

## **Create your 3D Eye: A Lesson Module for Grades 6-8 from ImageSTEAM Teacher's Workshop**

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## Abstract

Through an NSF-funded ITEST program, Labeled ImageSTEAM, a summer workshop was conducted in June 2024 with a diverse group of middle school teachers. The workshop aimed to integrate artificial intelligence (AI) into the K-12 curriculum by exploring computer vision and AI tools to augment science and technology education. ImageSTEAM specifically introduced visual media as a critical technology to engage middle school students, particularly in 7th-grade science, through AI-related topics, digital 3D modeling, and coding.

As a result of the workshop, the “Create your 3D Eye” lesson module was developed using AI tools such as Pixlr X, TinkerCAD, and ChatGPT prompts. This module helps students understand the structure and function of the eye and apply their knowledge through interactive digital tools. The summative assessment for the students is to design and build their 3D model of an eye from scratch using TinkerCAD's tools. The module includes a detailed lesson plan, student handouts, general TinkerCAD basics for students, and a slide presentation, all with links to online resources. Aligned with Next Generation Science Standards and the International Society for Technology in Education Standards, the module can be implemented in various curriculum settings.

In addition to the lesson module, students completed pre- and post-lesson surveys to track their interest in AI tools and topics. The results and experiences of both teachers and students are shared and discussed. An introduction is given, followed by a sample lesson, and an assessment.

## Introduction

### *Introduction to ImageSTEAM*

Recent advancements in artificial intelligence (AI) and its subfields, such as computer vision and machine learning, are revolutionizing multiple industries [1]. Many companies have integrated AI and machine learning platforms into their customer user face and employee workflow software. This trend calls for preparing the next generation of learners for this transformation, which requires innovation in the education sector, especially within the K-12 system [2]. ImageSTEAM, an NSF-funded initiative, was created in 2019 to bridge this gap by empowering middle school educators to integrate visual computing and AI technologies into their classrooms. The program provides professional development workshops for teachers and co-creates learning modules with researchers, fostering a learning environment where students engage with AI concepts through experiential activities. Specifically, these workshops explore fundamental concepts such as cameras, pixels, image processing, and computer vision. Student and teacher interactions with these workshops have been reported with success in a few publications [3],[4].

### *ImageSTEAM Create Your Create your 3d Eye*

As part of the ImageSTEAM initiative, the 2024 summer workshop developed a comprehensive lesson module titled “Create your 3D Eye” (CY3DE), where students and teachers could engage in hands-on activities using TinkerCAD and ChatGPT prompts to understand the structure and function of the different parts of the eye without the need laboratory dissecting equipment. Aligned with Next Generation Science Standards (NGSS) and the International Society for Technology in Education (ISTE) Standards, the lesson targets grades 6-8. Still, it can easily be implemented in a high school and collegiate science curriculum. TinkerCAD also has COPPA-certified ways for student engagement at various grade levels, including the middle school level [5]. The summative assessment for the students is to design and build their 3D model of an eye from scratch using TinkerCAD's tools. The module includes a detailed lesson plan, student handouts, general TinkerCAD basics for students, and a slide presentation, all with links to online resources.

TinkerCAD can be a cost-effective virtual lab experience that equips students to familiarize themselves with a 3D modeling platform. Similar to the lessons and experiences noted in [6], students in the software can create, manipulate, and dissect objects that model content in the curriculum without purchasing materials. Compared to a virtual lab dissection, dissection kits for eyeballs can be costly for a classroom. Recent searches revealed cow eyeball dissection kits can range from \$11-\$20 per student [7], [8]. Depending on the presence of previous dissecting tools, classroom size, and dissection type, costs can add up for a school. Considering that TinkerCAD is free, the lesson module can be a practical virtual lab for students to interact with a biology topic. Virtual labs have been studied to have valuable tools to help students engage in real-world examples at the collegiate, secondary, and primary school levels [9], [10]. Combining these two facets is the primary goal of the CY3DE lesson and the ImageSTEAM initiative: to broaden the development of 3D modeling experience for students early on while creating a cheap, interactive method to use visual technology.

## **Lesson module design and development**

### *Standards and Introduction*

The CY3DE lesson module is structured around three key objectives: Understanding the structure and function of the different parts of the eye, Enhancing skills in using digital tools for scientific learning, and Applying knowledge through a virtual lab simulation using TinkerCAD. Students simulate the scientific modeling and iteration process on TinkerCAD by labeling, reconstructing, and ultimately creating an eye model. These objectives are underpinned by ISTE’s Knowledge Constructor, Innovative Designer, and Creative Communicator standards, which emphasize digital resource curation, creative problem-solving, and effective digital communication. NGSS standards MS-LS1-3, MS-LS1-8, MS-ETS1-2, and MS-ETS1-4 apply to this lesson as students understand body systems, sensory receptor functions, and engineering design processes.

CY3DE is intended to be a 70 - 90 min lesson. The lesson structure follows the first PowerPoint presentation, Virtual lab using TinkerCAD, and students' exit tickets. All materials, presentations, student handouts, and links are provided in the lesson module and can be found on the ImageSTEAM resources page. Three differentiated levels within the lesson modules platform allow students of varying skill levels to engage meaningfully with the material and accommodate a variety of school settings.

### *Parts of the lesson module*

The first component of the lesson is a teacher-guided slideshow presentation covering each eye component's basic structure and function. This presentation is supported by visual aids and guided notes on the student handout about the eye's cornea, pupil, lens, retina, optic nerve, and iris. The presentation sets a baseline level of knowledge needed to complete the remaining portions of the lab. This baseline presentation can be differentiated depending on the academic level of the students and the specificity of a school's curriculum.

The following part of the lesson module, TinkerCAD Virtual Lab, initially requires teacher-led input depending on the student's background using TinkerCAD. The lesson module contains background information on TinkerCAD and provides first-time users access to links for navigating TinkerCAD. Due to the various digital literacy levels of the students and the curriculum backgrounds of multiple institutions, teachers can differentiate the virtual lab in the form of levels or progressively incorporate each level for the duration of the lesson. Create Your 3D Eye Level 1 (CY3DE.1) utilizes a premade 3D model of the eye on TinkerCAD. Students interact with the model by labeling each part, using the note feature of TinkerCAD to reinforce their understanding of basic eye anatomy [11]. For Level 2 (CY3DE.2), students use basic shapes in TinkerCAD to recreate eye components, label each part, and provide a description of its function [12]. Create 3D Eye Level 3 (CY3DE.3) advances students to design their 3D eye model from scratch, labeling each part and offering descriptions of the functions for each part. Across any level used, students can edit the eye components' shapes, textures, and colors. If 3D printers are available in the school, students can further their knowledge of 3D modeling in creating a physical product.

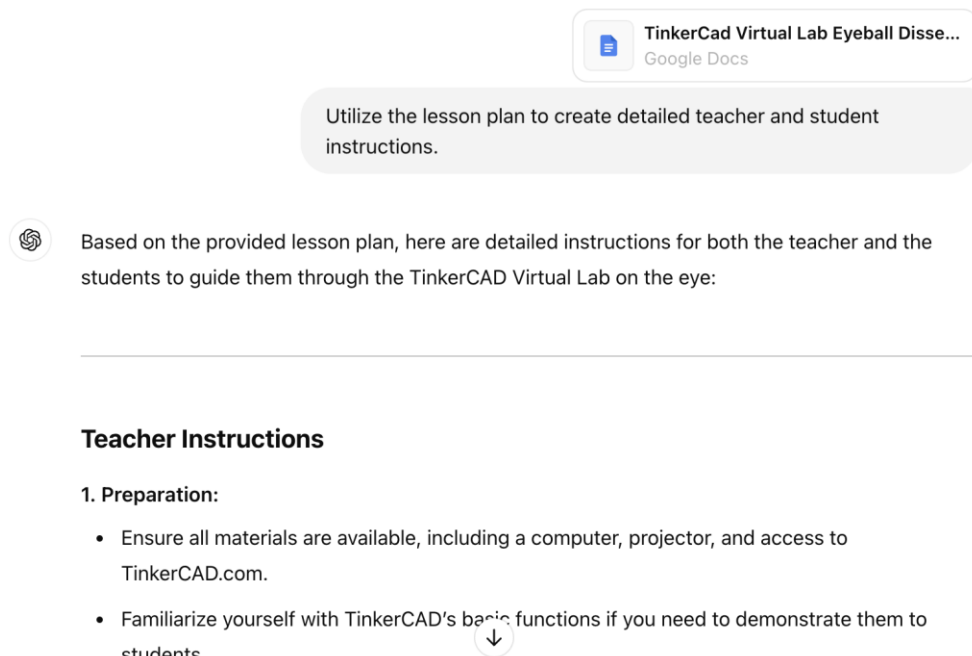
Foltynek et al. [13] express the need for an AI curriculum to have students understand the ethics of AI usage. The lesson concludes with a summative assessment to review the eye components, encouraging knowledge recall and engagement. Additionally, students complete an exit ticket activity, reflecting on TinkerCAD's potential applications in real-world scenarios, such as medical device development. This task encourages students to think critically about technology's role in biomedical engineering.

## **Resources**

### *ImageSTEAM and ChaptGPT*

ImageSTEAM program does not only promote student interaction and understanding of AI and visual technologies but also teacher engagement. For this workshop, teachers explored how to incorporate tools such as Chat-GPT, Co-Pilot School, Gemini, and Pixel Art into their lesson

planning. CY3DE lesson is a product of integrating educator ideas with Chat-GPT prompts to create a practical lesson. Chap-GPT prompt, as shown below in Figure 1 and Figure 2, was used to draft an outline of a lesson plan, student exit ticket, and assessment that was later refined with links and specific visual guides. The development of the CY3DE module was a collaborative effort aligning with ImageSTEAM's mission to integrate innovative technologies into middle school science education. Feedback from teachers involved in the ImageSTEAM maximized accessibility and engagement for diverse middle school classrooms.



**Figure 1** Screenshot of the Chat GPT prompt used to add teacher instructions for the lesson. [15]

create an exit ticket discussion for students comparing how we can use tinkercad in medicine make sure the prompt highlights the capabilities of using tinkercad to 3d print designs



#### Exit Ticket Discussion Prompt:

Title: "Exploring Tinkercad's Role in Medicine: Design and 3D Print Capabilities"

Prompt: Imagine you are a biomedical engineer tasked with creating innovative medical devices to improve patient care. Reflecting on today's lesson using Tinkercad to model the eye's structure:

1. **Compare and Contrast:** How can Tinkercad be utilized in the field of medicine compared to traditional design methods?
2. **Design Capabilities:** Discuss specific features of Tinkercad that enable you to create intricate medical device designs.
3. **3D Printing Advantages:** Explain the advantages of using Tinkercad's designs for 3D printing in medical applications.
4. **Real-world Impact:** Share potential real-world scenarios where Tinkercad's capabilities can revolutionize medical device development and patient treatment.

**Figure 2:** Screenshot of the Chat.GPT prompt used to add a student exit ticket for the lesson.

## Evaluation

### *Need for survey*

Considering the novelty of using TinkerCAD as a virtual lab, evaluating lesson effectiveness in many aspects is paramount. Evaluation of the lesson can be separated into two groups: student-focused and teacher-focused. Student-focused feedback is a powerful tool for lesson improvement and engagement. Equally important, teacher-focused evaluation of a lesson extends lesson improvement at a technical level and allows teachers to make the lesson more available for their students' needs. One teacher has conducted the CY3DE lesson to date with 39 students.

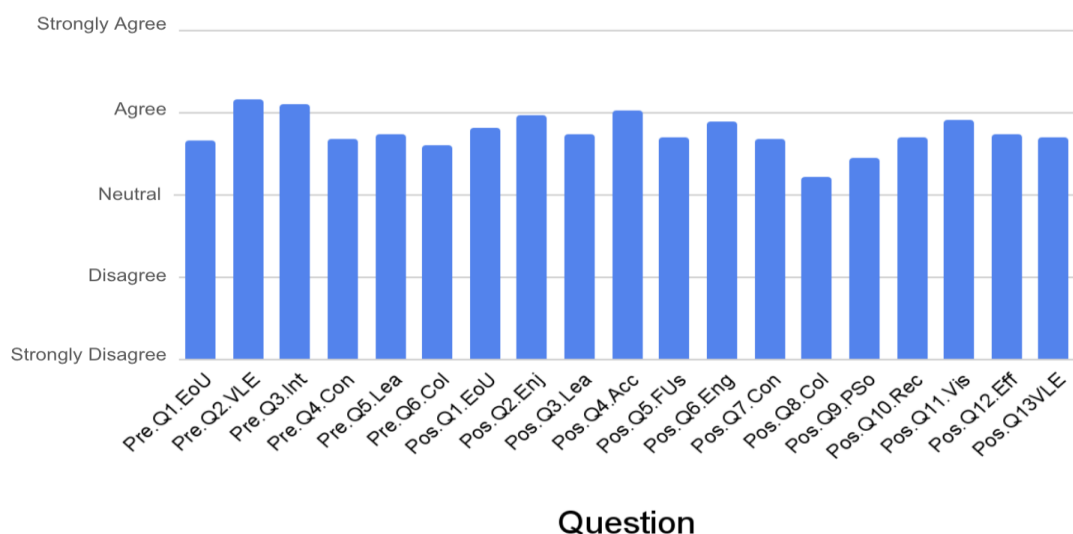
### *Survey in Lesson*

Pre-lesson and post-lesson surveys in the CY3DE module collected unbiased student feedback on using TinkerCAD as a virtual lab. Using a Likert scale rating system, the pre-lesson survey asked students to predict their interactions with TinkerCAD as a virtual lab. "1-Strongly Disagree" with the statement and "5-Strongly Agree" with the statement. The pre-lesson survey included the following questions: Ease of Use: "I believe using 3D Modeling tools will be easy and straightforward." (Pre.Q1.EoU) Virtual Lab Effectiveness: "I think using 3D modeling software can be an effective tool for learning about biological body systems." (Pre.Q2.VLE) Interest: "I am interested in using 3D Modeling tools for my project." (Pre.Q3.Int) Confidence: "I feel confident in my ability to learn and use 3D Modeling tools." (Pre.Q4.Con) Learning: "I believe 3D Modeling tools will help me understand the project topic better." (Pre.Q5.Lea) Collaboration: "I think 3D Modeling tools will make it easier to work with my classmates." (Pre.Q6.Col)

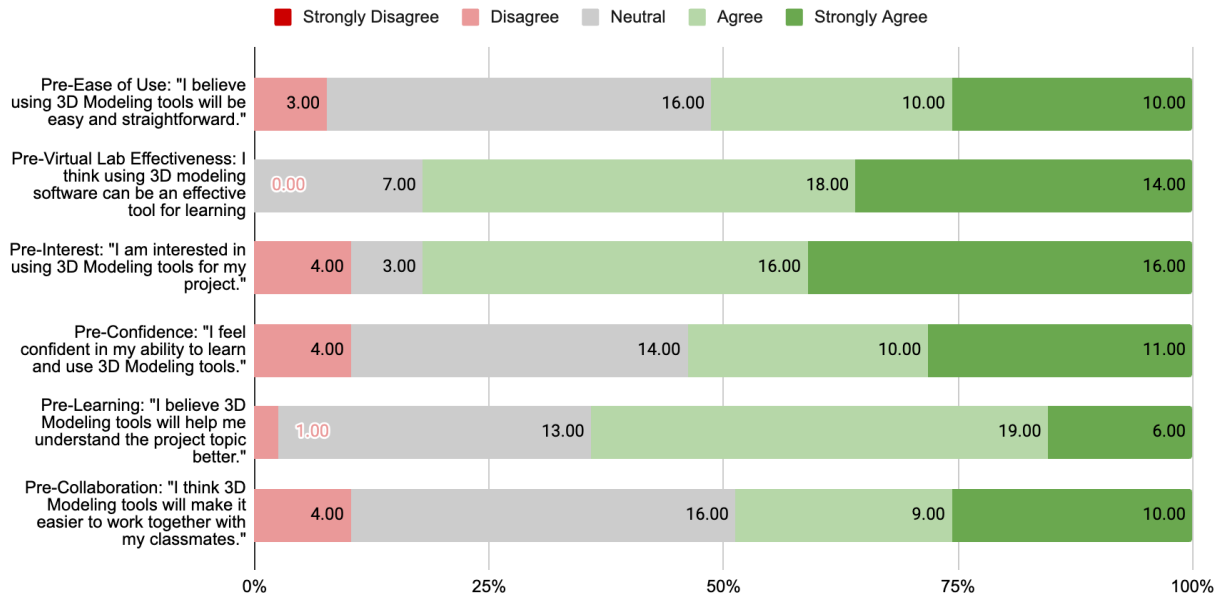
Post-lesson survey questions posed to the students served to help them reflect on the concept of using TinkerCAD as a virtual lab on the Likert Scale Rating system. “1-Strongly Disagree” with the statement and “5-Strongly Agree” with the statement. The post-lesson survey included the following questions: Ease of Use: "Using the 3D Modeling tool was easy and straightforward." (Pos.Q1.EoU) Enjoyment: "I enjoyed using the 3D Modeling tool for my project." (Pos.Q2.Enj) Learning: "The 3D Modeling tool helped me understand the project topic better." (Pos.Q3.Lea) Accuracy: "The 3D Modeling tool provided accurate results for my project." (Pos.Q4.Acc) Future Use: "I would like to use 3D Modeling tools for other science projects in the future." (Pos.Q5.FUs) Engagement: "Using the 3D Modeling tool made the project more engaging and interesting." (Pos.Q6.Eng) Confidence: "I feel more confident in my ability to use 3D Modeling tools after this project." (Pos.Q7.Con) Collaboration: "The 3D Modeling tool made working with my classmates easier." (Pos.Q8.Col) Problem-Solving: "Using the 3D Modeling tool improved my problem-solving skills." (Pos.Q9.PSo) Recommendation: "I would recommend using 3D Modeling tools to other students for their projects." (Pos.Q10.Rec) Visualization: "TinkerCAD helped me visualize 3D concepts better than traditional 2D drawings." (Pos.Q11.Vis) Effectiveness: "I found TinkerCAD to be an effective tool for practicing 3D design skills." (Pos.Q12.Eff) Virtual Lab Effectiveness: "I found TinkerCAD to be an effective tool for learning about the body system." (Pos.Q13.VLE). Pos.Q1.EoU, Pos.Q3.Lea, Pos.Q7.Con, Pos.Q8.Col, Pos.Q13.VLE has a pattern designed for the pre-lesson questions to minimize individual variance. Lastly, students were asked to reflect on their experiences using TinkerCAD in written responses: “2-3 sentences: In what ways did TinkerCAD help you as a virtual lab for 3D design?”

## Assessment

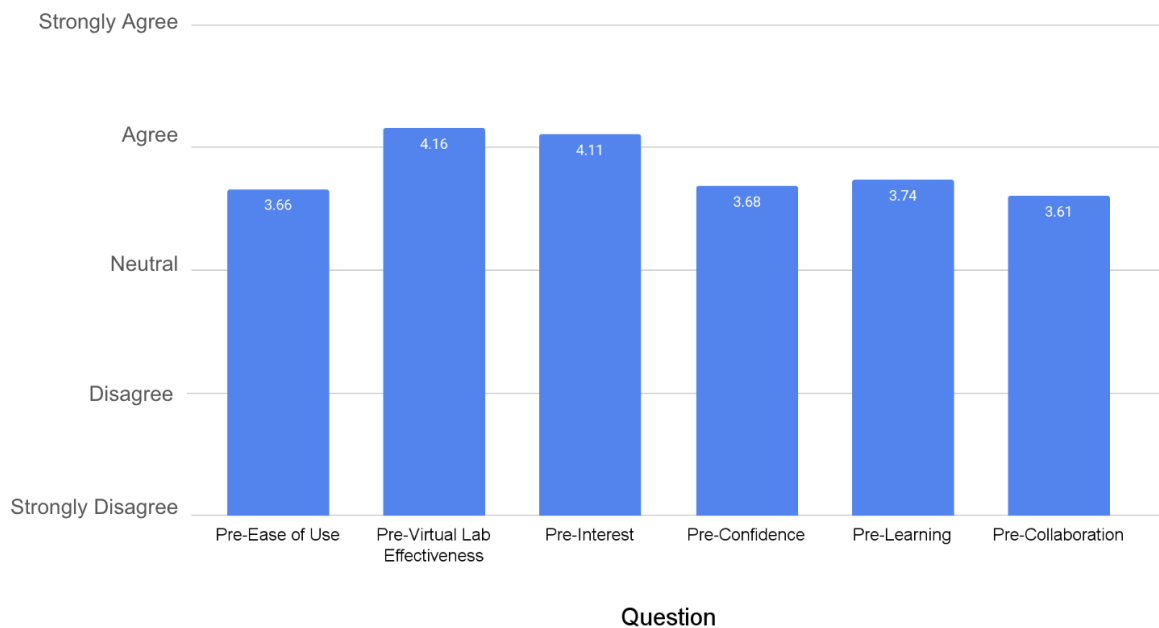
### Survey Results



**Figure 3:** Averages of the survey results from the pre-and post-lesson questionnaires. Question responses based on the Likert Scale 1-5. “1-Strongly Disagree” with the statement and “5-Strongly Agree” with the statement. The participants were 39 students.



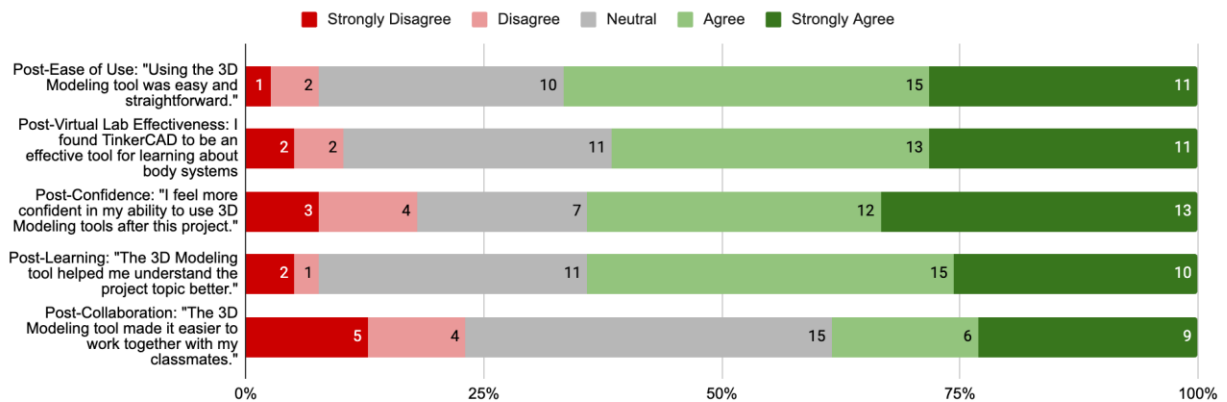
**Figure 4:** Totals of the survey results from the questionnaire, pre-lesson used in the Mann-Whitney U test. Question responses based on the Likert Scale 1-5. “1-Strongly Disagree” with the statement and “5-Strongly Agree” with the statement. The participants were 39 students.



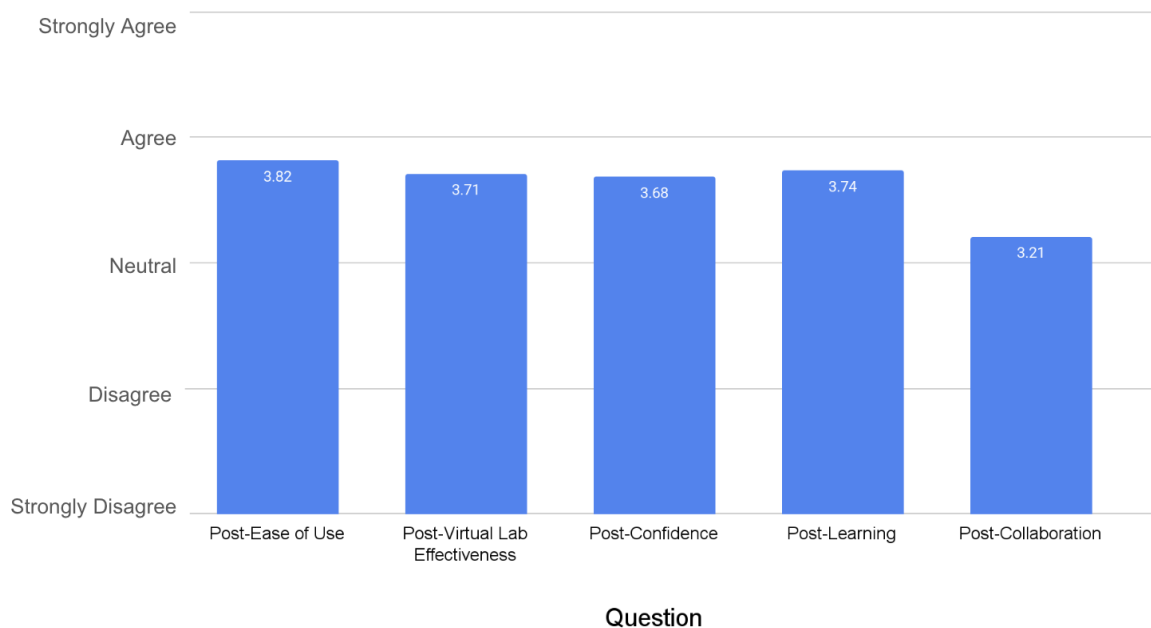
**Figure 5:** Averages of the survey results from the questionnaire, pre-lesson used in the Mann-Whitney U test. Question responses based on the Likert Scale 1-5. “1-Strongly Disagree” with the statement and “5-Strongly Agree” with the statement. The participants were 39 students.



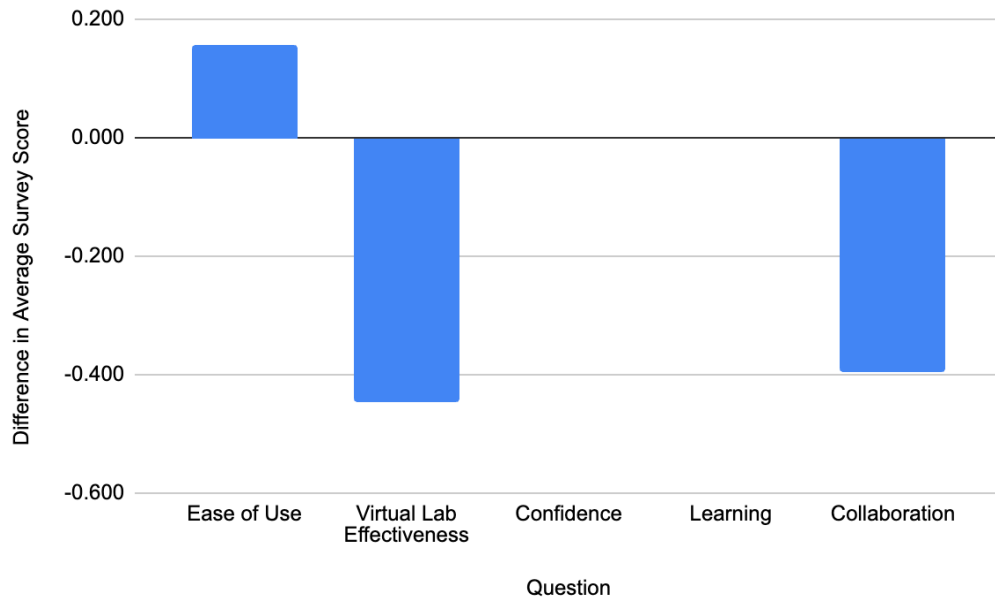
### Strongly Disagree, Disagree, Neutral, Agree and Strongly Agree



**Figure 6:** Totals of the survey results from the questionnaire, post-lesson used in the Mann-Whitney U test. Question responses based on the Likert Scale 1-5. "1-Strongly Disagree" with the statement and "5-Strongly Agree" with the statement. The participants were 39 students.



**Figure 7:** Averages of the survey results from the questionnaire, post-lesson used in the Mann-Whitney U test. Question responses based on the Likert Scale 1-5. "1-Strongly Disagree" with the statement and "5-Strongly Agree" with the statement. The participants were 39 students.



**Figure 8:** Differences in averages of the survey results from a questionnaire used in the Mann-Whitney U test.

#### *Analysis of results*

The data indicates that students entered the lesson with generally neutral or positive expectations and experiences with TinkerCAD. Average ratings across all pre- and post-survey questions were no lower than three on the Likert scale, suggesting a baseline level of interest or openness to using TinkerCAD as a virtual lab (see Figure 3). Notably, there was a high average interest in using TinkerCAD for 3D modeling, solid engagement, and enhanced visualization of 3D concepts (Figure 5). In terms of specific post-lesson survey items, students ranked enjoyment (Pos.Q2.Enj) the highest (Figure 7), highlighting a positive response to TinkerCAD as an interactive tool. Students had an aptitude for using TinkerCAD in this manner before or after the lesson.

Results remained consistent when comparing matched pre- and post-lesson questions, including Ease of Use, Virtual Lab Effectiveness, Confidence, Learning, and Collaboration. Ease of Use was the only area showing a positive post-lesson rating increase (see Figure 8). Ease of Use, Virtual Lab Effectiveness, Confidence, Learning, and Collaboration were survey questions used in pre- and post-lesson questions. As shown in Figure 8, among those questions, Ease of Use was the only question that yielded a net positive difference in the averages from post-lesson to pre-lesson. Virtual-Lab Effectiveness and Collaboration had a negative difference. These findings reflect a positive reception toward TinkerCAD's usability but suggest limitations in its effectiveness as a collaborative tool.

We performed a Mann-Whitney U test to assess the significance of differences between pre-and post-lesson scores for paired questions (Pre.Q1.EoU and Pos.Q1.EoU; Pre.Q5.Lea and Pos.Q3.Lea; Pre.Q4.Con and Pos.Q7.Con; Pre.Q6.Col and Pos.Q8.Col; Pre.Q2.VLE and

Pos.Q13.VLE). Results indicated no statistically significant changes in scores (two-tailed,  $p < 0.05$ ), suggesting TinkerCAD did not significantly alter students' perceptions in these areas. Although it might not seem like using TinkerCAD changed students' perception of a concept in a positive light, qualitative feedback reveals additional positive impacts. Many students commented on TinkerCAD's benefits, such as, "Tinkercad helped me with my project in multiple ways. It helped me with labeling and figuring out what stage is what and", "TinkerCAD helped me by showing me in a 3d form. It helped make it easier to understand. I recommend Tinkercad for other students.", or "It helped me see the process better. It also helped me understand it more." cement the overall positive results seen in figure 3 and figure 5. However, since students reported a neutral baseline (3 on the Likert scale) before the lesson, we can expect minimal differences in average scores post-lesson. The reduced effectiveness of the virtual lab and lower collaboration likely stem from students' overall engagement with the TinkerCAD platform. In written responses to the question in what ways did TinkerCAD help you as a virtual lab for 3D design?" students commented that the program was "frustrating" or "it did not; it was difficult and confusing from all the buttons." Using TinkerCAD in this manner highlights the need for more testing due to a small sample pool of  $n=39$  students.

## **Concluding remarks**

### *TinkerCAD Pros vs. Cons*

Virtual labs are helpful in the education sector due to their positive impact on student engagement with content in a curriculum [6], [10]. Without the constraints of physical resources, virtual labs offer a flexible approach to experiential learning [9], [14]. The CY3DE lesson on TinkerCAD aligns with this trend, bridging the gap between concept learning and hands-on application. Using TinkerCAD also introduces students to a standard modeling interface widely used by engineers. While TinkerCAD effectively supports the understanding of scientific concepts and 3D modeling skills, it does have some limitations. Lack of simulation for movable objects can restrict specific interactive learning experiences, especially in concepts of fluid dynamics. With various student backgrounds nationwide, teachers might have challenges in helping students navigate TinkerCAD's interface for the first time. However, Pejcinovic and Holtzman note that the difficulties of understanding TinkerCADinter for students outweigh the benefits as a visual aid for students in engineering concepts [6].

### *TinkerCAD and Workforce*

The ongoing implementation of TinkerCAD as a virtual lab by administrators and educators will be essential to gather further student and teacher input. Due to the small impartial sample pool for teacher input on the lesson, more data from the teacher survey is necessary to gain more robust insights. Constant feedback can help refine TinkerCAD's role in education. Incorporating virtual labs and modeling software into educational frameworks will further enhance student engagement and proficiency in digital skills, laying a stronger foundation for future STEM learning and careers.

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