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Understanding the needs of students to make Mathematics and other STEM Contents more accessible in college Engineering courses

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Understanding the needs of students to make Mathematics and other STEM Contents more accessible in college Engineering courses

Abstract

Making digital content accessible is essential for student success in engineering courses. Previously, we found that the digital books generated from lecture videos with transcriptions as a Universal Design for Learning (UDL) approach helped all students retain course content, particularly for Students with Disabilities (SWD). Furthermore, we found Students with Accessibility Needs (SWAN) improved their sense of belonging, self-efficacy, and perceived learning significantly. However, we recognize there is a common unmet need to make mathematical equations, terms, or subject-specific diagrams more accessible. In addition, there is a lack of understanding of the Math accessibility needs of students from different demographic backgrounds in Engineering schools.

In order to identify the students' needs for improved accessibility to Science, Technology, Engineering, and Mathematics (STEM) content that include equations and diagrams, we surveyed a large number of Engineering students (predominantly undergraduate students) regarding their experience with equations and diagrams in six Engineering courses of Fall 2024 at the University of Illinois Urbana-Champaign (UIUC).

We ask all students to respond to their experience and preferences in multiple elements in Math delivery, specific preferences in equation formats, diagram formats, equations and diagrams' captioning, and explanation styles. The surveys allow students with physical, mental, and/or emotional disabilities to self-report as SWD. Additionally, we identify students as Students with Access Challenges and Accommodation Needs (SACAN) if they faced conditions that prevented them from attending class at some point, regardless of whether they have an official letter of accommodations. In addition, we ask students for their gender and racial status so that their needs in learning Math and STEM contents can be understood.

The resulting 669 survey responses produced new insights on accessibility features of Math equations, diagrams, and better text captioning style commonly desired by students and differences between demographic groups as to disability, gender and ethnicity. Up until now, there have been few studies about the accessibility of Math in general, let alone large-scale studies about college Math/STEM content's accessibility.

We found most students in this study possessed a growth mindset that aligned with expert view although the Asian students are less positive about the potential growth of Math learning ability. Students predominantly appreciate worked-out examples, breaking-down of Math problems, and examples from real world applications when Math contents are presented. As to the format of

Math equations, most students prefer the Latex format for the presentation, and most students prefer the graphs to be presented from multiple perspectives with examples. SWD responded with mostly the same attitude and preferences regarding Math learning, although the physically disabled students need more support in “Breaking down of concepts/problems,” “Graphs and Diagrams,” and “Assessment/quizzes”. We also found female students may have a higher need for the support of “Voice to text description” and “Image to text description.”

With the identified needs, we will develop open source software tools and features based on our previous digital learning software platform to improve the accessibility of Math and STEM content in equations and diagrams accordingly.

Introduction

This paper presents findings from a two-part Universal Design for Learning (UDL) based survey conducted at the University of Illinois Urbana-Champaign during the Fall 2024 semester. The survey targeted over 1000 students across six engineering courses to explore their experiences with and preferences for MATH and STEM instructional content. Students were asked about their experiences and preferences for equation formats, diagram accessibility, captioning, and delivery methods. The survey also included self-reported demographic information such as gender, ethnicity, disability status (physical or mental), and whether they faced access challenges, allowing us to compare experiences across different student groups. The study aims to uncover specific barriers and preferences related to equations, graphs, and transcriptions in MATH content, providing actionable insights for designing tools that address diverse accessibility needs among student groups.

Background

Universal Design for Learning (UDL)

UDL is an inclusive teaching framework that improves learning for all students by providing multiple means of engagement, representation, and expression. It emphasizes flexible approaches, such as offering content in various formats (e.g., text, audio, video) and diverse assessment methods to accommodate different needs, particularly benefiting students with disabilities (SWD).

Prior research has explored various ways to apply UDL principles in STEM education. For example, researchers have developed digital note systems that automatically generate accessible content from lecture videos, combining text, images, image descriptions, and hyperlinks, and allowing instructor customization [1]. These tools have shown promise in improving both content accessibility and learning outcomes [2]. On the instructor side, a recent survey found high motivation among faculty to adopt UDL practices, though a lack of time and awareness remains a major barrier [3].

In particular, Mathematics and other STEM subjects present unique accessibility challenges due to the use of complex symbols, graphs, and technical content. In these contexts, applying UDL principles is especially important for building inclusive and effective learning environments.

Accessibility in Mathematics

A core motivation for UDL and accessibility tools in general is the accommodation of students with disabilities or accessibility needs. Most commonly, instructors may interact with visually impaired and hard of hearing students. However, much of educational content in Mathematics and STEM depend on auditory and visual information in the form of diagrams, graphs, tables, and equations. This imposes challenges towards inclusive and effective learning for students with accessibility needs, such as those with visual impairment, often requiring specialized accommodations or proactive application of accessible guidelines [4].

This need for accessibility guidelines and tools is magnified by modern practices in digitalization of educational content. As online learning management systems and virtual learning formats have popularized, ensuring inclusivity through techniques like those from UDL is critical [5]. While some academic fields are more textual in nature and can more easily incorporate accessibility practices like transcription of audio and text-to-speech, STEM courses can strongly benefit from a robust framework for making all forms of educational tools accessible. According to Wall Emerson, students desired descriptions of visual math images and that these descriptions provided greater accessibility and understanding [6]. Yet, descriptions alone were not sufficient for strong student performance in Math. Our study dives further into these descriptions of visual content to uncover best practices in textual representations of complex data.

Previous work in the accessibility of Mathematics span various techniques from gamification of math problems to auditory frameworks for graphics [4]. On handling mathematical equations, prescribed accessibility practices include standardized text rendering through software like MathML, support for Braille through Nemeth code, and many other guidelines for textual and spoken math. Notably, Phillips developed Process-Driven Math (PDM), a fully audio method of Math instruction and assessment to accommodate students with visual and/or physical disabilities, demonstrating the value of alternative learning modalities in presenting Mathematical material [7]. Another objective of this paper is to distill some of these methodologies and understand which tool features are preferred in maximizing student learning outcomes.

Student Attitudes in Mathematics

Past research indicates that student attitudes have a profound impact on educational outcomes. As measured by Grade Point Average (GPA) and difficulty level of enrolled courses, many studies have shown that students with growth mindsets performed significantly better than students with fixed mindsets [8]. This general conclusion naturally also applies to higher education Mathematics which studies by Warren Code [9] demonstrated. A primary representation of student attitudes in Mathematics is the belief in a growth mindset towards improving Math-related skills. In Code's Mathematics Attitudes and Perceptions Survey (MAPS) instrument, representative statements include "Math ability is something about a person that cannot be changed very much" and "nearly everyone is capable of understanding math if they work at it." Such statements allow for profiling of students in attitude categories of confidence, mindset, persistence, etc. In our study, emphasis was placed on understanding student mindsets and analyzing how such students' mindset associates with other responses from students in Math accessibility.

Methods

Survey Design

A two-part survey was administered to undergraduate and graduate students from various Engineering departments. The first survey primarily focused on students' demographic information, academic experiences/view regarding the Math learning process while the second survey analyzed students' preferences through direct comparison and Likert-type scale questions.

We emphasize two distinct types of Mathematical content: equations and diagrams. Presentations of Mathematical equations vary across multiple dimensions, including choice of rendering (plain text vs. LaTeX vs. markup vs. image) and transcription spellings (e.g. "equals" vs. "="). For diagrams, whether it be function plots or data visualizations, we investigate best practices for their usage and transcription.

Together, the surveys addressed the following research questions and all questions were investigated by stratification of students using disability, gender, and ethnicity information.

1. Do students have the same view regarding growth mindset?
2. Do students have differences/similarities regarding experience and importance for the different elements in learning Math (Process i.e. breaking down of concepts/problems, Worked out examples, Graphs, Tables, Diagrams, Simulation, Math equations, Voice recording, Voice-text description, Image-text description, assessment/quizzes, problem solving in class, games in class)? If yes, what are the differences/similarities?
3. Do students have differences/similarities regarding preferences for the description of Math or Programming using Voice? If yes, what are the different needs?
4. Do students have differences/similarities regarding preferences for the description of Math or Programming using images/captioning directly from images? If yes, what are the different needs?
5. Do students have differences/similarities regarding their purpose for the Math contents such as equation, diagrams?
6. Do students have differences/similarities regarding the format of Math equations such as images, latex, ML markup, etc?

The first question is directly motivated by Code's work on MAPS, generating additional data for learning attitudes of students to contextualize their learning preferences. Our survey selected a subset of the questions presented by Code to avoid exhaustion for student respondents. The other research questions follow from our objectives to understand student learning preferences and optimize best educational practices for improving accessibility and effectiveness of learning in mathematics and STEM courses.

These surveys were Institutional Review Board (IRB) approved and extra credit in courses selected for the survey were given to students who completed the surveys as an incentive to participate. However, to ensure voluntary participation, students were given alternatives to earn the extra credit in the form of attending a 30-minute workshop on UDL-based tools.

Survey Questions

In the first survey, optional demographic questions on gender identity, race/ethnicity, and disability (type, status, and learning impact) were given for understanding of student distributions and analysis of differences in preferences across demographic categories. Most notably, the series of disability-related questions enabled segmentation of the student body into students with disability (SWD), students with access challenges and accommodation needs (SACAN), and students without disability needs (SWOD). Additionally, through Likert-scale type questions, students were assessed on their belief in growth mindset for Math ability and frequency of experiences in accessibility problems within various educational tools. For the latter, example tools with potential accessibility issues are tables, math equations, voice recordings, assessment/quizzes.

The second survey focuses extensively on student preferences of various educational features. Many of the questions display an example of course material and query for students' preferences and perceived helpfulness of the course material's attributes. For example, one question provided a data visualization and asked for the importance of graphical features like axes labels, titles/labels, context, sample data points, and interpretations. Another question tested students' learning preferences by presenting a difficult equation and analyzing students' perceived value of various sample explanations of the equation. We have attached the full list of survey questions in the Appendix (Table 19 and 20).

Demographics

We collected survey responses from 669 students enrolled in various engineering courses. Part 1 received responses from all 669 students, while Part 2 received 604 responses. Although the surveys were distributed simultaneously, the difference in participation may be due to Part 2 requiring more time to complete compared to Part 1. Additionally, we requested that students at least complete Part 1 to ensure we gathered demographic information.

The survey allowed students to self-report their disability and accessibility needs. Students with Disabilities (SWD), including those with physical, mental, or emotional disabilities, were grouped with Students with Accessible Needs (SWAN)—students who faced conditions preventing them from fully participating in coursework but did not have an officially recognized disability. Together, SWD and SWAN formed the SACAN group. The remaining students who were neither identified as SWD nor SWAN were categorized as NON_SACAN. Additionally, Students Without Disabilities (SWOD) included both SWAN and NON_SACAN groups.

Both parts included students who identified as Male, Female, or Non_Binary, with the majority being Male. In terms of ethnicity, most participants identified as Asian, followed by White, with a smaller proportion representing other ethnic groups. The survey also captured responses from students across various engineering courses, reflecting a diverse range of disciplines.

Comprehensive demographic details, including gender, ethnicity, disability status, and course participation, are provided in Table 1 and 2.

Part	Total	Male	Female	Non-binary	White	Asian	Latinx	Other/ Mixed	CS Class	ECE&IE Class
1	669	479	186	4	113	522	20	30	487	193
2	604	433	167	4	104	470	20	26	438	151

Table 1: Demographics of two surveys - Gender, Ethnicity, and Course (CS for Computer science, ECE for Electrical and Computer Engineering, IE for Industrial Engineering)

Part	Total	SWD	Physical SWD	Mental SWD	Male SWD	Female SWD	SWAN	SWOD	SACAN	NON_SACAN
1	669	75	14	63	47	22	124	562	199	438
2	604	66	12	56	42	18	117	511	183	394

Table 2: Demographics of two surveys - Self-reported disability status

Data Analysis

The survey was anonymized, cleaned, and tested for internal consistency using Cronbach's alpha [10]. Cronbach's alpha values of 0.923 for Part 1 and 0.802 for Part 2 were obtained, indicating reliability and consistency in the survey.

Questions with categorical responses – for example, prefer Greek letter version or alphanumeric version when transcribing mathematical equations - were examined using contingency tables across demographic groups (e.g., gender, ethnicity, and disability status). Chi-square tests were performed to evaluate the independence of these groupings.

For questions with responses on a Likert scale, higher scores indicated more positive responses, while lower scores reflected more negative ones. At the individual question level, metrics such as mean, median, and positive rates were calculated. For comparisons among two groups, the Mann–Whitney U test was employed to identify differences, while for analyses involving more than two groups, such as ethnicity (e.g., White, Asian, Other Race), the Kruskal-Wallis test was used to evaluate overall differences. Pairwise comparisons between groups were subsequently conducted if significant differences were found. To ensure statistical rigor and account for multiple tests, p-values were adjusted using the Benjamini-Hochberg procedure to control the False Discovery Rate (FDR) [11].

Results

1) Findings about the differences and similarities of student groups' Math learning attitude via a published growth mindset instrument

Overall Attitudes

Most students align with the expert perspective that math ability and understanding can be improved through effort [9]:

a) 81.6% of students disagreed or were neutral toward the statement "Math ability is something about a person that cannot be changed very much."

b) 70.1% of students agreed that “Nearly everyone is capable of understanding math if they work at it.”

c) 68% of students disagreed or were neutral toward the statement “Being good at math requires natural (i.e., innate, inborn) intelligence in math.”

Differences Between Asian and White Student Groups

Significant differences (corrected p <0.001) were observed between Asian and White students for two of these questions, with White students aligning more closely with the expert perspective about growth mindset [9]:

a) For the statement “Being good at math requires natural (i.e., innate, inborn) intelligence in math” 82.3% of White students disagreed or were neutral, compared to 64.1% of Asian students

b) For the statement “Math ability is something about a person that cannot be changed very much” 91.2% of White students disagreed or were neutral, compared to 79.5% of Asian students.

Category	Survey Part 1				Survey Part 2			
	Positive	Neutral	Negative	Total	Positive	Neutral	Negative	Total
All	441 (64.9%)	101 (14.9%)	137 (20.2%)	679	403 (66.1%)	89 (14.6%)	118 (19.3%)	610
Male	314 (65.7%)	69 (14.4%)	95 (19.9%)	478	284 (65.7%)	63 (14.6%)	85 (19.7%)	432
Female	118 (63.4%)	30 (16.1%)	38 (20.4%)	186	110 (65.9%)	26 (15.6%)	31 (18.6%)	167
SWD	51 (68.0%)	10 (13.3%)	14 (18.7%)	75	45 (68.2%)	8 (12.1%)	13 (19.7%)	66
SWOD	372 (66.3%)	78 (13.9%)	111 (19.8%)	561	343 (67.3%)	71 (13.9%)	96 (18.8%)	510
SACAN	131 (65.8%)	26 (13.1%)	42 (21.1%)	199	124 (67.8%)	21 (11.5%)	38 (20.8%)	183
NON-SACAN	292 (66.8%)	62 (14.2%)	83 (19.0%)	437	264 (67.2%)	58 (14.8%)	71 (18.1%)	393

Table 3: Distribution of Mindset Categories Across Groups (Part 1 & Part 2)

Categorizing Growth Mindset for Further Analysis

To ensure consistency in the interpretation of responses regarding growth mindset, we reversed the Likert scale for the two statements where disagreement aligns with the expert perspective—“Math ability is something about a person that cannot be changed very much” and “Being good at math requires natural (i.e., innate, inborn) intelligence in math.” Specifically, responses were transformed such that $1 \rightarrow 5$, $2 \rightarrow 4$, making higher scores consistently indicate a stronger alignment with the expert-endorsed growth mindset.

We then computed an average mindset score based on these three questions. Students with an average score greater than 3 were categorized as having a positive mindset, those with an average score of exactly 3 as neutral mindset, and those with an average score below 3 as negative mindset. Table 3 presents the overall distribution of mindset categories, as well as breakdowns by key sub-groups.

After discussing other aspects of students’ learning experiences, we will present in the final section whether and how different mindset categories associate with responses to other survey questions.

2) Findings about the similarities and differences in the frequency of Math accessibility issues in common Math learning components

To explore the frequency of accessibility problems in Math learning, students were asked how often they encountered issues with various course components, such as breaking down concepts or problems, worked-out examples, etc.

Frequency of Math Accessibility Issues for All Students

Students reported experiencing accessibility challenges across various Math learning components. The top two components with the highest frequency of reported issues were “Breaking down of concepts/problems” (36.7%) and “Worked out examples” (33%). Table 4 lists all components ranked by the frequency of accessibility issues reported by students.

Gender-Based Differences in Accessibility Issues

Gender-based differences were observed in certain components of Math accessibility. Female students experienced more challenges than male students on average in “Voice to text description” (22.7% vs. 17.1%; corrected $p = 0.08$) and “Image to text description” (25.5% vs. 18.4%; corrected $p = 0.08$).

Differences in Accessibility Issues Between Asian and White Student Groups

Asian students reported encountering accessibility problems significantly more frequently than White students across nearly all components (corrected $p < 0.005$ for most components, except for two), possibly stemming from cultural or language-related factors. A detailed breakdown of these comparisons is shown in Table 5.

Difference in Accessibility Issues Between SWD and SWOD

The average frequency rate of encountering accessibility problems across the 12 Math learning components was significantly lower for SWD (18.8%) compared to SWOD (25.6%) ($p=0.034$).

Components	μ	Median	Positive rate (%)
Breaking down of concepts/problems	2.85	3	36.7
Worked out examples	2.77	3	33.0
Problem solving in class	2.65	3	29.3
Math equations	2.63	3	29.0
Graphs and Diagrams	2.65	3	28.6
Assessment/quizzes	2.57	2	27.7
Voice recording	2.38	2	21.0
Tables	2.49	2	20.8
Simulation	2.43	2	20.3
Image to text description	2.38	2	20.1
Voice to text description	2.32	2	18.2
Props/games in class	2.26	2	16.0

Table 4: Overall Frequency of Accessibility Challenges in Math Learning Components

Further analysis subdivided the SWD group into Physical SWD (n=14) and Mental SWD (n=63) and compared their frequency rates for each component against SWOD. In the Physical SWD group (Table 6), although the sample size is small and statistical significance was not achieved, these students reported noticeably higher frequency rates than SWOD in components such as “Breaking down of concepts/problems,” “Graphs and Diagrams,” and “Assessment/quizzes.” In contrast, the Mental SWD group (Table 7) exhibited significantly lower frequency rates compared to SWOD in components such as “Graphs and Diagrams” and “Tables” (corrected $p < 0.05$).

Since Mental SWD constitutes the majority of the SWD group, their results closely align with the overall SWD findings, showing a lower frequency rate of accessibility problems across most components. However, Physical SWD reported a rate of more than 50% (57.1% Physical SWD vs 36.9% SWOD, median of 4 Physical SWD vs 3 SWOD) in components such as “Breaking down of concepts/problems,” “Graphs and Diagrams,” and “Assessment/quizzes.” These findings suggest potential disparities in accessibility support for Physical SWD and should not be overlooked.

3) Findings about the similarities and differences in the importance of future improvements in common Math learning components

To identify which course components students considered most important to improve in terms of accessibility, we asked students to evaluate elements such as worked-out examples, breaking down concepts or problems, etc.

Components	White			Asian			
	μ	Median	Pos (%)	μ	Median	Pos (%)	Corrected p-val
Tables	2.03	2	12.4	2.58	3	22.5	< 0.001
Simulation	1.97	2	8.0	2.52	2	23.0	< 0.001
Graphs and Diagrams	2.20	2	16.1	2.72	3	30.5	< 0.001
Assessment/quizzes	2.11	2	17.7	2.65	3	29.7	< 0.001
Image to text description	2.01	2	13.4	2.45	2	21.7	0.002
Problem solving in class	2.24	2	20.4	2.71	3	30.5	0.002
Props/games in class	1.90	2	8.0	2.33	2	17.8	0.002
Worked out examples	2.38	2	23.0	2.85	3	35.2	0.002
Math equations	2.25	2	18.6	2.70	3	30.9	0.003
Breaking down of concepts/problems	2.47	2	27.7	2.91	3	38.2	0.005
Voice to text description	2.05	2	14.3	2.37	2	18.9	0.017
Voice recording	2.19	2	19.5	2.41	2	21.0	0.096

Table 5: Frequency of Accessibility Challenges between White and Asian student groups

Importance of Future Improvements in Math Learning Components

From the student responses, we found "Worked out examples" (74.5%) and "Breaking down of concepts/problems" (72.6%) are the most important components for future improvements, with much higher positive rates compared to other components. Table 8 ranks all components by the importance of future improvements as reported by students.

Gender-Based Differences in Importance

More percentage of female students considered it important to improve "Voice to text description" (43.7% vs. 32.7%; corrected $p < 0.01$) and "Image to text description" (44.8% vs. 34.4%; corrected $p < 0.01$) than male students. This indicates a potential gender difference in how students value tools for converting visual or spoken content into text.

Differences Between Asian and White Student Groups

Asian and White student groups showed significant differences in their views on the importance of improving "Graphs and Diagrams" (59.1% vs. 35.7%; corrected $p < 0.01$) and "Tables" (44.9% vs. 22.5%; corrected $p < 0.01$).

Differences Between SACAN and NON_SACAN Groups

SACAN students (n = 199) responded with higher positive rates for the importance of improving several course components compared to NON_SACAN students (n = 438), although some of

Components	Physical SWD			SWOD			
	μ	Median	Pos (%)	μ	Median	Pos (%)	p-value/ Corrected p
Breaking down of concepts/problems	3.14	4	57.1	2.85	3	36.9	0.371/0.846
Graphs and Diagrams	3.23	3	46.2	2.66	3	29.2	0.129/0.846
Assessment/quizzes	2.86	3	42.9	2.58	2	28.4	0.476/0.846
Worked out examples	2.64	2.5	28.6	2.76	3	32.8	0.665/0.846
Math equations	2.86	3	28.6	2.63	3	29.3	0.594/0.846
Problem solving in class	2.86	3	28.6	2.64	3	29.9	0.508/0.846
Tables	2.50	2.5	21.4	2.51	3	21.2	0.941/0.941
Simulation	2.50	2.5	21.4	2.46	2	21.3	0.941/0.941
Voice recording	2.21	2	7.1	2.38	2	21.3	0.705/0.846
Voice to text description	2.07	2	7.1	2.33	2	19.0	0.442/0.846
Image to text description	2.07	2	14.3	2.40	2	21.0	0.291/0.846
Props/games in class	2.00	2	7.1	2.25	2	16.4	0.409/0.846

Table 6: Frequency of Accessibility Challenges between Physical SWD and SWOD

these items reached significance only before correction. For “Breaking down concepts/problems,” 80.8% of SACAN students considered it important for improvement, compared to 69.8% of NON_SACAN students ($p < 0.004$, corrected $p = 0.056$). Similarly, 80.3% of SACAN students rated “Worked out examples” as important for improvement, compared to 73.0% of NON_SACAN students ($p = 0.019$, corrected $p = 0.116$). For “Props/games in class,” 32.8% of SACAN students identified it as important for improvement, compared to 30.0% of NON_SACAN students ($p = 0.047$, corrected $p = 0.19$).

4) Important purposes of the Math equations and diagrams

To explore the utility of Mathematical equations and diagrams in classroom activities, we asked students which activities these tools are most helpful for. Via Chi-square analysis, we found no significant differences among groups, with activities ranked by frequency as follows: (1) Homework assignments, (2) Exams/Quizzes, (3) Understanding concepts/information in course materials, (4) Searching for content, and (5) Collaboration with classmates during office hours. The consistent ranking and the over 200 responses for each activity highlight the overall importance of Mathematical equations and diagrams. Detailed counts are presented in Table 9.

5) Findings about the format preference for math equations in the common learning scenario

To determine which format for Math equations students prefer in various learning scenarios, we examined their preferences across contexts such as “First encountering math equations in Zoom,

Components	Mental SWD			SWOD			
	μ	Median	Pos (%)	μ	Median	Pos (%)	Corrected p-value
Graphs and Diagrams	2.14	2	11.1	2.66	3	29.2	0.015
Tables	2.08	2	9.7	2.51	3	21.2	0.015
Simulation	2.00	2	9.7	2.46	2	21.3	0.015
Image to text description	2.00	2	12.9	2.40	2	21.0	0.036
Assessment/quizzes	2.31	2	19.7	2.58	2	28.4	0.299
Math equations	2.40	2	21.0	2.63	3	29.3	0.308
Voice to text description	2.11	2	14.3	2.33	2	19.0	0.308
Props/games in class	2.10	2	12.7	2.25	2	16.4	0.451
Voice recording	2.27	2	17.5	2.38	2	21.3	0.547
Problem solving in class	2.51	3	23.8	2.64	3	29.9	0.547
Breaking down of concepts/problems	2.78	3	28.6	2.85	3	36.9	0.710
Worked out examples	2.75	3	31.7	2.76	3	32.8	0.951

Table 7: Frequency of Accessibility Challenges between Mental SWD and SWOD

lecture recording, or audio," "Reviewing or preparing for an exam," "Working on homework," and "Searching for content."

LaTeX format consistently held the highest preference across all scenarios, while image and text formats also remained important options. Chi-square analysis revealed a significant difference in the distribution of format preferences across scenarios ($p < 0.001$). Details are shown in Table 10.

For scenarios such as "First encountering math equations in Zoom, lecture recording, or audio," "Reviewing or preparing for an exam," and "Working on homework," over 50% of students preferred "LaTeX format," approximately 30% favored "Image format (e.g., screenshots)," around 10% chose "Text format (e.g., pure words, transcription)," and less than 10% selected "Structured markup language (e.g., MathML)."

In comparison, for the scenario "Searching for content," preferences were more evenly distributed: 48.2% preferred "LaTeX format," 21.9% each chose "Image format" and "Text format," and 8.0% opted for "Structured markup language."

Differences Between SWD and SWOD for "First Encountering Math Equations" Scenario

For the specific scenario of "First encountering math equations in Zoom, lecture recording, or audio," notable differences were observed between SWD and SWOD preferences. While SWOD showed the highest preference for LaTeX format (52.6%), SWD preferred the Image format (47.0%), slightly higher than LaTeX (42.4%). The Chi-square test indicated a statistically significant difference between the two groups ($p = 0.041$). This finding highlights the importance

Components	μ	Median	Positive rate (%)
Worked out examples	3.96	4	74.5
Breaking down of concepts/problems	3.93	4	72.6
Problem solving in class	3.74	4	65.2
Graphs and Diagrams	3.55	4	55.1
Math equations	3.51	4	54.9
Assessment/quizzes	3.52	4	54.4
Simulation	3.25	3	42.4
Tables	3.29	3	41.2
Voice recording	3.18	3	39.9
Image to text description	3.09	3	37.1
Voice to text description	3.06	3	35.8
Props/games in class	2.88	3	30.4

Table 8: Overall Importance of Future Improvements in Math Learning Components

Class Activity	Total Counts Considered "Helpful"
Homework assignments	542
Exams/Quizzes	501
Understanding concepts/information in course materials	459
Searching for content	237
Collaboration with other classmates (e.g., during office hours)	228

Table 9: Utility of Mathematical Equations and Diagrams in Class Activities

of both LaTeX and Image formats for SWD in this scenario, as shown in Table 11.

No Significant Gender-Based Differences in Format Preferences

Chi-square analysis showed no significant differences in math equation format preferences between male and female students. Both groups followed the same overall trend, with LaTeX format being the most preferred option across all scenarios.

6) The preference regarding the style of the transcription and derivation of Math equations

To understand preferences in transcribing Mathematical equations from images or audio to text, we asked students whether they preferred the use of Greek letters and math symbols or a purely alphanumeric representation.

Students were also shown two versions of a Mathematical derivation in Figure 1 and asked to

Scenario	LaTeX format	Structured markup language (e.g., MathML)	Image format (e.g., screenshot)	Text format (e.g., pure words, transcription)
First encountering math equations in Zoom, lecture recording, or audio	313 (51.1%)	37 (6.0%)	203 (33.2%)	59 (9.6%)
Reviewing or preparing for an exam	324 (53.1%)	53 (8.7%)	174 (28.5%)	59 (9.7%)
Working on homework	350 (57.2%)	44 (7.2%)	157 (25.7%)	61 (10.0%)
Searching for content	295 (48.2%)	49 (8.0%)	134 (21.9%)	134 (21.9%)

Table 10: Format Preferences for Math Equations in Common Learning Scenarios

Format	SWD Counts	SWOD Counts	p-val
LaTeX format	28 (42.4%)	269 (52.6%)	
Structured markup language (e.g., MathML)	1 (1.5%)	33 (6.5%)	
Image format (e.g., screenshots)	31 (47.0%)	158 (30.9%)	
Text format (e.g., pure words, transcription)	6 (9.1%)	51 (10.0%)	
Chi-square			0.041

Table 11: Preferences for Math Equation Formats in the "First Encountering Math Equations" Scenario (SWD vs. SWOD)

indicate which style they preferred, with a focus on the level of detail provided. The left version is more detailed and longer while the right version is more concise and shorter.

$$E[X] = \int_{-\infty}^{\infty} x \cdot p(x) dx$$
$$E[X] = \int_{0}^{\infty} x \cdot \lambda e^{-\lambda x} dx$$
$$E[X] = [-x \cdot e^{-\lambda x}]_0^{\infty} - \int_0^{\infty} (-e^{-\lambda x}) dx$$
$$E[X] = [-x \cdot e^{-\lambda x}]_0^{\infty} - [\frac{1}{\lambda} e^{-\lambda x}]_0^{\infty}$$
$$E[X] = [0 - 0] - [0 - \frac{1}{\lambda}]$$
$$E[X] = \frac{1}{\lambda}$$

$$E[X] = \int_{-\infty}^{\infty} x \cdot p(x) dx = \int_{0}^{\infty} x \cdot \lambda e^{-\lambda x} dx$$
$$= [-x \cdot e^{-\lambda x}]_0^{\infty} - \int_0^{\infty} (-e^{-\lambda x}) dx$$
$$= [-x \cdot e^{-\lambda x}]_0^{\infty} - [\frac{1}{\lambda} e^{-\lambda x}]_0^{\infty} = \frac{1}{\lambda}$$

Figure 1: Two versions of mathematical derivation

Transcription Style Preference

Across all students and sub-groups, approximately 85% preferred the use of Greek letters and Math symbols in transcription, while only about 15% favored a purely alphanumeric approach.

Derivation Style Preference

For the style of derivation, the majority of students (around 70%) preferred the longer and more detailed version, approximately 25% favored a more concise version, and around 5% reported no preference between the two. This similar pattern was observed across all sub-groups, indicating a general inclination toward detailed derivations for better understanding. Details are shown in Table 12.

Group	Prefer Left/Longer version	Prefer Right/Shorter version	Indifferent b/w versions
All	414 (67.6%)	158 (25.8%)	40 (6.5%)
Male	289 (66.7%)	112 (25.9%)	32 (7.4%)
Female	116 (69.5%)	44 (26.3%)	7 (4.2%)
Non-binary	4 (100.0%)	0 (0.0%)	0 (0.0%)
SWD	44 (66.7%)	19 (28.8%)	3 (4.5%)
SWOD	349 (68.3%)	128 (25.0%)	34 (6.7%)
SACAN	122 (66.7%)	52 (28.4%)	9 (4.9%)
Non-SACAN	271 (68.8%)	95 (24.1%)	28 (7.1%)
SWAN	78 (66.7%)	33 (28.2%)	6 (5.1%)
White	82 (78.8%)	17 (16.3%)	5 (4.8%)
Asian	299 (63.6%)	137 (29.1%)	34 (7.2%)
Other Race	39 (88.6%)	5 (11.4%)	0 (0.0%)

Table 12: Derivation Style Preference Across Groups

Differences Between Asian and Other Groups for Derivation Style

Chi-square analysis revealed significant differences in the preference for the longer detailed version between Asian students and other groups. White (78.8%, $p = 0.012$) and other ethnic groups (88.6%, $p = 0.003$) showed a significantly higher preference for the longer detailed version compared to Asian students (63.6%).

No Significant Differences Based on Gender or Accessibility Status

Chi-square analysis revealed no significant differences in derivation style preference based on gender or accessibility status. Both groups followed the overall trend, with a majority favoring the detailed left version, while a smaller portion preferred the concise right version.

7) The similarities and differences in the ways to explain Math equations in a lecture slideshow

To explore preferences for explaining Math equations in a lecture slideshow, students were asked to consider a scenario where an instructor follows a prepared slideshow filled with Mathematical equations for teaching a new chapter.

Methods	Mean	Median	Positive Rate (%)
Review of relevant prerequisite concepts	4.04	4	80.4
Giving examples or real-life applications of mathematical equations	4.04	4	76.6
Rigorous analysis of the presented mathematical content, breaking down the variables and applications of the equations	3.88	4	72.7
Generally use abstractions and explain holistic concepts behind the mathematical content being presented without going into specifics	3.47	4	53.4
Follow the slideshow verbatim without any significant deviations	2.96	3	32.0

Table 13: Overall Preferences for Explaining Math Equations in a Lecture Slideshow

General Preferences Across Groups

Across almost all sub-groups, the preferred methods for explaining Math equations in a slideshow were ranked similarly, with minor variations. The overall ranking was (Table 13):

1. Review of relevant prerequisite concepts
2. Giving examples or real-life applications of mathematical equations
3. Rigorous analysis of the presented mathematical content, breaking down the variables and applications of the equations
4. Using abstractions and explaining holistic concepts without going into specifics
5. Following the slideshow verbatim without significant deviations

Gender-Based Differences

Female students showed a significantly higher positive rate for both “Review of relevant prerequisite concepts” (86.8% vs. 77.6%; corrected $p = 0.025$) and “Follow the slideshow verbatim without any significant deviations” (40.1% vs. 28.9%; corrected $p = 0.025$) compared to male students, indicating a stronger preference for structured preparation and adherence to the slideshow.

Ethnicity-Based Differences

The Asian student group reported a significantly higher positive rate for "Follow the slideshow verbatim without any significant deviations" (35.5% vs. 17.3%; corrected p = 0.001) compared to the White student group, indicating a stronger preference for adherence to the slideshow.

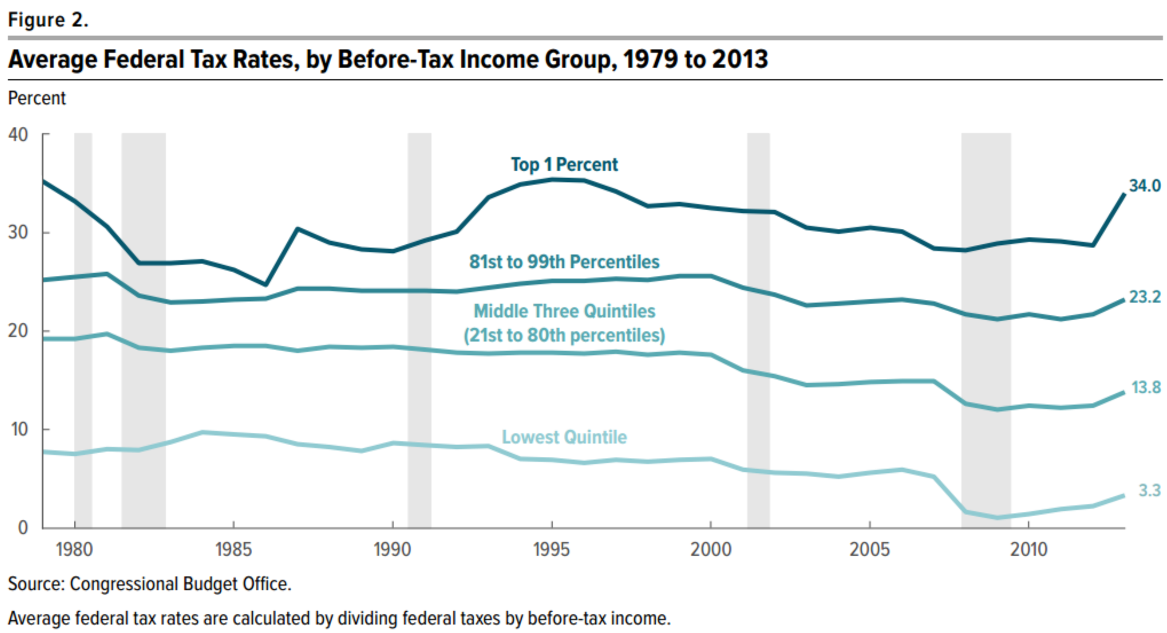

Figure 2: An example of the graph including different types of information

8) The similarities and differences in students' views about the important information of transcribing a graph into texts

To explore students' views on the most important information when transcribing a graph into text, we asked students to score various types of information based on their relevance to understanding a graph (Figure 2).

General Preferences Across Groups

All types of information listed in Table 14 were considered important for transcribing a graph into text, as evidenced by positive rates exceeding 50%. The "Title and purpose of the graph" (88.2%), "X- and Y-axis meanings and ranges" (85.6%), and "Interpretations of the graph" (84.6%) were rated the highest. The "Type of graph and layout" (75.0%) and "Context" (72.4%) followed closely, while "Example data points" had the lowest positive rate at 59.8%.

Gender-Based Differences

For "Type of graph and layout (e.g., describing the four lines)," female students responded with a significantly higher positive rate (83.2% vs. 71.8%; corrected p = 0.004) compared to male students.

Information type	Mean	Median	Positive Rate (%)
Title and purpose of the graph (e.g., what data it is presenting)	4.32	4	88.2
X- and Y-axis meanings and ranges	4.25	4	85.6
Interpretations of the graph (e.g., trends, relationships between the lines)	4.29	4	84.6
Type of graph and layout (e.g., describing the four lines)	3.98	4	75.0
Context (e.g., explaining key words, data collection process, sources)	3.95	4	72.4
Example data points (e.g., listing the numeric values of the last year's data)	3.64	4	59.8

Table 14: Importance of Information When Transcribing Graphs Into Text

Ethnicity-Based Differences

For "Example data points (e.g., listing the numeric values of the last year's data)," the Asian group responded with a significantly higher positive rate (62.6% vs. 44.2%; corrected p = 0.003) compared to the White group.

9) The similarities and differences in the student's view of the importance of different perspectives of a Math equation

To evaluate students' views on the importance of different components in explaining a Mathematical equation, we asked them to score elements such as definitions, intuition, examples, purposes, and derivations based on their contribution to understanding Math functions (e.g. Binary Cross Entropy function). The definitions and explanations of the Binary Cross Entropy elements (e.g., Definition, Intuition, Example, Purpose, and Derivation) are detailed in Table 15 for reference.

Group Definitions

Students were divided into two main groups based on their familiarity with the equation:

a) Unseen Group: Students who reported they had never seen the equation before (53.6%).

b) Seen Group: Students who reported they had seen the equation before but would not feel confident on a test about it (37.6%).

The group of students who had seen and fully understood the equation was excluded due to its small size (8.8%) and limited relevance to the analysis.

Elements	Explanation
Definition	The Binary Cross Entropy function takes multiple inputs, where y_i is the true binary (0 or 1) label for the i-th data point, $\hat{y}_i$ is the predicted probability that the i-th data point has a label of 1, and N is the number of data points.
Intuition	Intuitively, BCE operates by examining the true label. If the label is 1, the expression in the summation is equal to $\log(\hat{y}_i)$, meaning we only care about the logarithm of the deviation of $\hat{y}_i$ from 100% probability. Similar analysis can be done for the 0 label. Then, we can average across all N samples to quantitatively interpret how well the model is performing overall.
Example	As an example, suppose we have a model that predicts email as spam or not spam. If we have a spam email ($y_i = 1.0$) that the model predicts as 95% likely to be spam ($\hat{y}_i = 0.95$), we can compute BCE as $-(1 \cdot \log(0.95) + 0 \cdot \log(0.05)) = 0.022$, which can be considered a decent score.
Purpose	The purpose of Binary Cross Entropy is to measure the dissimilarity between a binary outcome (True / 1 or False / 0) and a predicted probability of that outcome being True, allowing you or a model to score the performance of that prediction.
Derivation	BCE is derived from the information theory concept of entropy that describes the uncertainty of a probability distribution through multiplying probabilities by their logarithm. Cross-entropy, as a formula, expands on entropy by summing across a dataset to measure the difference between two distributions.

Table 15: Common elements to explain Binary Cross Entropy function

Ranking of Explanation Components

Different groups of students ranked the importance of components differently:

a) Unseen Group: Example (85%) >Purpose (69.8%) >Definition (63.7%) >Intuition (56.9%) >Derivation (50.2%)

b) Seen Group: Example (79.1%) >Intuition (66.1%) >Purpose (65.2%) >Definition (62.6%) >Derivation (52.2%)

Both groups prioritized “Example” as the most important, with the unseen group focusing more on foundational elements like “Purpose” and “Definition,” while the seen group placed greater importance on “Intuition.” We also conducted comparisons between SWD and SWOD, as well as between different ethnicity groups, but did not find significant differences.

10) Mindset and Its Association with Learning Experience or Preferences

We examined how mindset is associated with various learning factors, including accessibility challenges, instructional preferences, and the level of detail preferred in mathematical derivations. After stratifying students into different groups based on their scores regarding growth mindset, we analyzed the summary statistics and conducted non-parametric hypothesis testing (Pairwise Mann–Whitney U test) for each question’s response in the survey.

Mindset and Frequency of Accessibility Challenges

Students with a negative mindset reported more frequent accessibility challenges in math learning compared to those with a neutral or positive mindset (Mean: Negative >Neutral >Positive), as shown in Table 16 (smaller values indicate reporting less frequency of challenges). The corrected p-value for positive vs. negative was statistically significant, indicating a strong association between mindset and accessibility difficulties. This pattern was observed across all sub-groups, with detailed results presented in the appendix (Tables 21–26). While smaller sub-groups like female and SWD did not reach statistical significance, likely due to limited sample sizes, the trend remained consistent.

Components	Mindset Categories			Corrected p-values		
	Positive (Mean)	Neutral (Mean)	Negative (Mean)	Pos vs. Neg	Pos vs. Neutral	Neg vs. Neutral
Breaking down of concepts/problems	2.66	3.09	3.31	<0.001	0.004	0.188
Worked out examples	2.58	3.00	3.23	<0.001	0.003	0.165
Graphs and Diagrams	2.45	2.82	3.14	<0.001	0.009	0.095
Tables	2.31	2.68	2.95	<0.001	0.007	0.149
Simulation	2.24	2.74	2.83	<0.001	<0.001	0.620
Math equations	2.41	2.92	3.14	<0.001	<0.001	0.221
Voice recording	2.21	2.62	2.76	<0.001	0.001	0.592
Voice to text description	2.13	2.58	2.70	<0.001	<0.001	0.620
Image to text description	2.22	2.66	2.65	<0.001	0.001	0.896
Assessment/quizzes	2.35	2.76	3.15	<0.001	0.003	0.022
Problem solving in class	2.45	2.81	3.15	<0.001	0.009	0.029
Props/games in class	2.08	2.60	2.57	<0.001	<0.001	0.802

Table 16: Frequency of Accessibility Challenges Across Mindset Categories

Mindset and the Importance of Improving Math Equations for SWD

A distinct pattern emerged among SWD regarding the importance of improving math equations for accessibility. Among negative mindset SWD, 92.9% identified math equations as a priority for improvement (Mean = 4.50), compared to 42.9% of positive mindset SWD (Mean = 3.16, corrected $p < 0.01$). This suggests that negative mindset SWD perceive math equations as a greater barrier, emphasizing the need for improved accessibility in this area.

Mindset and Preference for Following Slides

Students with a negative mindset showed a significantly stronger preference for instructors to follow the slideshow verbatim without any significant deviations compared to neutral or positive

Group	Mindset Categories			Corrected p-values		
	Positive (Mean)	Neutral (Mean)	Negative (Mean)	Pos vs. Neg	Pos vs. Neutral	Neg vs. Neutral
All	2.83	3.07	3.30	<0.001	0.123	0.258
Male	2.74	3.06	3.26	<0.001	0.077	0.612
Female	3.05	3.08	3.45	0.420	0.913	0.423
SWD	2.73	2.75	3.08	0.762	0.951	0.912
SWOD	2.83	3.06	3.28	0.003	0.327	0.386
SACAN	2.87	2.81	2.95	0.840	0.840	0.840
NON-SACAN	2.80	3.10	3.42	<0.001	0.124	0.258

Table 17: Preference for Following Slides Across Mindset Categories

mindset students (Mean: Negative >Neutral >Positive), as shown in Table 17. This trend was present across all sub-groups. While smaller sub-groups such as SWD, SACAN, and Female did not reach statistical significance, the pattern remained consistent.

Option	All	Positive Mindset	Neutral Mindset	Negative Mindset
I prefer the left version.	414 (67.6%)	291 (72.2%)	56 (62.9%)	65 (55.1%)
I prefer the right version.	158 (25.8%)	80 (19.9%)	29 (32.6%)	49 (41.5%)
I am indifferent between the two versions.	40 (6.5%)	32 (7.9%)	4 (4.5%)	4 (3.4%)

Table 18: Preference for Mathematical Derivation Version Across Mindset Categories

Mindset and Preference for Level of Detail in Mathematical Derivations

In Section 6, we introduced two versions of a mathematical derivation: the left version (detailed, step-by-step) and the right version (concise). As shown in Table 18, negative mindset students were less likely to prefer the detailed version (55.1%) than positive mindset students (72.2%), instead favoring the concise version (41.5% vs. 19.9%, p <0.001). This pattern remained consistent across all sub-groups, with detailed results provided in the appendix (Table 27).

Conclusion

About the mindset of the students in learning Math and STEM content

Students overall demonstrated a learning attitude aligned with expert views. Students with disability or accessibility needs have a similar growth mindset as the complement majority students. However there are racial differences in the learning mindset particularly between the White students and the Asian students with the White are more aligned with the expert view.

About the barriers and importance of the elements in the process of learning Math

Students are consistently experiencing barriers in the **breaking down of problems** and obtaining **worked out examples** in the process of learning Math. There are again significant differences between the White and the Asian students in their opinions about the frequency of difficulties and the importance of components with the Asian students encountering difficulties more frequently.

The students with physical disabilities on average have experienced more issues in “Breaking down of concepts/problems,” “Graphs and Diagrams,” and “Assessment/quizzes” compared with SWOD students.

Regarding the importance of the different components in the process of learning Math, a significant percentage of female students consider visual or audio transcriptions of a lecture important. The Asian students placed more importance on improving the tables and graph/diagrams of a lecture.

About the purposes of students in using equations and diagrams

Students across the groups have similar patterns of purposes in using equations and diagrams. The top two purposes for their use of equations are **working on Homework Assignment** and **Taking exams**.

About the preferred format of equations and display method

Most students prefer to have the LaTex format of equations for all purposes of their learning. The 2nd favored format is the image of equations.

Majority of the students preferred a more detailed display in the derivation of an equation, while the Asian students responded significantly more favoring the shortened version of the display of a derivation.

About the way to explain the equation in a lecture slide show

Students ranked the elements of the instruction in the following order of descending importance: 1) Review of relevant prerequisite concepts; 2) Giving examples or real-life applications of mathematical equations; 3) Rigorous analysis of the presented mathematical content, breaking down the variables and applications of the equations; 4) Using abstractions and explaining holistic concepts without going into specifics; 5) Following the slideshow verbatim without significant deviations.

About the style of transcribing a graph

Most students considered it important to include the given elements of a Math/STEM graph while female students attached significantly higher importance to describing “Type of graph and layout” and the Asian students emphasized the style of presenting “Example data points”.

About the student’s view of the importance of different perspectives of a Math equation

Most students considered giving an example for the explanation of the equation is important and the positive rates are as high as 79% or 85% depending on whether they have seen the equation previously. Even though the derivation of the equation is ranked lowest compared to other perspectives of the explanation of the equation, more than 50% students considered it important. Depending on whether a student has seen the equation, they place different weight on the intuition, purpose or definition of the equation. The responses are consistent across the student demographics groups regarding disability, gender or ethnicity.

Discussion

Understanding students' behaviors, attitudes, and experiences with math content is essential to ensure that Engineering courses are broadly accessible. We found the nature vs. nurture dichotomy about one's math ability is experienced by students, where most (70.1%) believe math ability can improve with effort, but differences were observed between demographic groups. Asian students were less confident in their ability to improve (35%) compared to White students (17%), while 18.4% of all students viewed math ability as innate. Most students possess a positive attitude that is aligned with research, which is very encouraging.

Accessibility challenges in math learning environments are common, especially when transcribing mathematical notions. Students reported that breaking down concepts and problems and improving worked out examples and exercises as the two most popular components for improving accessibility. Having the ability to incorporate these in the way we transcribe materials is a very important feature. Additionally, most students show a preference for using "Greek letters" and related notation in transcriptions and provided notes, with a minority opting for alphanumeric versions. To improve accessibility, we propose defaulting transcription capabilities to accommodate "Greek letters", with an option to switch it over to the alphanumeric version.

Another important element we have explored in terms of accessibility are frequent issues that students feel are important to their learning, such as "breaking down concepts" and "worked out examples". We found demographic variability in experiences where Asian students report more frequent accessibility issues and female students place greater importance on multimedia (video/voice) to text descriptions. While specific studies directly confirming these exact findings are limited, research on the digital divide in education indicates that disparities in access to technology and digital resources can vary across different demographic groups, potentially influencing their learning experiences and preferences.

However, other elements were consistent across demographics, such as the usefulness of equations and diagrams for activities such as homework, exams, and understanding concepts. In most scenarios, LaTeX was preferred by most students, followed by image formats, while text and markup formats were less popular. Regarding transcription preferences, approximately 85% of students favored the use of Greek letters and math symbols over alphanumeric transcriptions, and 70% preferred detailed derivations of equations.

For graph transcription, key elements such as titles, axis meanings, and trends were considered most important (around 85%), with females emphasizing graph layout and Asian students prioritizing detailed data points. Note that the gender difference is in preference as the effect seems to have no effect across genders. Interestingly, students with disabilities (SWD) reported fewer accessibility problems and rated improvements as less critical compared to students without disabilities, indicating lower perceived importance across all components. One possible explanation is that most of the courses involved have tried to use UDL approaches and technologies that will provide good accessibilities. In addition, we note that most of the students with disabilities in this study have a mental disability rather than physical disabilities.

We investigated the association between students' growth mindset level and students' responses regarding math accessibility. It was not surprising to find that students with a positive growth mindset report experiencing less accessibility challenges. Notably we see that in the subgroups based on disability or gender, the pattern remains. We are encouraged to see percentage wise students with disabilities demonstrate a more positive growth mindset. Our study could be limited by the number of questions on growth mindset in the survey and there are complex confounding factors in a students' background regarding learning a STEM subject.

Finally, our work suggested that students value reviewing prerequisites, real-life examples, and rigorous content analysis, with females and Asian students showing a stronger preference for instructors following slides verbatim. This is in part corroborated by some works such as this that found that clarity in teaching, which includes reviewing foundational concepts, and the use of interactive practices, such as real-life applications, are highly appreciated by students. However, our work seems to be the first to evaluate a rich set of instructional characteristics and several demographic indicators as listed above. Thus, our work suggests that more research is needed to confirm specific demographic preferences.

Given our results, there are immediate implications for developing the MATH extraction tools that facilitate LaTex code and other formats for students to learn Math effectively. In addition, while certain styles are preferred by the majority of students, as a UDL principle, the development of accessibility tools should provide multiple resources that will suit all students.

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Appendix

Question Type	Question
Demographics	1) Please select for which course you are responding. 2) What is your gender identity? 3) Choose one or more ethnic group that you consider yourself to be. 4) 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? 5) Students with mental or emotional disabilities are those who reported that they had one or more of the following conditions: speech or language impairment; 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? 6) 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?
Growth Mindset	7) For the following statement, choose from (*Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree*): 1.a) Math ability is something about a person that cannot be changed very much. 2.b) Nearly everyone is capable of understanding math if they work at it. 3.c) Being good at math requires natural (i.e. innate, inborn) intelligence in math.
Frequency of Challenges for Math Components	8) Consider the course you listed in the header of the survey and exclude the Math contents that belong to the prerequisite. How frequently do you encounter accessibility problems with the following components of the course? (Use the blank box to leave comments): • Breaking down of concepts/problems • Worked out examples • Graphs and Diagrams • Tables • Simulation • Math equations • Voice recording • Voice to text description • Image to text description • Assessment/quizzes • Problem solving in class • Props/games in class
Importance of Improving These Math Elements	9) Consider the course you listed in the header of the survey and exclude the Math contents that belong to the prerequisite. How important do you think it is to improve the accessibility of the following components of the course? (Use the blank box to leave comments): • Breaking down of concepts/problems • Worked out examples • Graphs and Diagrams • Tables • Simulation • Math equations • Voice recording • Voice to text description • Image to text description • Assessment/quizzes • Problem solving in class • Props/games in class

Table 19: Survey Question - Part 1

Question Type	Question
Purpose of Usage and Format of Math Equations	**10)** For which classroom activities do you find mathematical equations and diagrams helpful? • Exams/Quizzes • Homework assignments • Searching for content • Collaboration with other classmates (e.g., during office hours) • Understanding concept/information in course materials **11)** For each of the scenarios below, which format do you prefer to view? • First encountering math equations in Zoom, lecture recording, or audio • Reviewing or preparing for an exam • Working on homework • Searching for content Formats to choose from: LaTeX format, Structured markup language (e.g., MathML), Image format (e.g., screenshots), Text format (e.g., pure words, transcription)
About Caption/Description Style	**12)** When transcribing mathematical equations from images/audio to text, do you prefer the usage of Greek letters and math symbols or their alphanumeric counterparts? **Example:** Alphanumeric: *"The exponential distribution is defined by lambda times e to the power of negative lambda x for x greater than or equal to 0"* Symbols: *"The exponential distribution is defined by* $\lambda e^{-\lambda x}$ *for* $x \geq 0$*"* **13)** Below are two versions of work in finding the expected value of the exponential distribution. Assume that the instructor will explain each step in the derivation. Which do you prefer? **14)** Suppose a math instructor is following a prepared slideshow filled with mathematical equations for their lecture on a new chapter. For the following cases, select from (Not at all important, Not important, Neutral, Important, Very important): • Review of relevant prerequisite concepts • Follow the slideshow verbatim without any significant deviations • Use abstractions and explain holistic concepts behind the mathematical content without going into specifics • Rigorous analysis of the presented mathematical content, breaking down the variables and applications of the equations • Giving examples or real-life applications of mathematical equations
Understanding a Graph	**15)** Suppose an instructor needed to transcribe this graph below into purely words. Score each type of information based on how important they are towards understanding the graph: • X- and Y-axis meanings and ranges • Title and purpose of the graph (e.g., what data it is presenting) • Type of graph and layout (e.g., describing the four lines) • Example data points (e.g., listing the numeric values of the last year's data) • Interpretations of the graph (e.g., trends, relationships between the lines) • Context (e.g., explaining key words, data collection process, sources)
Understanding a Math Equation	**16)** Suppose an instructor was introducing this mathematical equation for the first time. Which of these options best describes you? **17)** Following up on the previous question, you have been given a randomly selected subset of an explanation to the equation below. Carefully read the explanation as if you were to be immediately tested on the equation afterwards. Score the components of the explanation by how important they were towards your understanding of the equation.

Table 20: Survey Question - Part 2

Components	Mindset Categories (Male)			Corrected p-values		
	Positive (Mean)	Neutral (Mean)	Negative (Mean)	Pos vs. Neg	Pos vs. Neutral	Neg vs. Neutral
Breaking down of concepts/problems	2.63	3.00	3.38	<0.001	0.047	0.054
Worked out examples	2.53	3.00	3.30	<0.001	0.009	0.114
Graphs and Diagrams	2.40	2.77	3.20	<0.001	0.041	0.048
Tables	2.27	2.74	3.00	<0.001	0.009	0.225
Simulation	2.21	2.79	2.91	<0.001	<0.001	0.575
Math equations	2.39	2.91	3.21	<0.001	0.003	0.165
Voice recording	2.16	2.64	2.75	<0.001	0.002	0.725
Voice to text description	2.05	2.58	2.67	<0.001	<0.001	0.822
Assessment/quizzes	2.32	2.87	3.26	<0.001	0.002	0.063
Problem solving in class	2.44	2.86	3.21	<0.001	0.016	0.069
Props/games in class	2.05	2.64	2.59	<0.001	<0.001	0.818
Image to text description	2.13	2.65	2.61	0.002	0.002	0.818

Table 21: Frequency of Accessibility Challenges Across Male Mindset Categories

Components	Mindset Categories (Female)			Corrected p-values		
	Positive (Mean)	Neutral (Mean)	Negative (Mean)	Pos vs. Neg	Pos vs. Neutral	Neg vs. Neutral
Breaking down of concepts/problems	2.71	3.33	3.17	0.209	0.156	0.803
Math equations	2.44	3.00	3.00	0.156	0.197	0.985
Assessment/quizzes	2.43	2.57	3.03	0.156	0.610	0.244
Problem solving in class	2.51	2.77	3.08	0.156	0.383	0.383
Graphs and Diagrams	2.57	2.97	3.03	0.209	0.240	0.966
Tables	2.38	2.60	2.87	0.192	0.383	0.610
Voice recording	2.33	2.63	2.82	0.192	0.383	0.719
Props/games in class	2.18	2.57	2.61	0.209	0.240	0.966
Worked out examples	2.68	3.03	3.11	0.209	0.273	0.966
Simulation	2.34	2.67	2.68	0.240	0.240	0.966
Voice to text description	2.40	2.63	2.79	0.209	0.462	0.628
Image to text description	2.47	2.73	2.79	0.287	0.462	0.966

Table 22: Frequency of Accessibility Challenges Across Female Mindset Categories

Components	Mindset Categories (SACAN)			Corrected p-values		
	Positive (Mean)	Neutral (Mean)	Negative (Mean)	Pos vs. Neg	Pos vs. Neutral	Neg vs. Neutral
Problem solving in class	2.54	2.88	3.36	0.010	0.301	0.232
Graphs and Diagrams	2.42	2.65	3.07	0.029	0.450	0.336
Math equations	2.47	2.88	3.17	0.029	0.275	0.484
Breaking down of concepts/problems	2.77	3.00	3.42	0.040	0.484	0.299
Worked out examples	2.69	3.08	3.31	0.055	0.275	0.556
Tables	2.24	2.48	2.74	0.084	0.484	0.484
Assessment/quizzes	2.46	2.44	3.02	0.159	0.968	0.232
Voice to text description	2.14	2.65	2.52	0.232	0.170	0.663
Simulation	2.27	2.56	2.71	0.159	0.313	0.760
Props/games in class	2.15	2.54	2.55	0.232	0.275	0.990
Image to text description	2.21	2.58	2.55	0.232	0.301	0.990
Voice recording	2.26	2.58	2.45	0.435	0.301	0.660

Table 23: Frequency of Accessibility Challenges Across SACAN Mindset Categories

Components	Mindset Categories (Non-SACAN)			Corrected p-values		
	Positive (Mean)	Neutral (Mean)	Negative (Mean)	Pos vs. Neg	Pos vs. Neutral	Neg vs. Neutral
Simulation	2.23	2.68	2.92	<0.001	0.011	0.230
Math equations	2.38	2.82	3.14	<0.001	0.020	0.154
Voice to text description	2.12	2.50	2.84	<0.001	0.022	0.136
Assessment/quizzes	2.32	2.77	3.20	<0.001	0.017	0.071
Breaking down of concepts/problems	2.62	3.06	3.27	<0.001	0.030	0.366
Worked out examples	2.52	2.87	3.18	<0.001	0.079	0.136
Graphs and Diagrams	2.46	2.77	3.16	<0.001	0.099	0.111
Tables	2.33	2.66	3.01	<0.001	0.071	0.136
Voice recording	2.20	2.56	2.88	<0.001	0.033	0.145
Props/games in class	2.04	2.61	2.51	0.006	0.001	0.599
Problem solving in class	2.41	2.71	3.05	<0.001	0.111	0.136
Image to text description	2.22	2.55	2.74	0.002	0.065	0.393

Table 24: Frequency of Accessibility Challenges Across NON-SACAN Mindset Categories

Components	Mindset Categories (SWD)			Corrected p-values		
	Positive (Mean)	Neutral (Mean)	Negative (Mean)	Pos vs. Neg	Pos vs. Neutral	Neg vs. Neutral
Math equations	2.12	3.22	3.36	0.057	0.089	0.872
Problem solving in class	2.24	3.30	3.29	0.063	0.067	0.902
Breaking down of concepts/problems	2.59	3.80	3.21	0.259	0.065	0.467
Worked out examples	2.47	3.50	3.14	0.315	0.089	0.731
Assessment/quizzes	2.22	2.11	3.21	0.089	0.872	0.097
Graphs and Diagrams	2.12	2.70	2.93	0.089	0.389	0.872
Tables	1.98	2.44	2.71	0.095	0.413	0.727
Props/games in class	1.98	2.50	2.29	0.401	0.389	0.872
Simulation	2.02	2.22	2.36	0.413	0.582	0.872
Voice recording	2.24	2.80	2.14	0.872	0.389	0.401
Image to text description	1.94	2.00	2.43	0.389	0.872	0.660
Voice to text description	2.02	2.60	2.21	0.727	0.409	0.727

Table 25: Frequency of Accessibility Challenges Across SWD Mindset Categories

Components	Mindset Categories (SWOD)			Corrected p-values		
	Positive (Mean)	Neutral (Mean)	Negative (Mean)	Pos vs. Neg	Pos vs. Neutral	Neg vs. Neutral
Breaking down of concepts/problems	2.68	2.95	3.33	$<$0.001	0.113	0.060
Worked out examples	2.59	2.86	3.24	$<$0.001	0.107	0.055
Graphs and Diagrams	2.49	2.74	3.16	$<$0.001	0.109	0.055
Tables	2.35	2.63	2.94	$<$0.001	0.073	0.131
Simulation	2.27	2.69	2.92	$<$0.001	0.006	0.250
Math equations	2.44	2.79	3.13	$<$0.001	0.035	0.109
Voice recording	2.22	2.54	2.81	$<$0.001	0.031	0.189
Voice to text description	2.14	2.54	2.80	$<$0.001	0.008	0.199
Assessment/quizzes	2.38	2.74	3.13	$<$0.001	0.031	0.061
Problem solving in class	2.48	2.69	3.14	$<$0.001	0.174	0.030
Props/games in class	2.09	2.60	2.55	0.022	0.001	0.748
Image to text description	2.25	2.63	2.71	0.014	0.025	0.684

Table 26: Frequency of Accessibility Challenges Across SWOD Mindset Categories

Category	I prefer the left version	I prefer the right version	I am indifferent between the two versions
Positive SWD	33 (73.3%)	9 (20.0%)	3 (6.7%)
Neutral SWD	4 (50.0%)	4 (50.0%)	0 (0.0%)
Negative SWD	7 (53.8%)	6 (46.2%)	0 (0.0%)
Positive SWOD	248 (72.3%)	67 (19.5%)	28 (8.2%)
Neutral SWOD	48 (67.6%)	21 (29.6%)	2 (2.8%)
Negative SWOD	52 (54.2%)	40 (41.7%)	4 (4.2%)
Positive SACAN	88 (71.0%)	27 (21.8%)	9 (7.3%)
Neutral SACAN	16 (76.2%)	5 (23.8%)	0 (0.0%)
Negative SACAN	18 (47.4%)	20 (52.6%)	0 (0.0%)
Positive Non-SACAN	193 (73.1%)	49 (18.6%)	22 (8.3%)
Neutral Non-SACAN	36 (62.1%)	20 (34.5%)	2 (3.4%)
Negative Non-SACAN	41 (57.7%)	26 (36.6%)	4 (5.6%)
Positive Male	205 (72.2%)	54 (19.0%)	25 (8.8%)
Neutral Male	35 (55.6%)	25 (39.7%)	3 (4.8%)
Negative Male	48 (56.5%)	33 (38.8%)	4 (4.7%)
Positive Female	79 (71.8%)	25 (22.7%)	6 (5.5%)
Neutral Female	21 (80.8%)	4 (15.4%)	1 (3.8%)
Negative Female	16 (51.6%)	15 (48.4%)	0 (0.0%)

Table 27: Preference for Mathematical Derivation Version Across Subgroup Mindset Categories