Evaluating the perceived outcomes and understanding the needs of engineering and computing students in connection to the use of multi-modal mathematical lecture content

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Abstract

The accessibility of digital course content is vital for the learning experience and success of students, especially for students with disabilities (SWD). Approaches for ensuring accessibility have been adapted and implemented in higher education. For example, the Universal Design for Learning (UDL) framework provides guidelines to align instructional design with multiple means of engagement, representation, and action and expression. Also, the Americans With Disabilities Act (ADA) standards contain guidelines on the accessibility of web content (WCAG), using four key metrics: perceivable, operable, usable, and robust (POUR).

One of the primary features of digital instruction is lecture content, which is often delivered through slides. Although previous research has evaluated the usage of several UDL approaches in courses, it is still unclear about the needs and perspectives of students when it comes to lecture slides, including details such as format, usage, style, content structure, and handwritten vs. typed content. Previous UDL research demonstrated that providing accompanying digital notes containing lecture content and transcriptions improved levels of perceived learning, self-efficacy, and belongingness for students with accessibility needs. Further survey-based UDL research showed the perspectives and needs of students in making mathematical content more accessible, including preferences for LaTeX-formatted math. In addition, previous UDL research explored open source computer vision models to perform processing tasks such as detecting and transcribing math content from slides in STEM courses. Drawing from this research, we take a UDL-based approach to providing an additional resource to lecture slides.

Our goal is to evaluate possible changes in perceived accessibility and learning outcomes before and after the usage of an additional UDL-based resource. This resource serves as an extension to lecture slides, by using an open source model to detect and convert math content into its formatted LaTeX representation, which is then provided to students. Our research questions are designed to evaluate the changes in student outcomes (POUR metrics, self-efficacy, belongingness) in connection with this additional resource, how students use and interact with lecture slides, and insights into future design or implementation features for existing digital tools. Furthermore, we aim to understand student perspectives and needs in the conversion of handwritten content.

We surveyed and received 236 engineering student responses across 3 courses at the University of Illinois Urbana-Champaign in two surveys before and after providing the extra UDL lecture contents. The first survey evaluates the perceived accessibility of lecture slides using POUR

metrics and metrics for belongingness and self-efficacy, and investigates student perspectives on the usage and format of lecture slides, especially their needs in the conversion of handwritten content. Also, the survey asks for students' demographics and lets students with mental, physical, and/or emotional disabilities to self report as SWD. Additionally, we identify students with accessibility needs (SWAN) as those who reported having conditions that prevented them from attending instruction without having an officially recognized disability by the university. The second survey was conducted to record the changes in the aforementioned metrics after providing the extra UDL lecture resource, as well as gather quantitative and qualitative feedback.

Post survey statistical analysis was conducted on student responses to measure changes in perceived accessibility (POUR), self efficacy, and belongingness. We also analyzed student responses regarding lecture slides, needs for conversion of handwritten content, and interest in additional features to improve lecture accessibility. Additionally, we evaluated if there are any similarities or differences in responses across different demographic groups.

We find that after using the additional UDL lecture resource, students overall experienced a statistically significant positive increase in robustness and self-efficacy. We identified mostly consistent patterns in how students engage with lecture slides, with the top two use cases for slides being exam preparation and homework/problem solving. Also, we identified important needs for the formatting of handwritten content, such as math content, in alternative formats. Finally, there was an overall need to make handwritten content more accessible and to create additional accessibility-related features in the future.

Introduction

Math is essential to STEM engineering education and beyond that one author makes the case it is essential for human flourishing [1]. However, it's challenging to make math contents accessible. For example, previously research found it's very difficult to transcribe math-rich STEM lecture slides containing a mix of equations, tables, figures, and handwriting [2]. In addition, through our prior work, we identified the preferences of college students in math delivery and found they appreciated the LaTeX format of math equations [3].

In this work, we created a resource that extended lecture slides by providing the LaTeX representations and code for math content. We applied the extended lecture slides (often including handwritten contents) in three large math-rich engineering and STEM courses to investigate whether such intervention would affect student learning outcomes. We adapted prior UDL work to measure students' perceived accessibility and social learning metrics such as self-efficacy and belongingness [4]. In our surveys, we included self-reported demographic information such as gender, ethnicity, disability status, so we can compare their outcomes across different student groups. In our research, we further gained insights as to students' perspectives on how the math-rich STEM lecture slides can be most useful for their learning.

Background

Universal Design for Learning (UDL)

Universal Design for Learning is an instructional framework designed to enhance the educational experience for students along different modes of learning [5]. UDL guidelines are built upon 3 foundational principles (multiple means of engagement, multiple means of representation, and multiple means of action and expression), which emphasize a flexible and inclusive approach to instruction to ensure that the needs of all students are accommodated. First, supporting multiple means of engagement involves providing instruction that supports the different interests and points of motivation for students when it comes to learning. Second, supporting multiple means of representation allows students to interact with instructional content in multiple formats (text, audio, visuals, etc) to best fit their learning styles. Finally, supporting multiple means of action and expression (alternative exam formats, flexible assignment deadlines, etc.) gives students the ability to demonstrate and express their academic progress [6]. Together, these 3 core UDL principles seek to foster instructional environments that allow all students, including students with disabilities, to succeed in their learning experiences. Research has shown that there is strong alignment between students' perspectives on learning and UDL principles, as well as UDL's potential to improve learning for all students [7].

Accessibility of Digital Content

In the context of American higher education, the Americans with Disability Act (ADA, 1990) and Section 504 of the Rehabilitation Act define the accessibility requirements for university education. The federal government utilizes the Web Content Accessibility Guidelines (WCAG), which are produced by the World Wide Web Consortium, as the basis for ensuring the accessibility of digital content. These guidelines can be grouped into 4 main components (POUR).

1. Perceivable - The presentation of digital content should be perceivable to users
2. Operable - Users should be able to use and navigate digital content
3. Understandable - Users should be able to understand the user interface and information of digital content
4. Robust - Digital content should be able to be processed by a range of technologies, such as assistive technologies

These principles emphasize the importance of multimodal accessibility, in order to align with the broad range of modalities with which users access digital content. In the context of education, this involves providing instructional content that allows all learners to learn the material (ex. Lecture videos have accompanying captions).

Self-efficacy and belongingness

In addition to accessibility, strengthening self-efficacy and belongingness is also crucial with regards to learning experiences. Self-efficacy can be defined as an individual's belief in their ability to perform the actions needed to achieve certain goals [8]. Also, belongingness for students can be defined by their feelings of support, connectedness, being respected, being accepted, and being cared for in their academic community [9]. Together, these two concepts have been connected to benefits in overall learning. For instance, academic self-efficacy has been shown to be a strong predictor to academic performance [10], while increasing levels of belongingness also leads to positive outcomes in wellbeing, engagement, and achievement [9]. Additionally, self-efficacy and belongingness can each predict STEM students' perspectives of active learning and their courses [11]. In the context of this study, we examined how a UDL-based approach to extending digital course materials could change students' perceived levels of academic self efficacy and belongingness.

UDL Applications to Digital Content

As digital learning continues to grow in higher education, there is a corresponding need for instructors to focus on developing and strengthening the accessibility of digital instruction. Particularly, online learning management systems (LMS) that accompany courses have become a prevalent resource for students. A study on the learning habits of undergraduate STEM students showed that the LMS or course website was the predominant digital tool that students used [12], and UDL research highlighted the need for continued iteration and improvement of LMS, especially for SWD [13].

Also, previous UDL research analyzed the outcomes after providing students with digital notes, which contained lecture content and transcriptions. With this additional format of instruction, self-efficacy, belongingness, and perceived learning increased for students with accessibility needs (SWAN) [14]. Drawing from this, expanding the options for which students can interact with their instructional materials, which can be facilitated on platforms such as LMS, can be an exciting and valuable objective in higher education. Furthermore, within STEM fields in higher education, there is still a need for more UDL research [15].

Lecture slides, a tool that is widely used by both SWD and SWOD in engineering courses [16], provide a compelling opportunity to apply UDL practices. Mathematical instruction can consist of complex notation, symbols, and visuals (graphs, diagrams, tables, etc.). This can cause difficulties for students with accessibility needs, like those who are visually impaired, which emphasizes the need for alternative applications and techniques in mathematical instruction [17]. When considering lecture slides, this is further highlighted by the often dense, complex, and multimodal content. Additionally, instructors frequently annotate these slides with handwriting either during or after class. However, there has been limited research on how handwritten content in STEM courses impacts accessibility or learning outcomes.

Extending Lecture Slides and Evaluating Students' Needs and Perspectives

As mentioned previously, UDL research has demonstrated the challenges in processing multimodal math content, as well as analyzed the needs and perspectives of students to make math more accessible (ex. Preference of LaTeX formatting)[2, 3]. For this study, we look to continue and merge the directions of these works. We explored a new computer vision approach to transcribe math content. From this, we created an accompanying resource to lecture slides, and evaluated its subsequent effects on accessibility and learning outcomes through a two phase survey design. Also, we added questions to the surveys to similarly evaluate the needs and perspectives of students, but within the scope of lecture slides and handwritten content in particular.

Methods

MinerU

When processing and converting academic materials, such as digital lecture slides, there exists a wide range of open source models that perform tasks like layout detection and formula recognition and transcription. A previous UDL research study [2] conducted a comprehensive evaluation of several of these models, finding that while specific models perform well on specialized, individual tasks, there was a lack of open source models that could effectively synthesize these actions into a streamlined process. Since then however, the rapid movement in the world of computer vision and document processing has seen the emergence of new and improved models that could address this gap.

MinerU 2.5 is a open source, vision language model (VLM), that implements a two stage process in order to convert documents (ex. Scientific documents with dense, complex layouts and notation) into Markdown, a markup language used to format content. Using a decoupled approach, the model first conducts a layout analysis on a downsampled input in order to locate and classify important regions (ex. Text, images, formulas). In the second stage, the model performs recognition tasks on these localized areas in their native resolution versions in order to accurately transcribe content, such as converting mathematical content into LaTeX. As a result, MinerU 2.5 achieves state of the art performance on document parsing tasks, including layout analysis, table recognition, and formula recognition [18].

Creating Extended Lecture Materials

In order to evaluate the learning outcomes from the additional UDL-based resource, namely, LaTeX-coded equations, we collected seven representative lecture slides from each of the 3 participating STEM courses at the University of Illinois Urbana-Champaign. The courses include two computer science (CS) classes and an electrical and computer engineering (ECE) course. We then created an accompanying version that provided the mathematical content on the slides in their LaTeX formatted representations. As a result, students could view the mathematical equations and expressions separately as an additional visual resource. With many of the original slides containing both typed and handwritten math that are often dense and unstructured, this extended set of lecture materials aimed to enhance instructional clarity and content readability. We utilized the MinerU 2.5 as the tool to produce the extended versions of our collection of STEM lecture slides. Our workflow for preparing these materials consisted of 3 main steps.

1. The original PDF files for a given lecture were inputted into the MinerU 2.5 VLM, which generates a Markdown file as well as an intermediate file containing the parsed content as well as their respective categories and bounding box coordinates. These bounding boxes are color coded by category (ex. Light green - math, red - text, yellow green - image, dark green - list). As our materials focused mainly on the converted versions of typed and handwritten math, we extracted these sections from the intermediate outputs. This provides us with the LaTeX representations of mathematical content for each lecture in our dataset.

2. The LaTeX code was then visually inspected, reviewed, and validated by several authors, including students and the instructors of these courses, in order to ensure a consensus level of accuracy. Any errors in the original LaTeX output of MinerU 2.5 were manually identified and corrected before the next stage.

3. An accompanying section for each lecture was created on the LMS page for its corresponding course, using the content editor feature. In these sections, the slides were provided, along with a table containing the LaTeX representation as well as LaTeX code for mathematical content on that particular slide. The rich content editor uses MathML (mathematical markup language) to display the math, allowing compatibility with screen reader technology. Additionally, slide numbers and titles were included for searchability and navigation. Due to technical limitations, the original slides needed to be converted to an image before being embedded into the LMS section. However, in the case that a

student needed to access the PDF version of a slide instead of its image version, they were able to refer back to the original lecture slides provided by instructors.

A visual explanation of these steps can be found in figures 1 and 2. Each figure shows the original slide paired with layout analysis visualization from MinerU 2.5 VLM, as well as the LaTeX extracted from these same slides, paired with the accompanying material provided on the LMS. We will refer to these sets of accompanying materials as “LaTeX converted materials”.

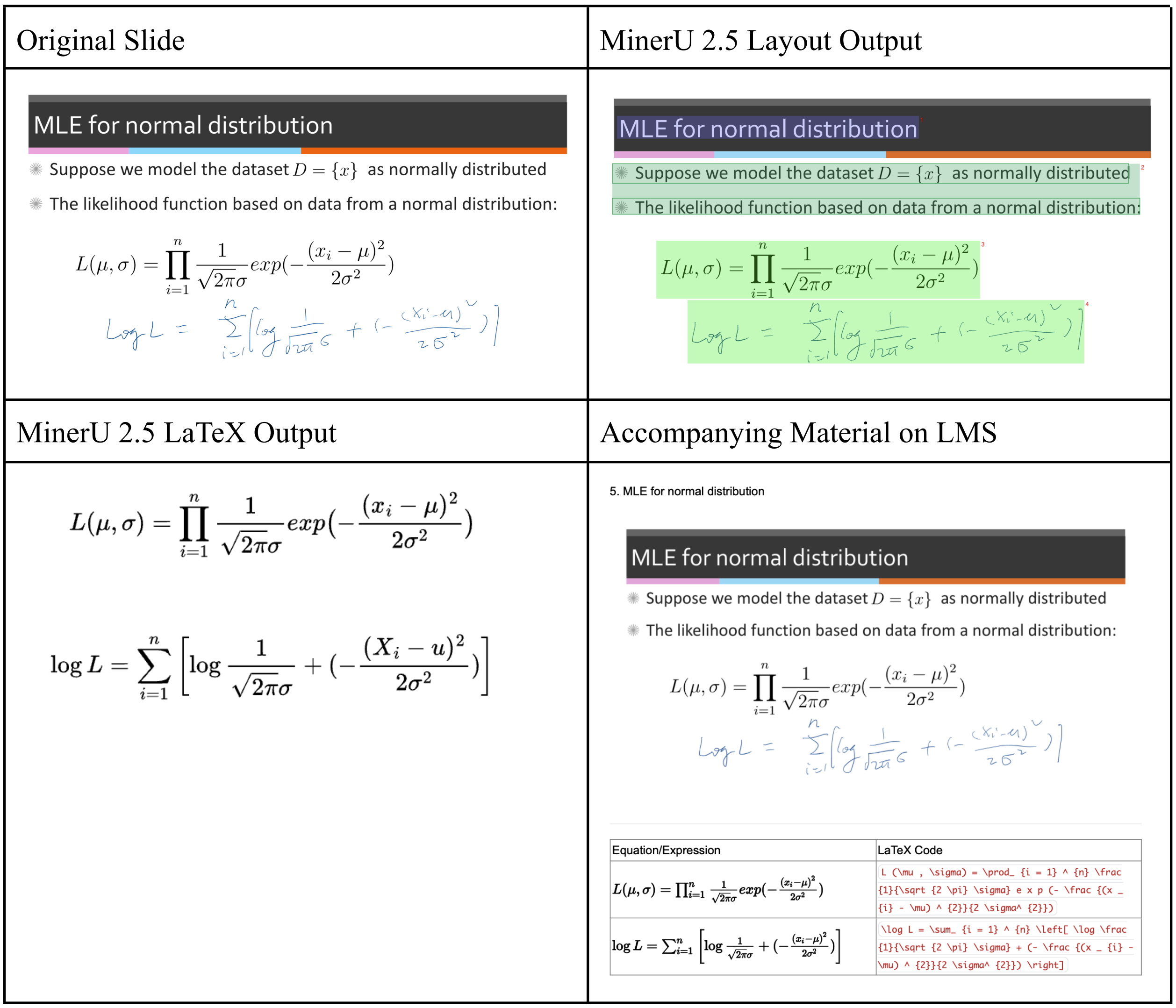

Figure 1. Creating LaTeX Converted Materials for Lecture Slides (Example 1)

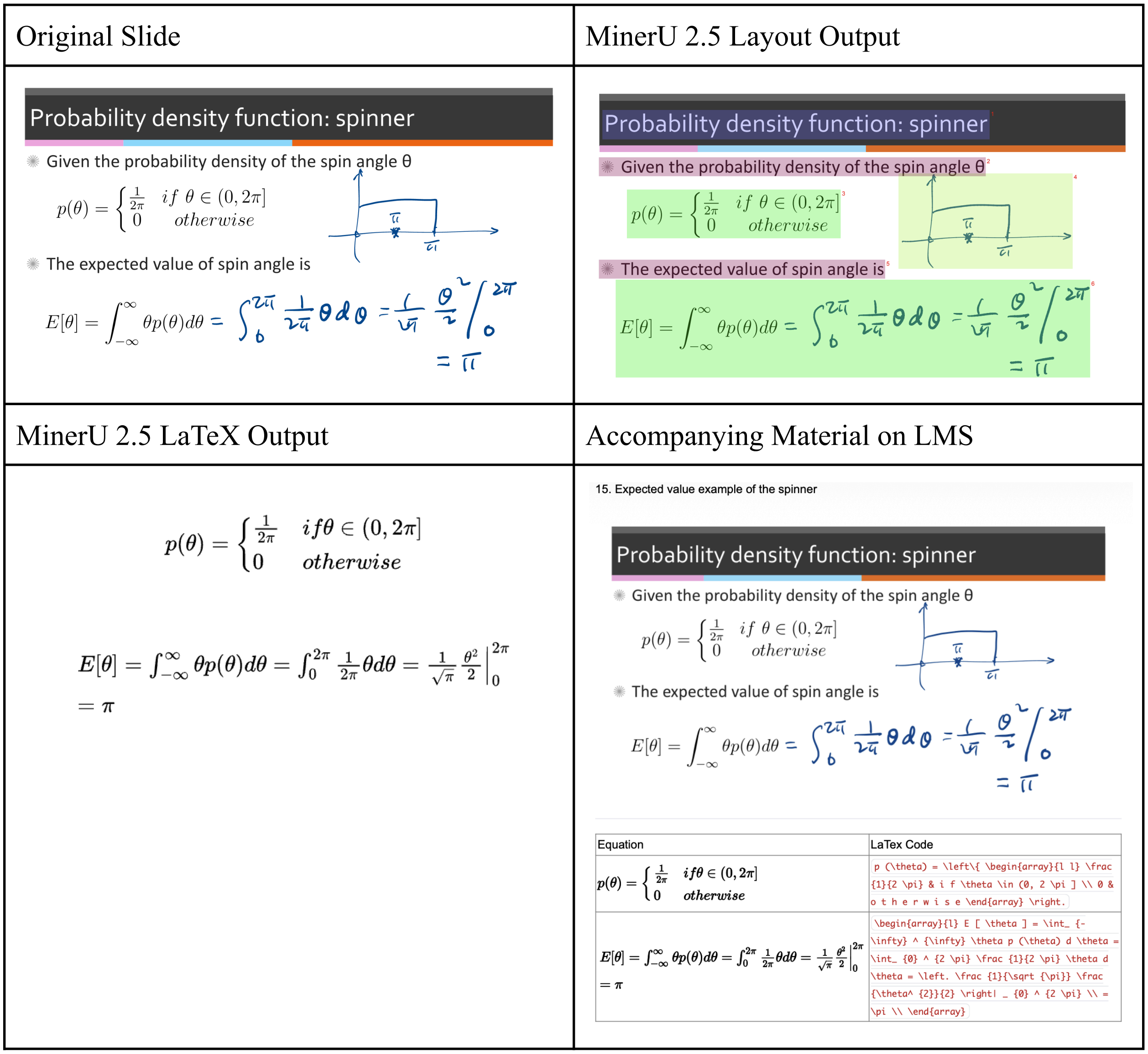

Figure 2. Creating LaTeX Converted Materials for Lecture Slides (Example 2)

Here, we aimed to give students an uniform and simplified way to comprehend, utilize, and engage with instructional mathematical content through providing the LaTeX format and code. Furthermore, it would serve as an additional means of representation for instructional content, aligning with UDL guidelines. Prior digital multimedia learning research also demonstrated that by segmenting content representation, placing similar content types close together, and signalling important information, learning improved for students [19]. Drawing from these principles, our materials were designed to effectively highlight and format mathematical content.

Survey Design and Distribution

Two surveys were designed in order to evaluate students' learning outcomes before and after their use of the LaTeX converted materials, and to understand their needs in STEM, math-rich lecture slides. For clarity, we draw a distinction in definition between LaTeX converted materials and lecture slides, as LaTeX converted materials are an extension to the lecture slides.

For the first survey, questions were designed to mainly gather demographic information, assess students' initial responses about the accessibility and learning use cases of lecture slides in their courses, responses about self-efficacy and belongingness, as well as their needs and perspectives in regards to handwritten content. Following the first survey, the LaTeX converted materials were prepared and released to the students on the respective LMS (Canvas specifically) pages of their courses in order for them to access and interact with. Then, a second survey was given out, which was designed to again gather responses about accessibility, learning outcomes, self-efficacy, and belongingness, this time after the use of the LaTeX converted materials. Additional open-ended questions were also included in this second survey to gather feedback about the LaTeX converted materials for future improvement. The surveys were approved by our IRB and extra credit was offered to students who completed the surveys, with the alternative of attending UDL-based workshops to earn this extra credit.

We then conducted data analysis with the completed responses for both surveys, along with stratifying respondents by demographic subgroups to evaluate similarities and differences. The full set of questions for both surveys can be found in the Appendix (Table 36 and 37). Using this survey design, we investigated the following research questions.

1. Are there similarities or differences in students' perceived accessibility for using lecture slides in their STEM courses?

As lecture slides in STEM courses often consist of multiple elements (ex. text, images, math, etc.), we prompted students to evaluate how frequent they've experienced accessibility problems from using lecture slides. For example, typed text may be difficult to read, or visuals like graphs and diagrams may have unlabeled components or have low resolution. The first survey uses a Likert style question to measure this frequency (1- Never, 5 - Always), allowing us to further analyze the quantitative responses.

2. Are there similarities or differences in how students use lecture slides in their STEM courses as a learning resource?

In the first survey, multiple questions presented students with a set of use cases for lecture slides (ex. Exam preparation, homework/problem solving), and we asked students to select the use cases that help them learn the content. Additionally, we prompted students to select and rank various presentation styles (illustrative visuals, detailed text explanations, etc.) also according to how useful the styles are to helping them learn.

3, 4. Does the intervention of providing students with LaTeX converted materials lead to any differences in levels of accessibility (perceivability, operability, understandability, robustness) or levels of belongingness and self-efficacy? If there are changes resulting from the intervention, do these changes have any similarities or differences across different demographic groups of the students?

A previous UDL-based research study delivered a survey to evaluate students' perceived levels of accessibility, belongingness, and self-efficacy in connection to the use of digital notes [3]. To measure perceived accessibility, the study adapted the PAIM instrument which was built on the POUR model [20]. For belongingness, the study adapted the 27-item Sense of Belonging Instruments and the 30-item Math Sense of Belonging Scale [21, 22]. And for self-efficacy, the study utilized the 8-item Self-Efficacy of Learning instrument [23].

For this study, we extracted a subset of questions from this previous UDL survey and adapted them to fit into the context of lecture slides in engineering and STEM courses. Representative Likert style statements (1 - Strongly disagree, 5 - Strongly agree) for accessibility of lecture materials, self-efficacy, and belongingness were presented to students both before and after the LaTeX converted materials were delivered, in order to analyze any quantitative changes in these levels, as well as any similarities or differences in these changes across demographic subgroups.

5. Are there similarities or differences in the needs of students when it comes to the presentation of handwritten content in STEM courses, such as equations, diagrams, graphs, or tables?

As another primary focus of our study is on improving the accessibility of handwritten content in STEM course contents, we prompted respondents in the first survey to select handwritten components that they would like to have in an alternate format (converting handwritten math to LaTeX, converting handwritten tables to Markdown). Additionally, we asked them to rank these formats in terms of their usefulness.

6. What accessibility-related features are students most interested in for lecture materials?

For future improvements to the accessibility of instructional materials, we presented students in the first survey with several accessibility-related features (ex. Integrating LaTeX formatting to live lecture captioning), and asked them to evaluate their usefulness through a Likert scale (1- not at all useful, 5 - extremely useful).

7. What potential design or implementation choices of our LaTeX converted materials emerge as a result of students' feedback?

In the second survey, which was administered after students had the opportunity to use the LaTeX converted materials, we designed several Likert-style questions to measure students' overall feedback to the usefulness of the LaTeX converted materials. Open ended questions were also included and analyzed to gather additional feedback.

Demographics

The 2 surveys were administered to students from 3 courses at the University of Illinois Urbana-Champaign, including 2 computer science courses and 1 electrical and computer engineering courses. Students were able to self report their status of having a disability or accessibility needs. Students who have a physical, mental, or emotional disability (SWD) and students with accessibility needs (SWAN), who were those that could not fully participate in coursework due to a health issue not officially recognized as a disability, were combined into the group of SACAN. The NON-SACAN group included those who did not identify as SWD or SACAN, while the Students without Disabilities group (SWOD) included both the SWAN and NON-SACAN groups. Demographic data can be found in Tables 1 and 2.

Total	Male	Female	Non binary	White	Asian	Latinx	Other/Mixed	CS Class	ECE Class
236	167	56	3	41	179	7	14	145	91

Table 1: Demographics - Gender, Ethnicity, Course

Total	SWD	Physical SWD	Mental SWD	Male SWD	Female SWD	Non binary SWD	SWAN	SWOD	SACAN	NON SACAN
236	18	1	16	11	5	1	29	196	47	167

Table 2: Demographics - Self-Reported Disability Status

Data Analysis

After responses from both surveys were received, the data was matched, cleaned, and anonymized. Cronbach's alpha was utilized to measure the internal consistency of both surveys, Cronbach's alpha values of 0.788 for the first survey and 0.837 for the second survey, demonstrated acceptable reliability for both surveys.

Due to limited sample sizes for several demographic groups, we chose to conduct data analysis across 9 main groups, which included "all respondents", and 8 subgroups: "male", "female", "SWD", "SWOD", "SACAN", "NON-SACAN", "White", and "Asian".

For questions that involved selecting categorical options (ex. Selecting classroom activities which lecture slides are useful for), contingency tables were constructed across demographic subgroups, and subsequent Chi-square analysis was performed to evaluate independence between different demographic subgroups.

For Likert style questions, responses were mapped to numerical values. For example, when prompting students about their perceived frequency of accessibility problems with different components of lecture slides, a selection of "Never" corresponds to 1 and "Always" corresponds to 5. After mapping, statistics such as mean and median values were calculated on a statement level for each likert statement within the question. For questions regarding POUR, self efficacy, and belongingness, which was measured in both the first and second survey, the change in mean values for each statement from the first to the second survey was calculated. This process was repeated for each demographic subgroup included in data analysis. Additionally, comparison between demographic subgroups was performed using either the Mann Whitney U test (comparing two groups) or the Kruskal Wallis test (comparing more than two groups). To account for multiple p values being tested for a specific question, we utilized the Benjamini-Hochberg Procedure to adjust p values, in order to control the False Discovery Rate (FDR).

For ranking questions (ex. Ranking different forms of presentation styles which best help in learning content), choices were assigned to numerical values, with in order of highest preference (1 - highest preference). Similar analysis to likert style questions was also conducted for ranking style questions, such as calculating mean and median for each choice for each demographic subgroup. Comparison between demographic subgroups was also conducted using either the Mann Whitney U test (comparing two groups) or the Kruskal Wallis test (comparing more than two groups).

Results

a) Accessibility and Learning outcomes before and After Student Interaction with LaTeX Converted Materials

1) Findings about the changes in levels of accessibility

Changes with regard to perceivability, operability, and understandability

We used the following Likert statements for perceivability, operability, and understandability.

1. Perceivability - “I can fully and easily perceive the materials in these lecture slides using my senses”
2. Operability - “I can fully and easily perceive the materials in these lecture slides using my senses”
3. Understandability - “Given the structure and presentation of the materials in these slides, I can understand the information in these slides”

Considering all the respondents, we found no significant difference in the average score for three three categories in the POUR model (Table 10 and 11 in Appendix). However, there is a positive trend in the average scores along all three categories.

Robustness was significantly increased

The statement for robustness was “The materials in these slides would be compatible with alternative formats (ex. Device format, screen reader, other assistive technologies).”

We evaluated robustness using the same Likert scale as that for perceivability, operability, and understandability, with the modification of having an option for “I don’t know” as some respondents may not be familiar with or use assistive technologies. Therefore, for this 4th element of the POUR model, we filter out responses that contained an “I don’t know” response.

We found for all respondents, robustness is significantly increased (+0.44, $p = 0.0006$) (Table 3). Similar significant increases were also found on a demographic sublevel (Tables 13 - 16 in Appendix)

1. male students (+0.44, p = 0.0009)
2. SWOD (+0.41, p = 0.0031)
3. NON-SACAN (+0.40, p = 0.0072)
4. asian students (+0.43, p = 0.0028)

For all other demographic subgroups, there was a general positive trend in average scores (Table 12 in Appendix).

Comparisons between demographic groups in their responses to the robustness question show no significant difference. This suggests all students have similar opinions about the effect on robustness pertaining to the intervention.

Question (Separate Item)	Pre Mean (SD)	Post Mean (SD)	Change	P-value
The materials in these slides would be compatible with alternative formats (ex. device format, screen reader, other assistive technologies)	3.77 (1.09)	4.21 (1.11)	+0.44	0.0006 ***

Table 3: Robustness Before and After Using LaTeX Converted Materials (All Respondents)

2) Findings about changes in levels of self-efficacy and belongingness

Similar to the analysis on POUR metrics, we analyzed how levels of student reported self-efficacy and belongingness changed in response to the LaTeX converted materials. We used the same Likert scale (1 - “Strongly disagree, 5 - “Strongly agree”), and provided 4 questions to prompt students about self efficacy and belongingness.

1. Self-efficacy - “After going through these slides, I am able to comprehend and utilize the information covered in these slides”
2. Self-efficacy - “After going through these slides, I am confident that I can succeed in classroom activities related to these slides”
3. Belongingness - “I feel that I belong to the course community and my educational needs are being met”
4. Belongingness - “I consider myself a member of the engineering computing world”

Additionally, we aggregated the scores for both self efficacy and belongingness in order to capture a broader overview of students' levels of perceived self efficacy and belongingness.

Students self-efficacy significantly increased after the intervention

Question Content	Pre Mean (SD)	Post Mean (SD)	Change	Raw P-val	Adj P-val (FDR)
After going through these slides, I am able to comprehend and utilize the information covered in these slides.	3.67 (1.06)	3.96 (1.09)	+0.29	0.0020 **	0.0039 **
After going through these slides, I am confident that I can succeed in classroom activities related to these slides (exam prep, homework, peer collaboration, etc.)	3.52 (1.06)	3.77 (1.11)	+0.25	0.0085 **	0.0085 **
OVERALL AGGREGATED SCORE	3.60 (0.99)	3.86 (1.05)	+0.27	0.0012 **	0.0012 **

Table 4: Self Efficacy Before and After Using LaTeX Converted Materials (All Respondents)

We found for all respondents together the aggregated self efficacy increased significantly (+0.27, p = 0.0012) (Table 4). Five additional subgroups also demonstrated statistically significant positive increases in aggregated self efficacy, including the following (Tables 17 - 21 in Appendix)

1. female students (+0.55, p = 0.0022)
2. NON-SACAN (+0.23, p = 0.0101)
3. SWOD (+0.26, p = 0.0030)
4. white students (+0.45, p = 0.0253)
5. asian students (+0.24, p = 0.0244)

Additionally, we found across all other demographic subgroups the change of average is positive even if the p value is not significant (Table 22 in Appendix).

We then found that when comparing male and female students, female students demonstrated a significantly greater increase in self efficacy (for aggregated delta, p val = 0.0270, as well as the statement "After going through these slides, I am confident that I can succeed in classroom activities related to these slides", p val = 0.0272) (Table 5).

Content	**Male Δ (SD) [n]**	**Female Δ (SD) [n]**	**Raw P-val**	**Adj P-val (FDR)**
After going through these slides, I am able to comprehend and utilize the information covered in these slides.	+0.20 (1.47) [n=167]	+0.50 (1.32) [n=56]	0.1562	0.1562
After going through these slides, I am confident that I can succeed in classroom activities related to these slides (exam prep, homework, peer collaboration, etc.)	+0.07 (1.43) [n=167]	+0.61 (1.32) [n=56]	0.0136 *	0.0272 *
OVERALL AGGREGATED DELTA	+0.13 (1.36) [n=167]	+0.55 (1.20) [n=56]	0.0270 *	0.0270 *

Table 5: Self Efficacy Before and After Using LaTeX Converted Materials (Mean Increase, Male vs Female)

Belongingness didn't change significantly after the intervention

We did not find significant changes in belongingness after the intervention, either for all students, or demographic subgroup/s, either on a question level or on an aggregated level. When aggregating the scores for the two questions related to belongingness, there were positive trends for female students (+0.05), SWD (+0.33), SACAN (+0.28), while there were negative trends for all respondents (-0.03), male students (-0.07), SWOD (-0.06), NON_SACAN (-0.11), white students (-0.09), and asian students (-0.01) (Table 23 in Appendix).

b) Survey about Needs and Perspectives

1) Findings about the similarities and differences in how students use lecture slides as a learning resource

Classroom Activities that Lecture Slides Benefit the Most

For all the respondents, the ordering of the classroom activities by how often they were selected, from the greatest proportion of the group to the least, is the following (Table 25 in Appendix)

1. Exam preparation (90.7%)
2. homework/problem solving (80.9%)
3. searching and reviewing of content (73.7%)
4. sharing/peer review (16.1%)
5. accessibility with assistive technologies (7.2%)
6. other (1.7%)

Interestingly, this ordering remains mostly consistent across all demographic subgroups, with the exception of the case of female students, where a higher percentage of the group selected "searching and reviewing of content" (76.8%) than "homework/problem solving" (75.0%), with the position of the other three choices remaining the same as other demographic subgroups.

We found a statistically significant difference regarding how often the "other" category of classroom activity was selected, comparing SWD vs. SWAN vs Non-SACAN using Chi-square analysis ($p = 0.0358$). However, the number of students who selected this option were extremely small (Table 26 in Appendix).

All four presentation styles are useful for students

For all respondents, here is the order of presentation styles most often selected to least selected: "Slides with visuals that illustrate key terms and concepts (72.0%), "slides with step by step derivations of equations and worked examples of concepts (69.5%), "slides with comprehensive and detailed text explanations" (66.9%), and "slides with a mix of text, images, examples, math, etc.", (Table 27 in the appendix).

Chi-square and Fisher's exact analysis used for comparing different demographic subgroups did not result in any statistically significant differences for the different presentation styles.

After ranking these presentation styles in order of preference (1 - most useful, 4 - least useful) (Table 28 in Appendix), students ranked the styles as the following

1. “slides with step by step derivations of equations and worked examples of concepts” (Mean = 2.32, Median = 2)
2. “slides with comprehensive and detailed text explanations” (Mean = 2.45, Median = 2)
3. “slides with visuals that illustrate key terms and concepts” (Mean = 2.47, Median = 2)
4. “slides with a mix of text, images, examples, math, etc.” (Mean = 2.76, Median = 3)

We found male and female students are significantly different in their opinion on the rankings for a style of slide presentation, specifically for slides with visuals that illustrate key terms and concepts ($p = 0.0230$) (Table 29 in appendix).

2) Findings in student feedback to LaTeX Converted Materials

Use cases for the LaTeX Converted Materials

Question Content	Mean (SD)	Median (IQR)
Exam preparation	3.66 (1.03)	4.00 ([3.00, 4.00])
Homework/problem solving	3.76 (1.03)	4.00 ([3.00, 5.00])
Searching or reviewing of content	3.83 (1.01)	4.00 ([3.00, 5.00])
Sharing/peer review	3.38 (1.05)	3.00 ([3.00, 4.00])
OVERALL AGGREGATED SCORE	3.66 (0.85)	3.75 ([3.00, 4.25])

Table 6: Classroom Activities for which LaTeX Converted Materials Would Be Helpful with (all respondents)

From all the respondents’ mean usefulness scores, the classroom activities ordered by most helpful to least, with respect to using the LaTeX Converted Materials, are the following (Table 6)

1. “searching or reviewing of content” (3.83)
2. “homework/problem solving” (3.76)
3. “exam preparation” (3.66)
4. “sharing/peer review” (3.38)

Across every demographic subgroup, this ordering is mostly consistent, with a few exceptions. Further data and analysis on this can be found in Table 33 in the Appendix.

When comparing between demographic subgroups, we found no statistically significant difference for any comparison regarding average score for a classroom activity.

For all respondents, the mean usefulness score for "using assistive technologies" was 3.72, indicating that the LaTeX converted materials can be moderately to very useful for this particular use case (Table 34 in Appendix). Additionally for this use case, there were no statistically significant differences when comparing between demographic subgroups.

Overall feedback on LaTeX converted materials

We examined responses for the three separate statements that summarize the overall experience of using the LaTeX converted materials. The mean levels of agreement (1 - Strongly disagree, 5 - Strongly agree) are very similar across the three statements for all demographic subgroups.

The three statements were "This set of converted and formatted lecture slides can help me better perceive the content presented on lecture slides", "This set of converted and formatted lecture slides can increase my understanding of the content", and "This set of converted and formatted lecture slides can increase my understanding of the content". For all respondents, the mean agreement score was 3.87, 3.85, and 3.94 respectively (Table 35 in Appendix).

There were no statistically significant differences in the average agreement scores for these statements when comparing different demographic subgroups.

3) Findings about the student's needs for navigating and accessing lecture slides in their STEM courses

Handwritten math/text ranked the most challenging in the 5 Different Components of Lecture Slides

When analyzing responses from all respondents, the different components of lecture slides ranked by frequency of accessibility problems, in descending order from most frequent to least frequent by mean score, is the following

1. Handwritten content (handwritten text or math, handdrawn images) (ex.illegible hard to understand)
2. Typed mathematical equations (ex. Unclear notation, hard to follow along)
3. Images (diagrams, graphs, figures, etc.)(ex. Unlabeled axes, low quality images)

4. Typed Tables (ex. Unclear row/column structure, inconsistent formatting)
5. Typed Text (ex. Text that is small, hard to read, or low contrast)

As we have expected the data demonstrates handwritten content and typed mathematical equations are the most challenging for students to process (Table 7).

Question Content	**Mean (SD)**	**Median (IQR)**
Handwritten content (handwritten text or math, handdrawn images) (ex. illegible, hard to understand)	2.28 (1.15)	2.00 ([1.00, 3.00])
Typed mathematical equations (ex. unclear notation, hard to follow along)	2.13 (1.04)	2.00 ([1.00, 3.00])
Images (diagrams, graphs, figures, etc.) (ex. unlabeled axes, low quality images)	1.87 (0.91)	2.00 ([1.00, 2.00])
Typed tables (ex. unclear row/column structure, inconsistent formatting)	1.74 (0.90)	2.00 ([1.00, 2.00])
Typed text (ex. text that is small, hard to read, or low contrast)	1.72 (0.91)	2.00 ([1.00, 2.00])
OVERALL AGGREGATED SCORE	1.95 (0.82)	1.80 ([1.20, 2.40])

Table 7: Frequency of Accessibility Problems With Different Components of Lecture Slides (All Respondents)

Additionally when examining average frequency of accessibility challenges on a demographic level, female students reported the highest average for typed text, images handwritten content (1.84, 1.95, and 2.64 respectively), and SWD had the highest average for typed mathematical equations and typed tables (2.39, 1.83 respectively) (Table 24 in Appendix).

Comparing average frequency of accessibility challenges across demographic subgroups, we did not find any statistical significance. This suggests an overall consensus in students' perceived levels of accessibility for different components of lecture slides.

4) Findings in the needs of students when it comes to handwritten content in STEM courses

For all respondents together, the types of handwritten components of lecture slides students need an alternate format, from highest percentage to lowest are as follows (Table 8):

1. handwritten mathematical equations (70.8%)
2. handwritten text (59.3%)
3. handdrawn images (diagrams, graphs, figures, etc.) (44.5%)
4. handdrawn tables (32.2%)

Ordering and ranking of different forms of handwritten content conversion

Group	Total N	Handwritten text	Handwritten mathematical equations	Hand -drawn images	Hand -drawn tables
All Respondents	236	140 (59.3%)	167 (70.8%)	105 (44.5%)	76 (32.2%)
Male	167	90 (53.9%)	117 (70.1%)	77 (46.1%)	52 (31.1%)
Female	56	41 (73.2%)	43 (76.8%)	24 (42.9%)	21 (37.5%)
SWD	18	9 (50.0%)	15 (83.3%)	8 (44.4%)	8 (44.4%)
SWOD	196	116 (59.2%)	135 (68.9%)	88 (44.9%)	62 (31.6%)
SACAN	47	27 (57.4%)	33 (70.2%)	25 (53.2%)	20 (42.6%)
NON_SACAN	167	98 (58.7%)	117 (70.1%)	71 (42.5%)	50 (29.9%)
White	41	28 (68.3%)	31 (75.6%)	16 (39.0%)	12 (29.3%)
Asian	179	104 (58.1%)	126 (70.4%)	81 (45.3%)	59 (33.0%)

Table 8: Handwritten content that Students Would Like to Have Access to in Alternate Format (All demographic subgroups)

This aligns with the intended purpose of the LaTeX converted materials provided to students, which provided the mathematical content on a slide in its LaTeX format and code representation.

Additionally, Chi-square analysis showed that male and female students are significantly different in how often they select the choice of converting handwritten text ($p = 0.0487$) (Table 30 in Appendix).

Using the same group of options for handwritten content conversion, students were asked to rank each type in order of preference for helping them learn content (1 - most useful, 4 - least useful). When analyzing all respondents, the selections were, in order of most useful to least, the following (Table 31 in Appendix)

1. "conversion of handwritten text to typed text" (Mean = 2.00, Median = 2)
2. "conversion of handwritten mathematical equations" (Mean = 2.02, Median = 2)
3. "conversion of handdrawn images" (Mean = 2.76, Median = 3)
4. "conversion of handdrawn tables" (Mean = 3.22, Median = 3)

Comparisons between demographic subgroups with regards to the distribution of rankings for a specific type of handwritten content conversion did not produce any statistical significance.

5) Findings in levels of interest for accessibility related features in regards to lecture materials

Student interest in potential new accessibility features

We found students prefer the feature of "LaTeX for equations in lecture transcripts", followed by "LaTeX for equations in live-streamed lecture captions", "conversion of handwritten content to alternate format", "integration of slides with ClassTranscribe's glossary feature" (ClassTranscribe is a UDL based instructional video platform), and "text to speech support for lecture slides" (Table 9). This result again confirmed our hypothesis that conversion of math content to LaTeX is very important for students.

The scores for these features per demographic subgroup can be found in Table 32 in the Appendix. We didn't find statistical significant differences in any of the comparisons regarding the average scores for each accessibility feature.

Question Content	Mean (SD)	Median (IQR)
LaTeX for equations in lecture transcripts	3.56 (1.06)	4.00 ([3.00, 4.00])
LaTeX for equations in live-streamed lecture captions	3.47 (1.09)	4.00 ([3.00, 4.00])
Conversion of handwritten content to alternate format (ex. handwritten text to typed text, handwritten mathematical notation to LaTeX code)	3.43 (1.06)	3.00 ([3.00, 4.00])
Integration of slides with ClassTranscribe's glossary feature	2.90 (1.22)	3.00 ([2.00, 4.00])
Text to speech support for lecture slides	2.40 (1.28)	2.00 ([1.00, 3.00])
OVERALL AGGREGATED SCORE	3.15 (0.85)	3.20 ([2.60, 3.65])

Table 9: Accessibility Related Features Students Would Like to have access to (All Respondents)

6) Open-Ended responses regarding experience with LaTeX converted materials

There were 4 open-ended questions that prompted students to respond about their experience with the LaTeX converted materials, with the specific categories of focus being benefits, complaints, overall experience, and feedback for certain features and areas of improvement. After the responses were collected, two rounds of qualitative coding were performed. In the first round, descriptive labels were assigned to each response, and then in the second round, these labels were grouped into higher order, thematic categories.

1. Benefits: A prevalent theme that emerged from the open ended responses was how the materials increased clarity and understanding for the students (improved readability, helpful with understanding concepts, more structured and better formatting). Another overarching theme was its beneficial application to academic tasks, such as studying and reviewing the content, completing homework, creating notes, or preparing for exams. The last theme was usability, as students reported benefits from aspects like better searchability of topics and mathematical content, an easy to use and accessible experience, improved variety of instructional resources, and using them with other technologies.

2. Complaints: The majority of students reported no major complaints or technical issues with the converted and formatted lecture slides. Among those who did provide feedback, the most common concerns involved formatting clarity, navigation challenges (such as difficulty searching with CTRL-F), and disliking the visual presentation of the LaTeX expressions. There was a small subset of students who used the question to give more general feedback on the class as a whole, who generally did not like the content of the slides and did not find the provided learning materials useful in general.
3. Overall Experience: As the other open-ended questions addressed aspects included in the student's responses about their overall experience (benefits, complaints, feedback), we decided to categorize responses for this question as either "positive", "neutral", and "negative", to reduce redundancy. Responses that did not clearly address the question were omitted. For a total of 211 responses, 161 were labelled "positive", 46 were labelled "neutral", and 4 were labelled "negative".
4. Feedback: Overall, student feedback suggested improving the organization and readability of the LaTeX converted materials on Canvas. Many students recommended integrating LaTeX equations directly into the slides or organizing them in a single location to reduce scrolling and confusion. Students also requested clearer explanations, typed text instead of handwritten notes, more examples and visualizations, and better navigation features such as searchable or downloadable slides. While some respondents had no suggested changes, the main feedback focused on clearer presentation, improved accessibility, and easier use of the materials for studying.

Conclusion

In this research, for the first time we found the positive effect on students' perceived accessibility and learning outcomes in math rich STEM courses by a single intervention, namely providing LaTeX coded math equations tandem to the lecture slides. First, the results show students consider their course contents more robust, with robustness being a part of the POUR model for perceived accessibility. Second, students perceived higher self-efficacy after being given the LaTeX converted materials, suggesting they are more confident in their ability to succeed in the course.

Closely related to the above result, we gained more insight into how students use and engage with math course slides, and their needs in math course slides. Responses of these STEM undergraduate students show that hand written contents especially improvement on or alternative delivery of handwritten math equations are the most urgently needed. The study also gave insights that handwritten math equation conversion embedded in lecture transcripts might be a good accessibility feature for making our college math courses more accessible.

Although all respondents have a general common trend in their responses, female and male students differ in several questions. For example, female students reported a significantly higher level of improvement on their self-efficacy after using the LaTeX converted materials.

Discussion

Modern symbolic mathematical equations didn't exist until the 16-18th century. Before the birth of the modern math format, equations were expressed in words or in some abbreviations. The difficulty of contemporary math equations is further exacerbated by the amount of new development/knowledge in mathematics. When two Turing award winners Donald Knuth and Leslie Lamport developed LaTeX, they intended to use that to help with document displays that include complex math equations [24, 25]. Now considering the LaTeX code for math equations, one can see that a lot of structures and concepts of the massive body of math knowledge could be represented by such a code system. In contrast, these structures and concepts are lost when equations are only viewed as images, especially as handwritten images.

Following the principle of multiple representation in the UDL pillars, we sought to give students the LaTeX code format of the math equations as alternative material. Then we measured how this intervention affected the students' perceived accessibility and learning outcomes such as self-efficacy and belongingness. As a result, we found that providing LaTeX converted materials indeed helped improve the robustness of course lectures and the student self-efficacy. This result is significant in that the improvement is for all students and female students reported higher degree of improvement in self-efficacy.

We're excited by these results and also expect research in this area will have greater/broader impact in the era of generative AI. The difficulty of converting/explaining math can be alleviated by using AI technology learning from published knowledge and that requires the ability to recognize math and search math in all kinds of formats. Our research would be one effort to bring that goal closer.

While students reported statistically significant gains in self-efficacy across the full sample and multiple demographic subgroups, no corresponding significant changes were observed in belongingness. This pattern is not contradictory; rather, it seems to reflect the fundamentally different mechanisms through which these two constructs are shaped and the scope of influence of a single, content-focused accessibility intervention.

The findings suggest a clear boundary on what a single accessibility-focused instructional intervention can accomplish. The LaTeX-converted materials effectively reduced perceived difficulty and improved students' confidence in their ability to comprehend, use, and succeed with course content—hence we see the gains in self-efficacy. However, belongingness, which depends on social integration and identity affirmation, remained largely unchanged because these dimensions were outside the scope of the intervention.

Self-efficacy is closely tied to students' *perceived ability to successfully engage with specific academic tasks*. The intervention directly targeted the cognitive and perceptual demands of interacting with lecture materials—particularly mathematical notation and handwritten content, which students overwhelmingly identified as the most challenging components of STEM slides. Before the intervention, students consistently reported high difficulty levels associated with: handwritten mathematical equations (ranked most challenging), handwritten text, and typed mathematical equations with unclear notation. After the intervention, LaTeX-converted materials addressed these precise

In contrast, belongingness reflects a student's social and identity-based relationship with the course, discipline, and broader academic community. Unlike self-efficacy, belongingness is not primarily shaped by content legibility or task-level accessibility. Instead, it emerges from sustained interactions, recognition, peer dynamics, instructional climate, representation, and institutional atmosphere. Thus, potential future analysis could study belongingness in-context; for instance, within the realm of group projects, where differences in accessibility could have an impact in peer dynamics.

In the study, we noticed the sample size decreased as we proceeded to the 2nd survey that was released at the end of the semester. Students who responded in the 1st survey may have skipped the 2nd due to various reasons. It's likely some students who had performed very well up to that time decided to drop the participation due to the fact that they don't perceive the benefit of the extra points. Another limit to the sample collection was due to the required fair practice of IRB, we offer students alternative ways to achieve extra points instead of participating in the survey. Despite these, we still received 236 complete responses including 18 SWD students. But indeed, we lacked the power of statistical tests for the SWD subgroup. In addition, a few other factors including minor differences in the time of the announcements in the 3 different courses, the limited usage of the material by the students and limited survey open time for students to take the surveys could have affected the number of responses as well.

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Appendix

Question Content	**Pre Mean (SD)**	**Post Mean (SD)**	**Change**	**Raw P-val**	**Adj P-val (FDR)**
I can fully and easily perceive the materials in these lecture slides using my senses (viewing, reading, etc.)	3.82 (1.04)	3.97 (1.13)	+0.14	0.0987 .	0.2961
I can visually navigate and follow along with the content in these lecture slides.	3.89 (1.02)	3.92 (1.15)	+0.03	0.6813	0.6813
Given the structure and presentation of the materials in these slides (layout, text, equations, figures, diagrams, etc.), I can understand the information in these slides.	3.83 (1.01)	3.94 (1.08)	+0.11	0.2141	0.3211
OVERALL AGGREGATED SCORE	3.85 (0.93)	3.94 (1.05)	+0.10	0.2290	0.2290

Table 10: Perceivability, Operability, and Understandability Before and After Using LaTeX Converted Materials (All Respondents)

Group	N	I can fully and easily perceive the materials in these lecture slides using my senses (viewing, reading, etc.) Δ	I can visually navigate and follow along with the content in these lecture slides. Δ	Given the structure and presentation of the materials in these slides (layout, text, equations, figures, diagrams, etc.), I can understand the information in these slides. Δ	Aggregated Δ
All Respondents	236	+0.14	+0.03	+0.11	+0.10
Male	167	+0.04	-0.02	+0.04	+0.02
Female	56	+0.43	+0.07	+0.25	+0.25
SWD	18	+0.28	+0.39	+0.06	+0.24
SWOD	196	+0.16	+0.04	+0.12	+0.11
SACAN	47	+0.30	+0.30	+0.17	+0.26
NON SACAN	167	+0.14	+0.00	+0.10	+0.08
White	41	+0.15	-0.07	+0.17	+0.08
Asian	179	+0.19	+0.08	+0.11	+0.13

Table 11: Perceivability, Operability, and Understandability Before and After Using LaTeX Converted Materials (Mean Increase, All Demographic Subgroups)

Although there was no significant difference when examining the adjusted P values for responses to these questions, there was a general positive increase in average scores, both on a question and aggregated level across all demographic subgroups. There were exceptions for the operability question, with male students having a change of -0.02, Non-SACAN students having a change of +0.00, and white students having a change of -0.07. Female students had the highest positive increase with regards to the perceivability and understandability subscale (+0.43, +0.25), while SWD had the highest positive increase with regards to the operability subscale (+0.39).

Group	N	The materials in these slides would be compatible with alternative formats (ex. device format, screen reader, other assistive technologies) Δ	Aggregated Δ
All Respondents	141	+0.44	+0.44
Male	101	+0.44	+0.44
Female	31	+0.29	+0.29
SWD	9	+0.33	+0.33
SWOD	121	+0.41	+0.41
SACAN	26	+0.42	+0.42
NON SACAN	104	+0.40	+0.40
White	25	+0.56	+0.56
Asian	106	+0.43	+0.43

Table 12: Robustness Before and After Using LaTeX Converted Materials (Mean Increase, All Demographic Subgroups)

Question (Separate Item)	Pre Mean (SD)	Post Mean (SD)	Change	P-value
The materials in these slides would be compatible with alternative formats (ex. device format, screen reader, other assistive technologies)	3.84 (1.07)	4.28 (1.02)	+0.44	0.0009 ***

Table 13: Robustness Before and After Using LaTeX Converted Materials (Male)

Question (Separate Item)	Pre Mean (SD)	Post Mean (SD)	Change	P-value
The materials in these slides would be compatible with alternative formats (ex. device format, screen reader, other assistive technologies)	3.75 (1.13)	4.17 (1.14)	+0.41	0.0031 **

Table 14: Robustness Before and After Using LaTeX Converted Materials (SWOD)

Question (Separate Item)	Pre Mean (SD)	Post Mean (SD)	Change	P-value
The materials in these slides would be compatible with alternative formats (ex. device format, screen reader, other assistive technologies)	3.79 (1.12)	4.19 (1.12)	+0.40	0.0072 **

Table 15: Robustness Before and After Using LaTeX Converted Materials (NON-SACAN)

Question (Separate Item)	Pre Mean (SD)	Post Mean (SD)	Change	P-value
The materials in these slides would be compatible with alternative formats (ex. device format, screen reader, other assistive technologies)	3.78 (1.12)	4.22 (1.10)	+0.43	0.0028 **

Table 16: Robustness Before and After Using LaTeX Converted Materials (Asian)

Question Content	Pre Mean (SD)	Post Mean (SD)	Change	Raw P-val	Adj P-val (FDR)
After going through these slides, I am able to comprehend and utilize the information covered in these slides.	3.43 (1.11)	3.93 (1.11)	+0.50	0.0119 *	0.0119 *
After going through these slides, I am confident that I can succeed in classroom activities related to these slides (exam prep, homework, peer collaboration, etc.)	3.29 (1.07)	3.89 (1.09)	+0.61	0.0023 **	0.0046 **
OVERALL AGGREGATED SCORE	3.36 (0.98)	3.91 (1.06)	+0.55	0.0022 **	0.0022 **

Table 17: Self Efficacy Before and After Using LaTeX Converted Materials (Female)

Question Content	**Pre Mean (SD)**	**Post Mean (SD)**	**Change**	**Raw P-val**	**Adj P-val (FDR)**
After going through these slides, I am able to comprehend and utilize the information covered in these slides.	3.74 (1.02)	4.03 (1.04)	+0.29	0.0045 **	0.0089 **
After going through these slides, I am confident that I can succeed in classroom activities related to these slides (exam prep, homework, peer collaboration, etc.)	3.63 (1.05)	3.81 (1.11)	+0.18	0.1076	0.1076
OVERALL AGGREGATED SCORE	3.69 (0.97)	3.92 (1.01)	+0.23	0.0101 *	0.0101 *

Table 18: Self Efficacy Before and After Using LaTeX Converted Materials (NON-SACAN)

Question Content	**Pre Mean (SD)**	**Post Mean (SD)**	**Change**	**Raw P-val**	**Adj P-val (FDR)**
After going through these slides, I am able to comprehend and utilize the information covered in these slides.	3.71 (1.05)	4.03 (1.06)	+0.31	0.0017 **	0.0034 **
After going through these slides, I am confident that I can succeed in classroom activities related to these slides (exam prep, homework, peer collaboration, etc.)	3.59 (1.07)	3.81 (1.12)	+0.21	0.0343 *	0.0343 *
OVERALL AGGREGATED SCORE	3.65 (0.99)	3.92 (1.03)	+0.26	0.0030 **	0.0030 **

Table 19: Self Efficacy Before and After Using LaTeX Converted Materials (SWOD)

Question Content	Pre Mean (SD)	Post Mean (SD)	Change	Raw P-val	Adj P-val (FDR)
After going through these slides, I am able to comprehend and utilize the information covered in these slides.	3.56 (1.00)	4.02 (0.94)	+0.46	0.0256 *	0.0512 .
After going through these slides, I am confident that I can succeed in classroom activities related to these slides (exam prep, homework, peer collaboration, etc.)	3.27 (1.03)	3.71 (1.03)	+0.44	0.0950 .	0.0950 .
OVERALL AGGREGATED SCORE	3.41 (0.90)	3.87 (0.88)	+0.45	0.0253 *	0.0253 *

Table 20: Self Efficacy Before and After Using LaTeX Converted Materials (White)

Question Content	Pre Mean (SD)	Post Mean (SD)	Change	Raw P-val	Adj P-val (FDR)
After going through these slides, I am able to comprehend and utilize the information covered in these slides.	3.72 (1.09)	3.97 (1.09)	+0.25	0.0207 *	0.0415 *
After going through these slides, I am confident that I can succeed in classroom activities related to these slides (exam prep, homework, peer collaboration, etc.)	3.62 (1.06)	3.80 (1.11)	+0.18	0.0650 .	0.0650 .
OVERALL AGGREGATED SCORE	3.67 (1.01)	3.89 (1.05)	+0.22	0.0244 *	0.0244 *

Table 21: Self Efficacy Before and After Using LaTeX Converted Materials (Asian)

Group	**N**	**After going through these slides, I am able to comprehend and utilize the information covered in these slides. Δ**	**After going through these slides, I am confident that I can succeed in classroom activities related to these slides (exam prep, homework, peer collaboration, etc.) Δ**	**Aggregated Δ**
All Respondents	236	+0.29	+0.25	+0.27
Male	167	+0.20	+0.07	+0.13
Female	56	+0.50	+0.61	+0.55
SWD	18	+0.33	+0.61	+0.47
SWOD	196	+0.31	+0.21	+0.26
SACAN	47	+0.40	+0.49	+0.45
NON_SACAN	167	+0.29	+0.18	+0.23
White	41	+0.46	+0.44	+0.45
Asian	179	+0.25	+0.18	+0.22

Table 22: Self Efficacy Before and After Using LaTeX Converted Materials (Mean Increase, All Demographic Subgroups)

Group	N	I feel that I belong to the course community and my educational needs are being met. Δ	I consider myself a member of the engineering or computing world. Δ	Aggregated Δ
All Respondents	236	+0.03	-0.09	-0.03
Male	167	+0.00	-0.15	-0.07
Female	56	+0.04	+0.07	+0.05
SWD	18	+0.56	+0.11	+0.33
SWOD	196	-0.03	-0.09	-0.06
SACAN	47	+0.38	+0.17	+0.28
NON_SACAN	167	-0.08	-0.14	-0.11
White	41	+0.10	-0.27	-0.09
Asian	179	+0.01	-0.03	-0.01

Table 23: Belongingness Before and After Use of LaTeX Converted Materials (Mean Increase, All Demographic Subgroups

Group	N	Typed text Mean (SD)	Typed mathematical equations Mean (SD)	Images Mean (SD)	Typed tables Mean (SD)	Handwritten content Mean (SD)	Aggregated Mean (SD)
All Respondents	236	1.72 (0.91)	2.13 (1.04)	1.87 (0.91)	1.74 (0.90)	2.28 (1.15)	1.95 (0.82)
Male	167	1.68 (0.89)	2.07 (1.00)	1.85 (0.89)	1.75 (0.90)	2.16 (1.08)	1.90 (0.82)
Female	56	1.84 (0.95)	2.34 (1.18)	1.95 (1.02)	1.77 (0.93)	2.64 (1.34)	2.11 (0.86)
SWD	18	1.83 (1.25)	2.39 (1.24)	1.83 (0.86)	1.83 (1.10)	2.56 (1.29)	2.09 (0.93)
SWOD	196	1.68 (0.87)	2.09 (1.02)	1.86 (0.91)	1.72 (0.88)	2.22 (1.15)	1.91 (0.81)
SACAN	47	1.83 (1.05)	2.36 (1.07)	1.91 (0.93)	1.79 (1.04)	2.47 (1.23)	2.07 (0.88)
NON SACAN	167	1.65 (0.86)	2.04 (1.02)	1.84 (0.89)	1.71 (0.86)	2.19 (1.14)	1.89 (0.80)
White	41	1.61 (0.77)	2.00 (0.89)	1.83 (0.77)	1.66 (0.66)	2.46 (1.14)	1.91 (0.66)
Asian	179	1.73 (0.92)	2.15 (1.06)	1.88 (0.94)	1.76 (0.95)	2.23 (1.17)	1.95 (0.85)

Table 24: Frequency of Accessibility Problems with Different Components of Lecture Slides (All Demographic Subgroups)

For this table, examples of accessibility problems:

1. Typed Text - text that is small, hard to read, or low contrast
2. Typed mathematical equations - unclear notation, hard to follow along
3. Images (diagrams, graphs, figures, etc.) - unlabeled axes, low quality images
4. Typed tables - unclear row/column structure, inconsistent formatting
5. Handwritten Content (handwritten text or math, handdrawn images) - illegible, hard to understand

Group	Total N	Exam prep	Homework/ problem solving	Searching and reviewing of content	Sharing/ peer review	Accessibility with assistive technologies	Other
All Respondents	236	214 (90.7%)	191 (80.9%)	174 (73.7%)	38 (16.1%)	17 (7.2%)	4 (1.7%)
Male	167	151 (90.4%)	138 (82.6%)	121 (72.5%)	30 (18.0%)	11 (6.6%)	2 (1.2%)
Female	56	51 (91.1%)	42 (75.0%)	43 (76.8%)	6 (10.7%)	4 (7.1%)	2 (3.6%)
SWD	18	13 (72.2%)	12 (66.7%)	12 (66.7%)	2 (11.1%)	0 (0.0%)	2 (11.1%)
SWOD	196	179 (91.3%)	164 (83.7%)	145 (74.0%)	32 (16.3%)	14 (7.1%)	2 (1.0%)
SACAN	47	39 (83.0%)	35 (74.5%)	30 (63.8%)	7 (14.9%)	3 (6.4%)	3 (6.4%)
NON_SACAN	167	153 (91.6%)	141 (84.4%)	127 (76.0%)	27 (16.2%)	11 (6.6%)	1 (0.6%)
White	41	36 (87.8%)	34 (82.9%)	27 (65.9%)	5 (12.2%)	0 (0.0%)	3 (7.3%)
Asian	179	164 (91.6%)	146 (81.6%)	134 (74.9%)	31 (17.3%)	16 (8.9%)	1 (0.6%)

Table 25: Classroom Activities For Which Lecture Slides Are Useful For (All demographic subgroups)

Content	SWD Count (%) [n]	SWAN Count (%) [n]	Non SACAN Count (%) [n]	Raw P-val	Adj P-val (FDR)
Exam preparation	13 (72.2%) [n=18]	26 (89.7%) [n=29]	153 (91.6%) [n=167]	0.0364 *	0.1092
Homework/problem solving	12 (66.7%) [n=18]	23 (79.3%) [n=29]	141 (84.4%) [n=167]	0.1566	0.3131
Searching and reviewing of content	12 (66.7%) [n=18]	18 (62.1%) [n=29]	127 (76.0%) [n=167]	0.2320	0.3480
Sharing/peer review	2 (11.1%) [n=18]	5 (17.2%) [n=29]	27 (16.2%) [n=167]	0.8366	0.8366
Accessibility with assistive technologies	0 (0.0%) [n=18]	3 (10.3%) [n=29]	11 (6.6%) [n=167]	0.3779	0.4534
Other	2 (11.1%) [n=18]	1 (3.4%) [n=29]	1 (0.6%) [n=167]	0.0060 **	0.0358 *

Table 26: Classroom Activities For Which Lecture Slides are most Helpful With (SWD vs SWAN vs NON SACAN)

Group	Total N	Slides with comprehensive and detailed text explanations	Slides with visuals that illustrate key terms and concepts	Slides with step by step derivations of equations and worked examples of concepts	Slides with a mix of text, images, examples, math, etc.
All Respondents	236	158 (66.9%)	170 (72.0%)	164 (69.5%)	155 (65.7%)
Male	167	108 (64.7%)	120 (71.9%)	111 (66.5%)	110 (65.9%)
Female	56	41 (73.2%)	38 (67.9%)	43 (76.8%)	38 (67.9%)
SWD	18	11 (61.1%)	13 (72.2%)	12 (66.7%)	8 (44.4%)
SWOD	196	132 (67.3%)	142 (72.4%)	136 (69.4%)	134 (68.4%)
SACAN	47	29 (61.7%)	35 (74.5%)	33 (70.2%)	29 (61.7%)
NON SACAN	167	114 (68.3%)	120 (71.9%)	115 (68.9%)	113 (67.7%)
White	41	25 (61.0%)	26 (63.4%)	27 (65.9%)	27 (65.9%)
Asian	179	123 (68.7%)	129 (72.1%)	123 (68.7%)	118 (65.9%)

Table 27: Presentation Styles of Lectures that are most helpful (All demographic subgroups)

For the different presentation styles, female students selected “slides with comprehensive and detailed text explanations” and “slides with step by step derivations of equations and worked examples of concepts” at the highest percentage of any demographic subgroup (73.2% and 76.8% respectively), SACAN selected “slides with visuals that illustrate key terms and concepts the most out of the demographic subgroups (74.5%), and SWOD selected “slides with a mix of text, images, examples, math, etc.” with the greatest percentage out of the demographic subgroups (68.4%).

Question Content	Mean Rank (SD)	Median Rank (IQR)
Slides with comprehensive and detailed text explanations	2.45 (1.20)	2.00 ([1.00, 4.00])
Slides with visuals that illustrate key terms and concepts	2.47 (1.04)	2.00 ([2.00, 3.00])
Slides with step by step derivations of equations and worked examples of concepts	2.32 (1.10)	2.00 ([1.00, 3.00])
Slides with a mix of text images, examples, math, etc.	2.76 (1.09)	3.00 ([2.00, 4.00])

Table 28: Ranking of Presentation Styles of Lectures that are most helpful (All respondents)

Content	Male Mean (SD) [n]	Male Median (IQR)	Female Mean (SD) [n]	Female Median (IQR)	Raw P-val	Adj P-val (FDR)
Slides with comprehensive and detailed text explanations	2.51 (1.20) [n=167]	3.00 ([1.00, 4.00])	2.21 (1.16) [n=56]	2.00 ([1.00, 3.00])	0.1140	0.2280
Slides with visuals that illustrate key terms and concepts	2.42 (1.04) [n=167]	2.00 ([2.00, 3.00])	2.86 (0.94) [n=56]	3.00 ([2.00, 4.00])	0.0057 **	0.0230 *
Slides with step by step derivations of equations and worked examples of concepts	2.35 (1.09) [n=167]	2.00 ([1.00, 3.00])	2.18 (1.15) [n=56]	2.00 ([1.00, 3.00])	0.2936	0.3915
Slides with a mix of text images, examples, math, etc.	2.72 (1.11) [n=167]	3.00 ([2.00, 4.00])	2.75 (1.08) [n=56]	3.00 ([2.00, 4.00])	0.9091	0.9091

Table 29: Ranking of Presentation Styles that are Most Helpful (Male vs Female)

Content	Male Count (%) [n]	Female Count (%) [n]	Raw P-val	Adj P-val (FDR)
Handwritten text	90 (53.9%) [n=167]	41 (73.2%) [n=56]	0.0122 *	0.0487 *
Handwritten mathematical equations	117 (70.1%) [n=167]	43 (76.8%) [n=56]	0.3930	0.5500
Handdrawn images (Diagrams, graphs, figures, etc.)	77 (46.1%) [n=167]	24 (42.9%) [n=56]	0.7569	0.7569
Handdrawn tables	52 (31.1%) [n=167]	21 (37.5%) [n=56]	0.4125	0.5500

Table 30: Handwritten content that Students Would Like to Have Access to in Alternate Format (Male vs Female)

Question Content	Mean Rank (SD)	Median Rank (IQR)
Conversion of handwritten text to typed text	2.00 (1.07)	2.00 ([1.00, 3.00])
Conversion of handwritten mathematical equations to LaTeX Code	2.02 (1.02)	2.00 ([1.00, 3.00])
Conversion of handdrawn images to alternate format (ex. Markdown)	2.76 (0.96)	3.00 ([2.00, 3.25])

Conversion of handdrawn tables to alternate format (ex. Markdown)	3.22 (0.90)	3.00 ([3.00, 4.00])

Table 31: Ranking of Different Types of Converted Handwritten Content (All Respondents)

Group	N	Text to speech support for lecture slides Mean (SD)	Integration of slides with ClassTranscribe's glossary feature Mean (SD)	Conversion of handwritten content to alternate format (ex. handwritten text to typed text, handwritten math notation to LaTex code) Mean (SD)	LaTex for equations in lecture transcripts Mean (SD)	LaTex for equations in live streamed lecture captions Mean (SD)	Aggregated Mean (SD)
All Respondents	236	2.40 (1.28)	2.90 (1.22)	3.43 (1.06)	3.56 (1.06)	3.47 (1.09)	3.15 (0.85)
Male	167	2.43 (1.29)	2.92 (1.25)	3.43 (1.10)	3.57 (1.06)	3.50 (1.11)	3.17 (0.88)
Female	56	2.46 (1.26)	2.98 (1.09)	3.52 (0.99)	3.61 (1.07)	3.48 (1.04)	3.21 (0.78)
SWD	18	2.11 (1.08)	2.61 (1.24)	3.50 (1.10)	3.50 (1.15)	3.33 (1.14)	3.01 (0.89)
SWOD	196	2.44 (1.29)	2.89 (1.23)	3.44 (1.06)	3.60 (1.05)	3.51 (1.08)	3.17 (0.88)
SACAN	47	2.57 (1.38)	2.87 (1.31)	3.49 (1.12)	3.53 (1.12)	3.40 (1.10)	3.17 (0.98)
NON_SACAN	167	2.37 (1.25)	2.87 (1.21)	3.43 (1.04)	3.60 (1.04)	3.51 (1.09)	3.16 (0.85)

White	41	1.98 (1.13)	2.61 (1.38)	3.10 (1.22)	3.32 (1.21)	3.10 (1.22)	2.82 (0.95)
Asian	179	2.51 (1.28)	2.96 (1.17)	3.50 (1.02)	3.63 (1.01)	3.57 (1.03)	3.23 (0.84)

Table 32: Accessibility Related Features Students Would Like to have access to (All Demographic Subgroups)

For the group of accessibility related features, SACAN had the highest mean score for potential usefulness with respect to “text to speech support for lecture slides” (2.57). For “integration of slides with ClassTranscribe’s glossary feature” and “conversion of handwritten content to alternate format”, female students reported the highest mean scores (2.98, 3.52 respectively). Asian students had the highest mean score for “LaTeX for equations in lecture transcripts” and “LaTeX for equations in live-streamed lecture captions” (3.63, 3.57 respectively).

Group	**N**	**Exam prep Mean (SD)**	**Homework/problem solving Mean (SD)**	**Searching or reviewing of content Mean (SD)**	**Sharing/ peer review Mean (SD)**	**Aggregated Mean (SD)**
All Respondents	236	3.66 (1.03)	3.76 (1.03)	3.83 (1.01)	3.38 (1.05)	3.66 (0.85)
Male	167	3.66 (1.03)	3.78 (1.00)	3.80 (1.02)	3.37 (0.98)	3.65 (0.82)
Female	56	3.71 (0.99)	3.71 (1.11)	3.95 (0.92)	3.34 (1.18)	3.68 (0.90)
SWD	18	3.44 (0.98)	3.56 (0.92)	3.56 (1.10)	3.17 (1.10)	3.43 (0.84)
SWOD	196	3.69 (1.01)	3.80 (1.03)	3.88 (0.99)	3.41 (1.04)	3.70 (0.84)
SACAN	47	3.66 (0.81)	3.91 (0.83)	3.91 (0.97)	3.45 (1.02)	3.73 (0.76)

NON SACAN	167	3.67 (1.06)	3.74 (1.07)	3.84 (1.01)	3.38 (1.06)	3.66 (0.86)
White	41	3.61 (1.00)	3.63 (0.94)	3.78 (0.91)	3.32 (1.06)	3.59 (0.75)
Asian	179	3.72 (1.02)	3.84 (1.02)	3.86 (1.03)	3.40 (1.05)	3.70 (0.86)

Table 33: Classroom Activities for which LaTeX Converted Materials Would Be Helpful with (all demographic subgroups)

After evaluating across every demographic subgroup, this ordering is mostly consistent, with a few exceptions. For female students, “exam preparation” and “homework/problem solving” had the same average score. For SWD, “homework/problem solving” and “searching or reviewing of content” had the same average score. For SACAN, “homework/problem solving” and “searching or reviewing of content” also had the same average score. SACAN reported the highest aggregated average usefulness score (3.73), while SWD reported the lowest (3.43).

Question Content	**Mean (SD)**	**Median (IQR)**
Using assistive technologies (ex. screen reader)	3.72 (1.06)	4.00 ([3.00, 5.00])
OVERALL AGGREGATED SCORE	3.72 (1.06)	4.00 ([3.00, 5.00])

Table 34: Classroom Activities for which LaTeX Converted Materials Would Be Helpful with (all respondents)

Group	N	This set of converted and formatted lecture slides can help me better perceive the content presented on lecture slides. Mean (SD)	This set of converted and formatted lecture slides can increase my understanding of the content. Mean (SD)	This set of converted and formatted lecture slides can help other students in the course, and I would recommend it to others. Mean (SD)	Aggregated Mean (SD)
All Respondents	236	3.87 (0.90)	3.85 (0.89)	3.94 (0.89)	3.89 (0.82)
Male	167	3.90 (0.93)	3.86 (0.88)	3.97 (0.89)	3.91 (0.84)
Female	56	3.82 (0.81)	3.86 (0.90)	3.89 (0.91)	3.86 (0.80)
SWD	18	3.72 (0.96)	3.67 (0.97)	3.67 (0.91)	3.69 (0.87)
SWOD	196	3.90 (0.91)	3.89 (0.89)	3.98 (0.90)	3.92 (0.83)
SACAN	47	4.00 (0.83)	3.91 (0.86)	3.83 (0.92)	3.91 (0.79)
NON SACAN	167	3.85 (0.94)	3.86 (0.91)	3.99 (0.90)	3.90 (0.85)
White	41	4.07 (0.69)	3.95 (0.71)	4.12 (0.78)	4.05 (0.63)
Asian	179	3.87 (0.94)	3.85 (0.92)	3.94 (0.91)	3.89 (0.86)

Table 35: General Feedback on LaTeX Converted Materials (All Demographic Subgroups)

<table>
<tr><th>Question Type</th><th>Question</th></tr>
<tr><td>Experience with lecture slides</td><td>1) When going through slides for a given lecture in your course, how frequently do you encounter accessibility problems with the following components of the slides? (Never, Sometimes, About half the time, Most of the time, Always)
a) Typed text (ex. text that is small, hard to read, or low contrast)
b) Typed mathematical equations (ex. unclear notation, hard to follow along)
c) Images (diagrams, graphs, figures, etc.) (ex. unlabeled axes, low quality images)
d) Typed tables (ex. unclear row/column structure, inconsistent formatting)
e) Handwritten content (handwritten text or math, handdrawn images) (ex. illegible, hard to understand)
2) For which of the following classroom activities does using lecture slides help you? Please select all that apply.
a) Exam preparation
b) Homework/problem solving
c) Searching and reviewing of content
d) Sharing/peer review
e) Accessibility with assistive technologies (ex. screen reader, magnifier)
f) Other
3) Which of the following presentation styles of lectures best helps you learn the content? Please select all that apply.
a) Slides with comprehensive and detailed text explanations
b) Slides with visuals that illustrate key terms and concepts
c) Slides with step by step derivations of equations and worked examples of concepts
d) Slides with a mix of text, images, examples, math, etc.
4) Please rank the following presentation styles of lecture slides in terms of how useful they are to you for learning content (1-most useful, 4-least useful)
a) Slides with comprehensive and detailed text explanations
b) Slides with visuals that illustrate key terms and concepts
c) Slides with step by step derivations of equations and worked examples of concepts
d) Slides with a mix of text, images, examples, math, etc.</td></tr>
<tr><td>Accessibility, self-efficacy, and belongingness</td><td>1) Please select how much you agree with the following statements (Strongly disagree, Somewhat disagree, Neither agree nor disagree, Somewhat agree, Strongly agree)
a) I can fully and easily perceive the materials in these lecture slides using my senses (viewing, reading, etc.)
b) I can visually navigate and follow along with the content in these lecture slides.
c) Given the structure and presentation of the materials in these slides (layout, text, equations, figures, diagrams, etc.), I can understand the information in these slides.</td></tr>
</table>

	d) The materials in these slides would be compatible with alternative formats (ex. device format, screen reader, other assistive technologies) e) After going through these slides, I am able to comprehend and utilize the information covered in these slides. f) After going through these slides, I am confident that I can succeed in classroom activities related to these slides (exam prep, homework, peer collaboration, etc.) g) I feel that I belong to the course community and my educational needs are being met. h) I consider myself a member of the engineering or computing world.
Handwritten content	1) Out of the following **handwritten** components of lecture slides, which would you like to have access to in an alternate format (ex. Handwritten to typed text, handwritten equations and tables to LaTeX and Markdown)? Please select all that apply. a) Handwritten text b) Handwritten mathematical equations c) Hand-drawn images (Diagrams, graphs, figures, etc.) d) Hand-drawn tables 2) Please rank the following features in terms of how useful this feature for lecture slide would be to you in helping you learn the content (1-most useful, 4-least useful a) Conversion of handwritten text to typed text b) Conversion of handwritten mathematical equations to LaTex code c) Conversion of handdrawn images to alternate format (ex. Markdown) d) Conversion of handdrawn tables to alternate format (ex. Markdown)
Accessibility related features	1) If you were preparing for a classroom activity (ex. Exam prep, homework, peer collaboration, etc.) please indicate how helpful the feature would be. (*Not at all useful, Somewhat useful, Moderately useful, Very useful, Extremely useful*) a) Text to speech support for lecture slides b) Integration of slides with ClassTranscribe's glossary feature c) Conversion of handwritten content to alternate format (ex. handwritten text to typed text, handwritten mathematical notation to LaTeX code) d) LaTeX for equations in lecture transcripts e) LaTeX for equations in live-streamed lecture captions
Demographics	1) Please select the course for which you are responding. 2) What is your gender identity? 3) Choose one or more race/ethnic group you consider yourself to be 4) I have a disability or disorder that makes it harder for me to succeed in this course. 5) Students with physical disabilities are those who reported that they had one or more of the following conditions: blindness or visual impairment that cannot be corrected by wearing glasses; hearing impairment (e.g. deaf or hard of hearing); orthopedic or mobility impairment; physical impairment or problem. Do you identify as a person with a physical disability?

	a) (If yes was selected) Which of the following describes your physical disability? (*Blind or Visual impairment, Deaf or Hard of hearing, Both of the above, none of the above*) 6) Students with mental or emotional disabilities are those who reported that they had one or more of the following conditions: speech of language impediment; learning, mental, emotional, or psychiatric condition (e.g. serious learning disability, depression, ADD, or ADHD); or other mental or emotional health impairment or problem. Do you identify as a person with a mental/emotional disability? 7) Do you utilize Disability Resource & Education Services (DRES)? 8) Are there times when you are unable to attend scheduled course activities due to a health issue (e.g. chronic migraine, chronic digestive issue, period pain) that is not classified as a disability?

Table 36: Survey 1 Questions

Question Type	**Question**
Accessibility, Self-efficacy, and Belongingness	1) Please indicate how much you agree with the following statements, after interacting with the additional lecture materials in Canvas that provided the lecture slides with formatted mathematical content. (*Strongly disagree, Somewhat disagree, Neither disagree nor agree, Somewhat agree, Strongly agree*) a) I can fully and easily perceive the materials in these lecture slides using my senses (viewing, reading, etc.) b) I can visually navigate and follow along with the content in these lecture slides. c) Given the structure and presentation of the materials in these slides (layout, text, equations, figures, diagrams, etc.), I can understand the information in these slides. d) After going through these slides, I am able to comprehend and utilize the information covered in these slides. e) After going through these slides, I am confident that I can succeed in classroom activities related to these slides (exam prep, homework, peer collaboration, etc.) f) I feel that I belong to the course community and my educational needs are being met. g) I consider myself a member of the engineering or computing world. 2) Please indicate how much you agree with the following statements, after interacting with the additional lecture materials in Canvas that provided the lecture slides with formatted mathematical content. If you do not use assistive technologies, please select “Don’t know”. (Strongly disagree, Somewhat disagree, Neither disagree nor agree, Somewhat agree, Strongly agree, Don’t know) a) The materials in these slides would be compatible with alternative

	formats (ex. device format, screen reader, other assistive technologies)
Use cases for LaTeX Converted Materials	1) Given these converted and formatted lecture slides on Canvas, please indicate how useful this format of slides can be for you when preparing for the following classroom activities. (*Not at all useful, Slightly useful, Moderately useful, Very useful, Extremely useful*) a) Exam preparation b) Homework/problem solving c) Searching or reviewing of content d) Sharing/peer review 2) Given these converted and formatted lecture slides on Canvas, please indicate how useful this format of slides can be for you when preparing for the following classroom activities. If you do not use assistive technologies, please select "Don't know). (*Not at all useful, Slightly useful, Moderately useful, Very useful, Extremely useful, Don't know*) a) Using assistive technologies (ex. screen reader) 3) Please indicate how much you agree with the following statements about the converted and formatted lecture slides in Canvas (*Strongly disagree, Somewhat disagree, Neither agree nor disagree, Somewhat agree, Strongly agree*) a) This set of converted and formatted lecture slides can help me better perceive the content presented on lecture slides. b) This set of converted and formatted lecture slides can increase my understanding of the content. c) This set of converted and formatted lecture slides can help other students in the course, and I would recommend it to others.
Open-ended Questions	1) What benefits do you see from using these additional converted and formatted lecture slides on Canvas, apart from the extra credit you receive? If you see none, please enter N/A. 2) Did you have any complaints regarding these additional converted and formatted lecture slides on Canvas, or did you encounter any issues or errors while using them? If so, please explain. If you have none, please enter N/A. 3) How would you describe your experience using these additional converted and formatted lecture slides on Canvas? 4) Do you have any feedback for certain features or areas of improvement for these additional converted and formatted lecture slides on Canvas? If so, please explain. If you have none, please enter N/A. 5) How many of the lectures from the additional set of converted and formatted lecture slides on Canvas did you review?

Table 37: Survey 2 Questions