Augmented Reality as a tool for teaching a course on Elements of Engineering Drawing

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Abstract— **Engineering drawing is a universal language of an Engineer which allows engineers to create designs, represent them on a drawing sheet, calculate distances, and create a blue print before manufacturing. All engineering students undergo a complete course on engineering drawing where orthographic projections are taught. In orthographic projections, the students are asked to imagine a 3D situation and make the 2D orthographic projection drawing. This part of 3D imagination and converting it into orthographic projection is difficult for students to mentally visualize. To ease the student's imagination, An Augmented Reality solution is developed jointly by BMSCE and Bosch (RBEI), Bangalore. A powerful 3D graphics association has been developed which forms the primary source of developing the drawing as orthographic projections that is viewable in 3D in real world.**

The current article focuses on the importance of AR in engineering education and its benefits.

Keywords— ***Engineering Drawing, Augmented Reality, Technology***

I. INTRODUCTION

Introduction: Engineering drawing is an important means of communication between engineering professionals across the globe. It is highly important for engineering professionals to be capable of producing, understanding and interpreting engineering drawings [1].

Engineering drawing is the subject which demands good amount of imagination skills. The students are required to produce a professional drawing. Besides understanding the relationship between three dimensional (3D) objects and their 2D projections, the student need to comprehend geometric relationships of points, lines, planes, projections of solid entities, etc... However, in the classroom, due to restriction in time, it is challenging for the faculty to explain the concepts clearly by using only standard teaching methods.

Spatial ability is an important component of human intelligence, but there is no agreement about the sub-factors that compose this component of intelligence [1]. Most accepted theories coming from researchers [2, 3] have proposed three major sub-factors for categorizing spatial skills: spatial relations, spatial visualization and spatial orientation.

From the basic research it has been found that the learner (student) faces difficulties in visualizing the concepts in engineering graphics irrespective of the college where he is pursuing this course and would need help in 3D visualization. But the methods which a course instructor currently uses are limited and have limited impact on the student. Hence there is a strong need of alternative tools which helps the students thoroughly understand the 3D scenario of concepts.

Virtual Reality (VR) Caves which create immersive 3D Visualizations are very expensive. With the rapid development of new computing platforms (Tablets, Mobiles, Eye-gears (Google Glass)) and maturity in Advanced Software Platforms

(Computer Vision, Machine Learning, 3D Authoring Tools) Augmented Reality emerged as an affordable solution that can run on mobile devices with camera to Visualize virtual 3D objects in real world. Unlike Virtual Reality, Augmented reality does not create a simulation of reality. Instead, it takes a real object or space as the reference and integrates context specific data to deepen a learners understanding of the subject. Augmented reality has many applications in several other fields. Within the educational sector, educators have started to provide the students with more immersive knowledge by linking the subject related content with specific products, process and industries. In many domains, industry visits are a part of the course, by supplementing these explorations with emerging technologies like AR visualizations the understanding can be extended beyond the industry visit.

Augmented reality (AR) is one such tool where virtual elements are integrated with real elements to create a real-time mixed reality using affordable tools. This AR tool helps the student in clarifying the doubts, thorough understanding of the subject and various possibilities of representing an object in 3D space.

II. DEVELOPMENT & METHODOLOGY

The development & implementation of the tool involves two major parts; i) Technical details of the course to be built into the Solution ii) AR Software Module Development

The first activity involves thorough understanding of the subject, which inturn will be the input for further Software Module Development. Let us consider an example to understand the various dimensions involved in learning the course.

The two mangos on a tree A & B are 1.5 m and 3.00 m above ground and those are 1.2 m & 1.5 m from a 0.3 m thick wall but on opposite sides of it. Find the real distance if the distance measured between them along the ground and parallel to wall is 2.6 m. This is a typical case to be solved in engineering drawing. This requires the student to understand, interpret the situation the way as shown in Figure 1.

From the Figure 1, one can clearly understand the difficulties involved in imagining the situation exactly as in Figure 1. To help student imagine a situation, AR augments his understanding by visualizing the complete 3D scenario in real world.

This Solution is jointly developed between BMS College of engineering and Bosch(RBEI). The team worked on developing an AR tool for about 8 months. There were many iterations done with respect to the interface, functional elements and so on. Typical use cases from six different chapters were selected (two from each chapter) and were built into the AR tool. The student has the option to vary parameters like the angle of inclination with respect to horizontal plane or vertical plane, changing the dimensions of the geometric entity etc, which makes him to understand perfectly about the situation that is supposed to be drafted. This skill will not only help the student in excelling in his exams but also in his engineering domain.

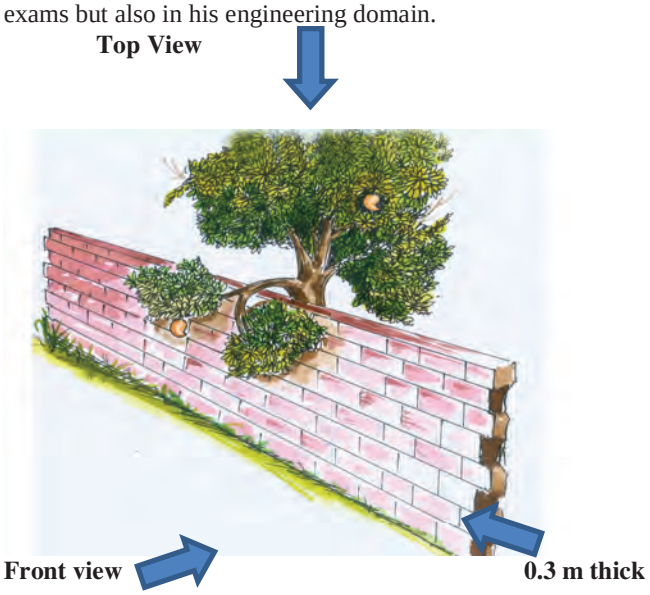

Figure 1: Actual 3D scenario to be understood by top and front views

The AR tool requires a smart device which can be a desktop computer or laptop or Smartphone but needs to have a good resolution web camera. The device will be used with marker which is nothing but a sheet of high contrast images which acts as a place holder for visualizing AR Content. The AR tool has got various advantages: It is portable, affordable, user friendly, do not demand much system requirements, flexible and accommodates many features.

Let us understand the working of AR Solution by considering an example from projections of plane surfaces, a chapter from elements of engineering drawing course. The student is expected to draft the solution on the drawing sheet. The data is given as; a circular lamina of 60mm diameter rests on HP such that the surface of the lamina is inclined at 40 to HP. The diameter through the point on which it rests on HP appears to be inclined at 30 to VP in the top view. The projections are to be drafted with the given data. If the circular lamina is seen, it actually looks like as shown in Figure 2. The Figure 2,3,4 is a demonstration of AR tool user interface where the user has the options to change the inclination with respect to horizontal plane, vertical plane or both and visualize it for better understanding.

The student who is in a learning process can use this AR tool to actually visualize different views, projections over various planes and its inclination etc. This needs to be done when the course instructor teaches the concepts via traditional methods.

The tool also provides options to make the 3D object viewed as translucent/opaque. The overall process of learning will be much more effective than the traditional teaching alone. The impact of AR tool in helping the student to learn the concepts in more immersive way is clearly evident.

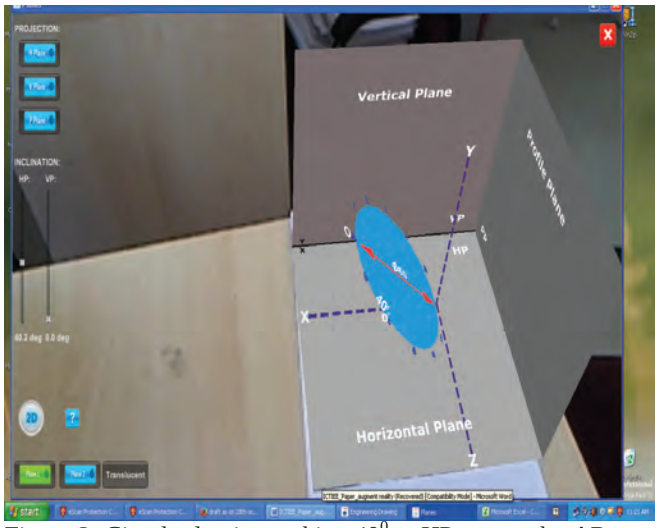

Figure 2: Circular lamina making 40^0 to HP as seen by AR tool

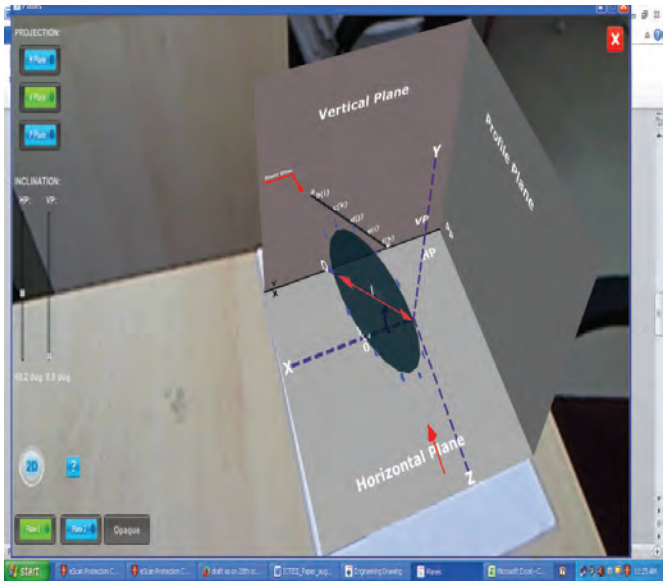

Figure 3: Front view of the circular lamina as seen by AR tool

III. CHALLENGES AND FURTHER IMPROVEMENTS

The product that is developed is first of its kind for the Indian context and it is not available commercially yet. It is also planned to make this tool available to the Indian market in short time thereby making the teaching learning process more effective which in turn contributes to the quality of learning.

There were quite a few challenges during the product development. Experts from Bosch (RBEI) and BMS had to synchronize their efforts, perform lot of iterations, test it rigorously and repeat the exercise to make sure it offers an optimal user experience for the students.

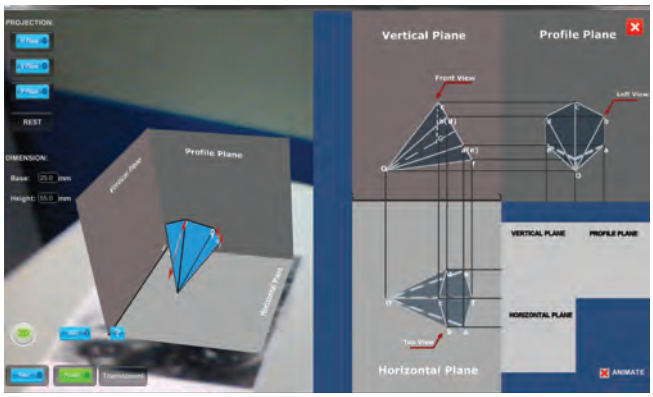

Figure 4: Projection of Solids

It is also planned to extend the use of AR tool for courses like Machine drawing, Theory of Vibrations, Field Theory where the students find it difficult to understand the course only by traditional ways of learning.

IV. CONCLUSION

The AR tool is proven to be an affordable, effective and immersive way to teach engineering drawing course. It can be concluded that AR tool can be extended to areas/courses where there are opportunities for a faculty to improve his delivery by teaching concepts with augmented information into the real world.

Acknowledgment

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