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Attitudes Toward and Usage of Animations in an Interactive Textbook for Material and Energy Balances

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Abstract

The concept of active learning or "learning by doing" is applied through animations within an interactive textbook. A Material and Energy Balance (MEB) course for undergraduate chemical engineering students has generated large data sets by using an interactive textbook from zyBooks. MEB is a foundational course that includes new terminology, the basic principles of mass and energy conservation, and tools for problem solving. Here, outside of class engagement was measured using student views of multi-step animations that introduce course concepts in small chunks. Students' usage of the interactive textbook has been logged for several years, and median reading participation was measured as high as 99%. Within the reading participation data are the clicks to start, complete, and re-watch over 100 animations, which has not been explored in detail. The research questions are specifically related to animations. First, do students view all steps in animations and what is the rate of re-watch? Next, do certain animations gather significant re-watch views across five cohorts? Also, what is students' understanding of and attitude about using animations in their engineering education? We are administering pre- and post-surveys to understand students' interest in chemical engineering as well as animation use. This paper is a work in progress.

Introduction

Interactive textbooks can improve student learning through active learning or "learning by doing" [1-4]. The influence and familiarity of electronic devices among the "digital native" student population makes interactive learning an appealing platform for higher education students [5]. One challenge is configuring educational material, such as textbooks, learning exercises, and homework into a format that applies technological tools in a familiar and engaging way that benefits learning [5].

Animation advancements with digital technology bring imagination to life through games, videos, and movies with computer-generated action that holds user attention. Animation is more than entertainment, and familiarity with animation lends itself to engaging students in the learning environment. Animations in engineering education may involve the physical world, deriving equations, conceptual representations, figures, or spreadsheet principles. Educational animations should match new content with the cognitive processes to be meaningful [2, 6]. Matching cogitative processes to animation content will be an area for future research. In this paper, animations in an interactive textbook are configured as a progressive sequence of images that change the text, figures, or diagrams when initiated by student clicks. Usage and student attitudes about animation will be explored through research questions, which are presented next.

Research Questions

Student usage quantifies animation usage through clicks over five cohorts between 2016 and 2020. This assessment evaluates two research questions. First, do students view all 100+ animations in the interactive textbook? Second, what percentage of students re-watch interactive textbook animations?

Student attitudes about animation in engineering education applies a validated tool, the Colorado Learning Attitudes about Science Survey (CLASS), as well as a set of additional animation-themed questions. This evaluation addresses two research questions. First, what are students' understanding and attitudes about animations in engineering education? Second, what are students' attitude and interest about engineering studies?

Materials and Methods

A chemical engineering course, primarily taught to freshman students majoring in chemical or environmental engineering, used the Material and Energy Balance (MEB) zyBook textbook. The interactive textbook generates big data through different ways. First, reading participation includes the animations of interest as well as interactive question sets. In addition, challenge activities are auto-graded homework with scaffolded questions across multiple levels. The animations are dynamic visuals with student-initiated steps using clicks to advance through the animation. This multi-step approach divides the new content into small chunks of information that engage the student and require attentiveness and interaction [7, 8]. Each click is recorded and analyzed. Enrollment ranged from 89 to 104 students per semester between 2016 and 2020 at a public university. This paper briefly aggregates student animation watch and re-watch data. The animations are spread across almost every section and chapter (Table 1).

Table 1. MEB zyBook Chapter titles and animation count by year.

		Number of Animations per Chapter by Year					
Chapter	Chapter Title	2016	2017	2018	2019	2020	2021
1	Quantities, Units, Calculations	9	9	9	9	9	10
2	Material Balances	19	19	19	19	19	19
3	Reacting Systems	11	13	13	13	13	13
4	Solids, Liquids, and Gases	9	10	11	11	14	14
5	Multiphase Systems	8	13	13	13	15	15
6	Energy Balances	8	8	15	15	15	15
7	Reaction and Energy Balances	5	5	7	7	7	7
8	Transient Systems	3	3	4	4	4	4
9	Spreadsheets	0	0	41	41	47	47
All	Total Animations	72	80	132	132	143	144

As part of assigned reading of the interactive textbook, the students' clicks are uniquely recorded including the individual sequenced steps of the animation (Figure 1). The initial static image of the animation includes a "start" button (not shown) and once initiated, the animation "builds" a balanced chemical reaction in Step 1. The arrow to the right of the step numbers appears when the step is complete. Clicking the arrow continues the animation and builds on the previous steps to completion. The final step completes construction of the initial static image and a completed view is recorded. Re-watch may be initiated at any time. Data collection across cohorts was compiled and used for answering the research questions. Chapter reading assignments included viewing animations, and the % views are calculated by dividing total completed views by the total number of students. [9]

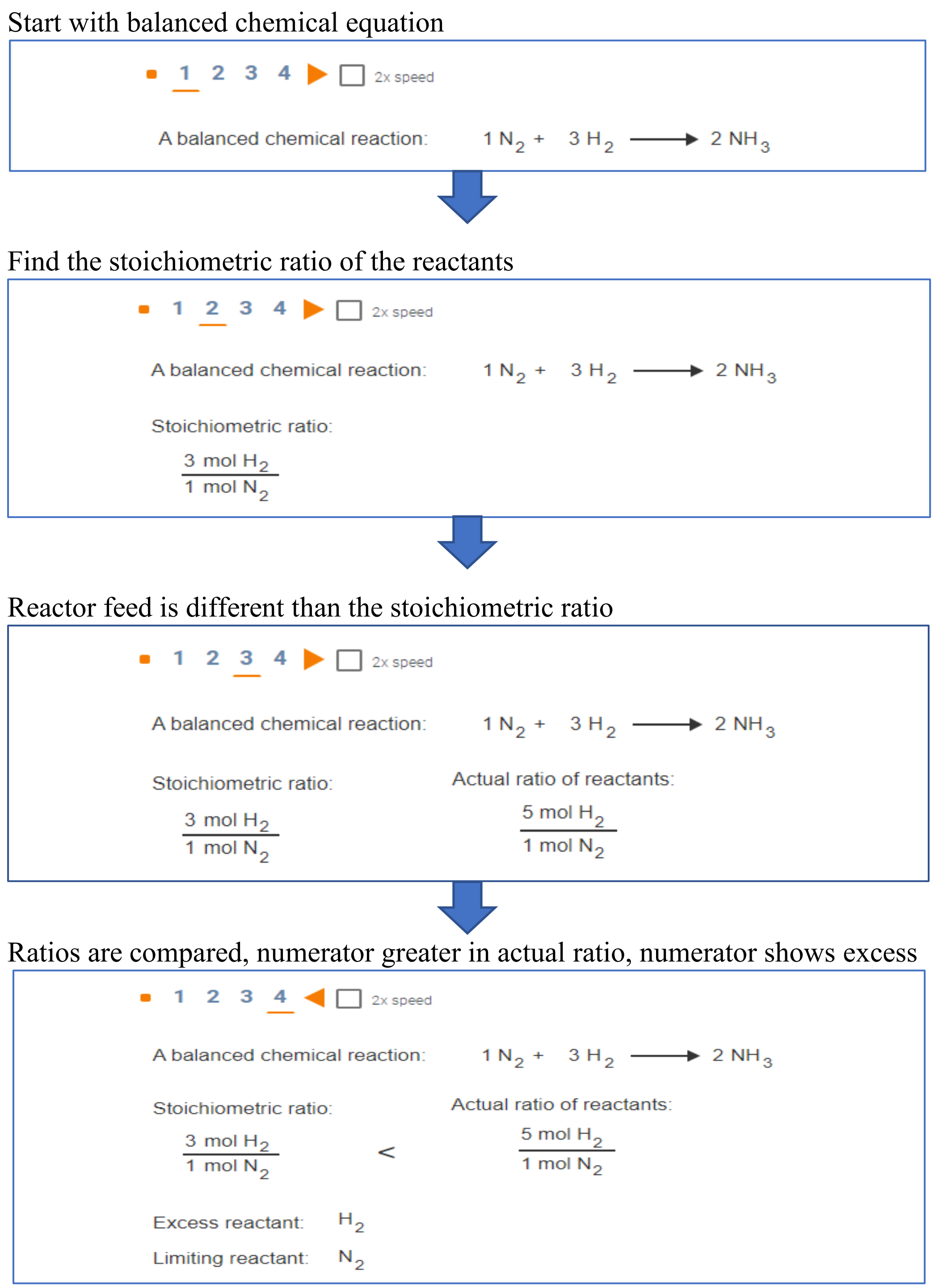

Figure 1. An example of an MEB zyBook interactive animation for finding excess and limiting reactants.

The click data was partitioned by chapter and animation using Pivot Tables in Microsoft Excel. Only complete animation views were analyzed, i.e., a student clicking through only 3 of 5 steps in an animation is not counted as an animation view.

The Colorado Learning Attitudes about Science Survey (CLASS) was originally used to assess student attitudes about physics. Over time, CLASS has been modified and used to assess other science courses including chemistry, biology, astronomy, and math [7]. One recent paper used the CLASS for chemical engineering [10], which will be expanded upon here. The original survey used a five-point Likert scale (strongly agree, agree, neutral, disagree to strongly disagree), with 42 questions. The Likert scale was modified to eliminate the neutral response for this assessment similar to other previous work [10, 11].

In addition to the 42 core CLASS questions, 9 additional questions focus on attitudes about animations. Table 2 identifies these animation-specific questions. In this way, the original CLASS questions were retained and separated from the additional animation attitude questions. The survey was administered through Microsoft Forms within the first 2 weeks of the spring 2021 semester. The class was being offered only through remote delivery. The same survey will be re-distributed during the final 2 weeks of the semester.

Table 2 – Additional survey questions about animations

Question Statement
I am familiar with watching animation in movies (e.g., Disney, Pixar)
I am familiar with using or watching animation in slide presentations (e.g., PowerPoint, Google Slides)
I am familiar with using or watching animations in my university classes.
In engineering studies, it is helpful to know Adobe Suite (i.e., Adobe Flash, Adobe Photoshop)
Animation is a helpful medium to learn engineering concepts.
Animation is a helpful medium to learn non-technical concepts (e.g., English, business, humanities)
In your university courses, animation helps my learning more than reading static text (e.g., standard textbook reading)
In your university courses, animation helps my learning more than using static figures (e.g., textbook graphs and tables)
In your university courses, animation helps my learning more than video recordings (e.g., pre-recorded lectures)

The survey is designed to be completed in about 10 minutes, with voluntary participation, freedom to choose not to answer any questions, end participation at any time, and assurance that the names of participants were not collected. The analysis of the CLASS data is in progress at this time. The approach will compile the responses according to the specific categories of student attitudes defined in the original CLASS questions and compare these to the Expert Responses as a benchmark [11].

Results and Discussion

Animation views were compiled across 5 cohorts as a function of chapter (Figure 2) in order to address several research questions. These research questions build upon reading participation rates of over 90% reported previously [9]. The first research question was: Do students view all animations in the interactive textbook? Students watched 100% or more of the animations in all years and for almost every chapter.

The second research question was: What percentage of students' re-watch animations in the interactive textbook? Student views above 100% in Figure 2 indicated that some students re-watched the animations, but a decline in re-watching was observed for later chapters. One possible explanation may be attributed to students having a greater workload as the semester progresses and fewer opportunities to re-watch the animations. No additional points were awarded toward the course grade for animation re-watches. Thus, self-motivation to more deeply learning new concepts presented in the animations may provide one rationalization for the large numbers of re-watched animations.

The high percentage re-watch in Chapters 1, 2 and 3 during the first year the interactive textbook was available quantifies the novelty in chemical engineering education. The slightly higher re-watch rates of 9 to 17% in Chapters 1 to 5 compared to the 1% to 12% re-watch in chapters 6 to 8. Chapters 6 and 7 are energy balance sections that come relatively late in the semester, which allows fewer weeks to re-watch animations. In addition, Chapter 8 material on transient systems, was not covered on the Final exam which likely explains the low re-watch rate. Chapter 9 covering spreadsheets was assigned at several points throughout the semester.

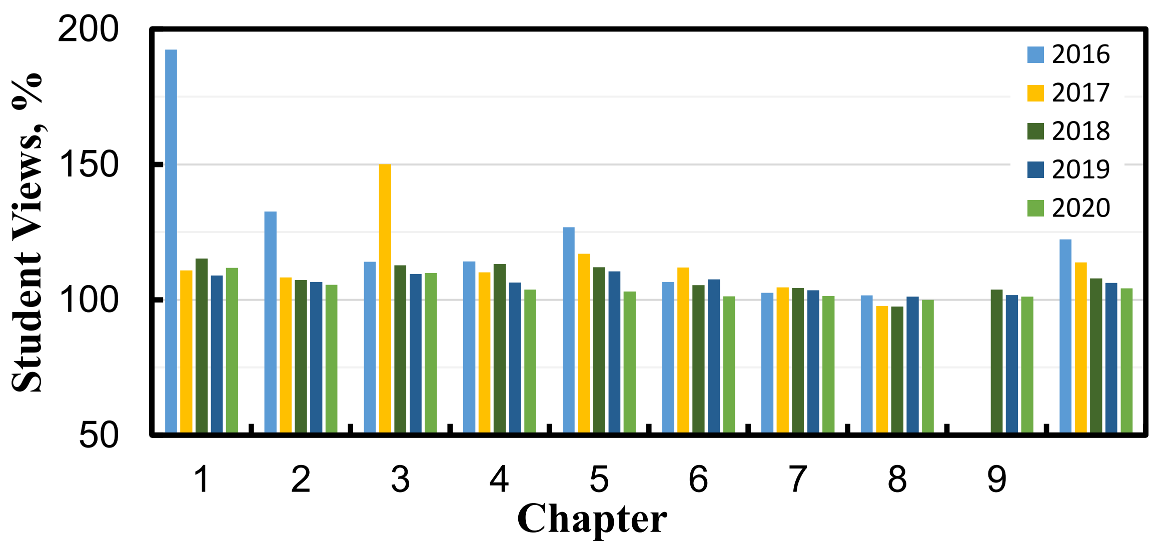

Figure 2: Animation views by chapter for five cohorts. Chapter 9 was new in 2018

For the CLASS survey, 57 of 78 students participated in the pre phase, and analysis has not started.

Conclusions

A comprehensive data set of animation views is being analyzed to answer the research questions. The preliminary findings are that students do view nearly all animations in the interactive textbook. Chapter-by-chapter views were at or above 100% views across all five cohorts. The high views and engagement may be due to students earning a grade for completion. Also, students do re-watch animations in the interactive textbook indicating interest and motivation. The analysis of the survey data related to attitudes will be evaluated in the future.

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Disclaimer

One of the authors may receive royalties from sales of the zyBook detailed in this paper.

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