Rubik's cube, students' critical thinking and creativeness will be developed, and their visualization will be enhanced. Finally, the design of the developed Detachable Rubik's cube has satisfied the provision that the device is a very effective tool in orthographic and isometric drawing application in the drafting course.

Recommendation

On the basis of the conclusions drawn, the following are recommended. The faculty handling drafting should be encouraged to develop and use a device like the Detachable Rubik's cube as a tool for teaching and learning in the drafting course. A similar study should be conducted to validate and further improve the Detachable Rubik's cube in terms of the most desired design, function, and the cheapest materials to be used. It is also recommended that another set of this innovated device be produced adding other details like forming holes and circles.

APPENDIX A

Prototype Evaluation of Detachable Rubik's cube

Name:________________________Designation:_______

School:_______________________Course:___________

Direction: Please indicate in the table with a check mark (/) that perfectly suits your needs that the Detachable Rubik's cube can provide.

Legend: SA- Strongly Agree D- Disagree
A – Agree SD- Strongly Disagree

	4	3	2	1
I. Functionality	SA	A	D	SD
1. It can form the different objects for orthographic views (i.e., front, side, top) by moving and detaching the components.				
2. Color-coded components or panes give easy visualization of the different orthographic views.				
3. Components can be assembled and disassembled.				
	4	3	2	1
II. Durability	SA	A	D	SD
1. It is made of good quality materials that will last even with constant use.				

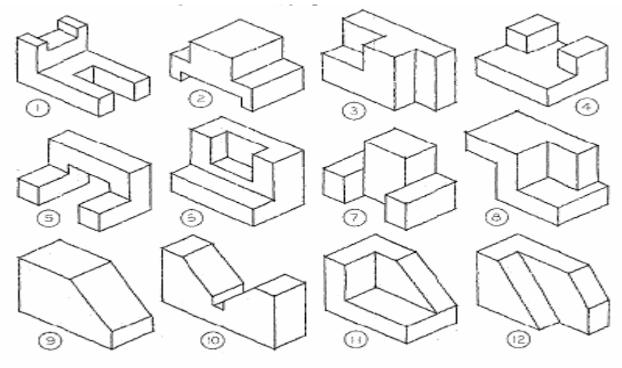
2. The components can be assembled and disassembled without possibility of damaging the inter links or connection.				
	4	3	2	1
III. Aesthetic	SA	A	D	SD
1. The device is presentable.				
2. The device uses color-coded panes or components that enhance and capture the attention of the users or students.				
IV. Convenience	4	3	2	1
	SA	A	D	SD
1. It can be manipulated easily.				
2. It is handy and lightweight.				
3. The component can be assembled and disassembled easily.				
V.Safety	4	3	2	1
	SA	A	D	SD
1. The device is made of wood and magnet with no small parts and sharp edges that may injure the users.				
VI. Cost	4	3	2	1
	SA	A	D	SD
1. The device is made of locally- available and affordable materials.				
VII. Effectiveness in term of accuracy	4	3	2	1
	SA	A	D	SD
1. The device can form the different objects based on the given isometric drawing.				

Worksheet
Instruction: Form this isometric drawing using detachable Rubik's cube as a tool on visualizing the views for your orthographic drawing.

APPENDIX B
February 14, 202
AMELIA T. BUAN, PhD
DEAN
COLLEGE OF EDUCATION
MSU-IIT, ILIGAN CITY

Ma'am,

Grace and peace to you!



I am currently conducting a study- entitled "Detachable Rubik's Cube as an Innovative Learning Strategy in Drafting". In concomitance with this, I humbly request your good office to allow me to conduct and gather data from First Year BTVTED-Drafting students and faculty as my respondents. Your positive response regarding this request will be a valuable contribution for the success of the study.

Thank you so much and God bless!
Respectfully yours,
MARGIE R. MENDOZA
Researcher
Noted by:
ALENOGINES L. SAN DIEGO, DTE Adviser
Approved by:
AMELIA T. BUAN, PhD
Dean- College of Education

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