

Opportunities and Barriers to UDL-Based Course Designs for Inclusive Learning in Undergraduate Engineering and other STEM Courses

Sujit Varadhan, University of Illinois, Urbana-Champaign

Sujit Varadhan is a Junior at the University of Illinois at Urbana-Champaign majoring in Computer Science. He is an undergraduate research assistant as well as a frontend developer on ClassTranscribe.

Xiuhao Ding, University of Illinois, Urbana-Champaign

Xiuhao Ding is a Math and CS senior student at University of Illinois Urbana-Champaign.

Delu Louis Zhao

Ananya Agarwal, University of Illinois, Urbana-Champaign

David Dalpiaz, University of Illinois, Urbana-Champaign

Dr. Chrysafis Vogiatzis, University of Illinois, Urbana-Champaign

I am a teaching assistant professor for the Department of Industrial and Enterprise Systems Engineering at the University of Illinois at Urbana-Champaign. Prior to that, I was an assistant professor at North Carolina A&T State University. My current research interests lie in network optimization and combinatorial optimization, along with their vast applications in modern socio-technical and biological systems.

Prof. Yun Huang

Dr. Yun Huang is faculty in the School of Information Sciences at the University of Illinois at Urbana-Champaign. Her expertise is in the area of social computing, human-computer interaction, Internet of Things, and human-AI interaction. In her work, she

Dr. Lawrence Angrave, University of Illinois, Urbana-Champaign

Dr. Lawrence Angrave is an award-winning computer science Teaching Professor at the University of Illinois Urbana-Champaign. He creates and researches new opportunities for accessible and inclusive equitable education.

Dr. Hongye Liu, University of Illinois, Urbana-Champaign

Hongye Liu is a Teaching Assistant Professor in the Dept. of Computer Science in UIUC. She is interested in education research to help students with disability and broaden participation in computer science.

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Abstract

Understanding the needs of students with disabilities (SWD) is crucial for inclusive learning in college education. Universal Design for Learning (UDL)-based methodologies are recognized as a best practice to improve the accessibility for SWD. Although we see increased technology usage and changes in course design after COVID-19, it is still unclear if UDL-based practices will continue to be adopted and persist in their use, and where the future opportunities are for more inclusive engineering education for all students, and for SWD in particular.

In this study, we surveyed faculty and undergraduate students (predominantly in engineering) about their experiences with 16 UDL-based course design practices and their perceived usefulness at the University of Illinois Urbana-Champaign (UIUC). These practices span the three UDL guidelines (representation, engagement, action-expression) and essential accessibility features. We also surveyed instructors about their knowledge of UDL and the barriers to implementing these practices in engineering/STEM courses. We also identified the differences in responses between underrepresented groups in engineering and the general student population, as well as differences between students and faculty.

The survey design allowed students with physical, mental, and/or emotional disabilities to self-report as a 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 while not having an officially recognized disability by the university or if they are a SWD. Preference regarding feedback methods, class formats, and demographic questions such as gender and major were also included.

Our preliminary survey results from 148 students (including 50 SWD, 77 SACAN) of more than 20 majors showed that: 1) The five most useful UDL practices among all students are: searchable recorded lectures, flexible deadlines, transcripts for videos, official discussion platform, and alternative learning formats to lectures (i.e: textbooks, and slides); 2) Female students experience UDL practices in their courses significantly less (False Discovery Rate (FDR) controlled $p < 0.03$ for 13 practices); 3) Female students and SWD are significantly more uncomfortable giving direct feedback to instructors (chisq $p < 0.006$); 4) SWD experience recorded lectures, onboarding forms for accessibility, and alternative learning formats significantly (FDR controlled $p < 0.015$) less than students without disabilities (SWOD); 5) All groups of students rank and experience the UDL guidelines in the following order: representation, action-expression, and engagement; 6) Although students rate the usefulness of all the UDL features higher than their frequency (except

“autograders”), some features show large differences between students perceived usefulness and how often they are actually experienced. For example, “flexible deadlines” is considered useful (ranked 2nd in usefulness) while experienced very infrequently (ranked 7th in frequency).

The 25 faculty responses on rankings of the UDL practices differ with that of the students; notably, “frequent low-stake tests” is valued among the faculty, but was not in the top five of the students’ responses. Faculty responses suggest that the major barriers in implementing UDL practices are the lack of awareness of accessibility features and lack of training for technologies such as creating recordings and transcripts.

Our study provides empirical findings about opportunities and barriers for implementing UDL practices for all stakeholders in developing more inclusive courses.

Introduction

This paper presents findings from two UDL-based surveys, one designed for students and one for faculty, both distributed at UIUC during the Fall 2022 and Spring 2023 semesters. The surveys were designed to gauge student and faculty experiences and opinions with course instructional features (e.g., recorded lectures, video transcripts, frequent low stakes tests, an official discussion platform). Students were asked specifically about their opinions on methods of course feedback (e.g., official course evaluation forms, anonymous google forms) as well as their opinions regarding various course formats (e.g., in-person lecture, fully asynchronous, flipped classroom). Data about student demographics (college major, gender identity, disability status, disclosure status) were also collected and statistical analysis was conducted to identify any significant differences between these populations. Specifically, we found statistically significant differences between male and female students as well as SWD and SWOD. Additionally, faculty were asked about barriers they experienced in implementing UDL-based practices. This may help us improve and foster future effective implementations of UDL best practices.

Background

Supporting Students with Disabilities

Students with disabilities are severely underserved in the education system. The National Center for Education Statistics, found 19% of undergraduate students reported a physical or cognitive disability, (e.g: blindness or vision impairment, speech impairment; learning or psychiatric conditions). The majority of students do not report their disabilities to their university [1]. A study by Love et al. found that 75% of students who self-disclosed a disability in a survey, chose not to inform their instructor [2]. Similarly, UIUC’s 2019 survey found that 8% of students had indicated having a disability while 28% of them stated their disability needs were not being met [3]. Additionally, Dewantoro et. al. found that SWD were less prepared for online courses, when compared to SWOD [4]. These studies highlight the need to further investigate which instructional features can foster success for SWD, especially when a large proportion may hesitate to disclose their disability status.

Achieving educational equity has important social significance. With this term of educational equity, we refer to the equal opportunity of education [5], which in turn includes three aspects: equal starting point, equal process, and equal outcome [6]. There are many prior research studies

discussing the relationship between the use of new learning technologies and educational equity, and some researchers have posited that new learning technologies could promote educational equity [7].

Universal Design for Learning (UDL)

In this work we measured student and faculty perceptions around the three Universal Design for Learning (UDL) principles and accessibility in order to see where improvement and additional instructor-education around UDL should be focused.

Universal Design for Learning (UDL) is an inclusive pedagogical framework and set of principles to improve learning for all students by emphasizing the importance of accommodating multiple modes of student learning, action, and engagement [8]. UDL organizes a large set of best practices into three key principles, Representation, Engagement, and Action-expression. Representation is the means through which content is presented to students [9]. An inclusive framework can benefit all students (e.g., by creating accurate captions that can be indexed and searched), but can be particularly valuable for students with disabilities. For example, students with sensory disabilities (low vision, deafness) may benefit from content represented in different modes (spoken, text-based). Engagement refers to the means through which students engage with the content. Stimulating interest in the course content will be different for each student. Therefore, UDL recommends many forms of engagement for the same content (individual vs group work, gamification, a discussion forum) [9]. Action-expression refers to the manner in which students are assessed. Students with disabilities differ in the way in which they can express themselves (mobility impairments, executive function disorders, language barriers) so it is imperative to provide many modes for students to express their learning. Examples include alternative exam formats (e.g., oral exams), flexible deadlines, and frequent low stakes tests [9]. Accessibility is also a key component to UDL. Specific technologies that enable increased access to course material and accommodating of SWD are important to the overall inclusiveness of learning.

Adoption and Knowledge Around UDL

Knowledge of UDL-based best practices have been studied in the past. Manuscripts such as [10] examine educational literature around UDL and provide practical solutions for instructors to increase course accessibility. Additionally studies such as [11] provide statistical findings around the preferences of students and SWD relating to UDL practices. Other studies [12] [13], present findings around faculty experience with and barriers around implementing UDL in online courses. The studies also analyze motivation around UDL and conclude that there is in fact high motivation among faculty to learn more about UDL [13].

Methods

Survey Design

Two online surveys were designed for undergraduate students and instructors respectively. While individual questions varied across the two surveys, both shared the same sample of 16 UDL instructional features for the UDL-oriented questions.

The 16 UDL practices are: transcripts/captions on course-related videos, official discussion platforms (Discord, GroupMe, etc.), recorded lectures, flexible assessment deadlines, alternative learning formats to lectures (textbook, slides, etc.), accessibility checker for web pages, auto-graders, Immersive Reader, text-to-speech, provision of learning objectives or other motivational content, on-boarding form for accessibility, frequent low-stake tests, alternative assessments (presentations), anonymous polls on course content, gamification (points systems, Kahoot!, etc.), and props/physical objects in teaching.

To take a representative sample across the three key principles of UDL, an initial pool of practices were derived from Boothe et al. (2018) [10] using their highlighted themes within each key principle. These themes included alternative content sources, multiple lecture formats, and flexible opportunities. The pool of instructional features were then extended with practices that ranged in frequency of use and difficulty in implementation. For example, official discussion platforms (Piazza, Discord, etc.) can be perceived as a more commonly used and non-intrusive UDL feature. On the other hand, gamification in learning as a means of engagement is rarer and may be harder to implement large-scale. As a whole, these selections enable us to assess how opinions change across features of varying usage and difficulty.

Specifically, the surveys addressed the following research questions:

- 1) How much do the students experience these representative UDL approaches?
- 2) How useful do students consider these representative UDL approaches?
- 3) How useful do instructors consider these representative UDL approaches?
- 4) How knowledgeable or proficient are instructors regarding these representative UDL approaches?
- 5) What are the barriers that prevent instructors from implementing these representative UDL approaches?
- 6) How do SWD or SACAN or female students differ from the rest of the students regarding the frequency or usefulness of these UDL approaches?
- 7) How do students differ from instructors regarding the usefulness of these UDL approaches?
- 8) What format of feedback and classroom lecture type do students prefer?

Student Survey Questions

The student survey aimed to examine students' perspectives on and experience with UDL features and how these changed across different demographic groups. The questions can be broken down into three categories: demographic information, opinions on UDL features, and student communication.

Demographic questions included academic major, gender identity, type of disability, and disability status. The latter three questions enabled us to split student responses into the following groups: 1) female vs. male vs NBCDO (Non-binary or prefer not to disclose gender); 2) SWD vs. SACAN vs. SWOD.

Opinions on UDL features were largely collected using Likert-type scale questions. For each of the 16 instructional features, students were asked to rate both how frequently they experienced the feature and how useful they feel the feature was (if experienced) or might be (if not experienced). Students were also asked to rate alternative formats for lectures (lecture-based classrooms, flipped

classrooms, fully asynchronous courses, and fully synchronous online classrooms) in terms of conduciveness to learning. For non-Likert-type questions, students were asked to list learning management systems that they have used (such as Canvas) and what their favorites were.

Evaluation of student preferences for providing feedback consisted of two parts. Students were first given a True or False question on whether they felt comfortable bringing up curriculum issues or giving course feedback to instructors. Then, students were asked in a Likert-type scale question to rate how valuable each of four feedback methods (anonymous Google forms, unofficial teaching evaluation forms, intermediary groups to receive/transmit feedback, and instructor encouragement of course feedback) were in promoting student feedback.

The student survey was approved by UIUC IRB and five \$100 gift cards were distributed as part of a raffle to incentivize survey responses.

Instructor Survey Questions

The faculty survey engaged with instructors' experiences and perspectives on implementing UDL framework tools in the classroom. Questions are broken down into the two categories of teaching profile and opinions on UDL features.

Teaching profiles were constructed from the following question topics: primary subject area, primary format of course(s), level of students taught, average course enrollment sizes, and experience in developing digital learning material.

Similar to the student survey, instructors' opinions on UDL features were collected through Likert-type scale questions. For each UDL feature, instructors rated their experience (novice to expert) on the feature and the usefulness of the feature for their students. However, unlike the student survey, instructors were additionally asked about barriers that might exist in implementing UDL practices. For each of the 16 UDL features, instructors could check any or all of the following options: lack of awareness, lack of training offered, learned and adopted this practice by own initiative, lack of expertise from university procurement, insufficient time, insufficient technology, belief in practice as ineffective, no barrier, successfully adopted practice by own initiative, and other. Finally, a free-response box was given for instructors to share what school level support might be beneficial to them in implementing UDL-based course designs.

Demographics of Student and Instructor respondents

148 students from majors which were mainly in Engineering or other STEM subjects in the University of Illinois completed the survey. Students were given the option not to disclose a disability or their gender. Among the students, 50 self-identified as SWD while 98 were SWOD. There were 41 disclosed cognitive or mental disabilities and 30 female SWD. Furthermore, there were 77 students who did not indicate a disability but faced a circumstance that inhibited them from attending course activities, who were grouped with SWD into the SACAN category. "NBCDO" indicates the category of students who self identified as "Non-binary" or "prefer not to disclose gender". The students' demographics are shown in Table 1 and Table 2.

For the instructor survey, 25 instructors responded. Table 3 shows the demographics of these faculty.

Total	SWD	SWOD	SACAN	NotSACAN	Male	Female
148	50	98	77	71	76	63
NBCDO	Physical SWD	Mental SWD	SWD-Male	SWD-Female	SACAN-Male	SACAN-Female
9	9	41	12	30	21	48

Table 1: Student demographics

Total	Other STEM	CS	Stats	Other Non-STEM	Comp. Engr.	Physics	Mech. Engr.	Aero. Engr.	Elec. Engr.	Bio. Engr.	Civil Engr.	Chem. Engr.	Material science Engr.
148	43	39	19	13	11	5	4	3	3	2	2	2	2

Table 2: Student majors

Data Analysis

Survey data was anonymized, cleaned, and checked for internal consistency using Cronbach’s alpha [14]. Cronbach’s alpha values of 0.896 and 0.804 were obtained for the student and instructor surveys, respectively, indicating reliability and consistency within each survey.

For questions in the student survey with categorical responses — for example, whether attending fewer in-person lectures, whether feeling comfortable giving feedback and the preference of learning management system — contingency tables were constructed between various groupings (disability status, gender identity, etc). To test for independence between groups, a Chi-Square test was used.

For questions with responses on a Likert scale, higher scores were used to indicate a positive response, while lower scores indicated relatively negative responses. At the individual question level, in addition to mean, median, and positive rate for both student and instructor, a Mann–Whitney U test was used to detect differences between certain groups of students. When multiple tests were performed, p-values were corrected to control the False Discovery Rate (FDR) using the Benjamini-Hochberg procedure.

To understand instructional-feature questions at the system level, instructional-feature Likert scale questions were grouped into four factors: representation, action expression, engagement and offering for accessibility. For each factor, Mann-Whitney U tests were used to examine the differences between different groups of students.

Total	Female	Male	CS	Other Non- STEM	Computer Engr.	Industrial Engr.	Statistics	Physics	Civil Engr.	Bio Engr.	Aerospace Engr.	Material sci- ence Engr.
25	12	11	6	5	3	2	2	2	2	1	1	1

Table 3: Instructor demographics

Results

1) UDL practices' frequency reported by students

Frequency of UDL practices for all students

The top five most frequently experienced UDL practices among all students were: 1) *Auto-graders (online assessments)*; 2) *Alternative learning formats to lectures (textbook, slides, etc.)*; 3) *Transcripts/captions on course-related videos*; 4) **Official discussion platform**; 5) *Recorded lectures that students can search for content*. Students reported more than 60% positive rate for these top frequent UDL practices. The rest of the practices received between 15% to 50% positive rate. Table 4 lists all the practices in descending order of frequency experienced by students.

We then aggregate the practices into four types that are the three UDL guidelines and accessibility. We found students experience these types in the following order: ***representation, action-expression, engagement, and accessibility features.***

Differences in SWD, SACAN, SWOD student responses

SWD experienced significantly less frequent than SWOD for half of the UDL practices. The top five most frequently experienced UDL practices for SWD were 1) Auto-graders; 2) Transcripts/captions on course-related videos; 3) Alternative learning formats to lectures (textbook, slides, etc.); 4) Instructors providing learning objectives or other motivational content; 5) Official discussion platform.

Table 5 summarizes the significant statistical differences between SWD and SWOD responses regarding frequency. After the comparison between SWD and SWOD for each practice, the notable major differences were in 1) **Recorded lectures that students can search for content**; 2) ***On-boarding form for accessibility***; 3) ***Anonymous polls on course content***; 4) ***Alternative learning formats to lectures*** (textbook, slides, etc.); 5) ***Accessibility checker for web pages.*** **SWD experienced all of these practices significantly less frequently than SWOD.** Table A1 lists all of the significant differences between SWD and SWOD regarding frequency.

The top five most frequently experienced UDL practices for SACAN were 1) Auto-graders 2) Transcripts/captions on course-related videos 3) Alternative learning formats to lectures (textbook, slides, etc.) 4) Official discussion platform 5) Recorded lectures that students can search for content.

Question	Mean	Median	Standard deviation	Positive rates %
Auto-graders	4.1	4	1.07	79
Alternative learning formats to lectures (textbook, slides, etc.)	3.69	4	1.08	62
Transcripts-/captions on course related videos	3.57	4	1.08	61
Official discussion platform (Discord, GroupMe, etc.)	3.6	4	1.11	60
Recorded lectures that students can search for content	3.64	4	1.08	60
Instructors providing learning objectives or other motivational content	3.31	3.5	1.18	50
Flexible assignment-/assessment deadlines	2.93	3	1.21	32
Accessibility checker for webpages	2.75	3	1.23	27
Anonymous polls on course content	2.59	2	1.18	26
Frequent low-stake tests	2.6	3	1.18	22
On-boarding form for accessibility	2.55	3	1.18	19
Alternative assessments (such as presentations)	2.47	2	1.03	18
Immersive Reader	2.5	3	1.18	17
Text-to-Speech	2.35	2	1.19	16
Utilizing props or physical objects in teaching	2.34	2	1.1	16
Gamification (points systems, Kahoot!, achievements, etc.)	2.12	2	1.18	15

Table 4: All the practices in descending order of frequency experienced by students

Table 6 summarizes the statistical differences between SACAN and all other student responses regarding frequency. **Overall, according to the responses, SACAN experienced less frequent than all other students for 6 out of the 16 UDL practices.** After the comparison between the two groups for each practice, the notable major differences were in 1) Flexible assignment/assessment deadlines; 2) Anonymous polls on course content; 3) Recorded lectures that students can search for content; 4) Accessibility checker for web pages; 5) Alternative learning formats to lectures (textbook, slides, etc.). SACAN experienced all of these practices less frequently than all other students.

For the aggregated four UDL practice types, SWD responses showed the same descending order of representation, action-expression and engagement and accessibility features (Table 7). SWD

Question	Mean SWD	Mean SWOD	Positive SWD %	Positive SWOD %	p_val	corrected p_val
Recorded lectures that students can search for content	3.12	3.91	40	70	<0.001	<0.001
On-boarding form for accessibility	2.08	2.79	8	24	<0.001	0.002
Anonymous polls on course content	2.22	2.78	18	30	0.002	0.013
Alternative learning formats to lectures (textbook, slides, etc.)	3.38	3.85	48	69	0.003	0.013
Accessibility checker for webpages	2.38	2.94	12	35	0.005	0.014
Official discussion platform (Discord, GroupMe, etc.)	3.3	3.75	44	68	0.008	0.021
Flexible assignment/assessment deadlines	2.62	3.09	22	38	0.01	0.023
Auto-graders	3.86	4.21	68	85	0.017	0.033

Table 5: Significant differences between SWD and SWOD responses regarding frequency

responses show they experienced less frequently for all four types significantly (FDR $p < 0.002$). SACAN responses have the same trend for all 4 types (FDR $p < 0.02$).

Differences between female and male responses

Overall, **female students experienced significantly less frequent than male students for 13 of the 16 UDL practices.**

Table 8 summarizes the statistical differences between female and male student responses regarding frequency. After the comparison between the two groups for each practice, the notable major differences were in 1) Auto-graders; 2) Anonymous polls on course content; 3) Alternative learning formats to lectures; 4) On-boarding form for accessibility; 5) Frequent low-stake tests.

2) Findings about the usefulness of UDL practices ranked by students and instructors

The top-ranked UDL practices considered useful by all students

The top five useful UDL practices according to all students are: 1) ***Recorded lectures that students can search for content*** 2) ***Flexible assignment/assessment deadlines*** 3) ***Transcripts/captions on course-related videos*** 4) ***Official discussion platform*** 5) ***Alternative learning formats to lectures*** (textbook, slides, etc.). More than 86% Students reported positively for these top practices. The rest of the practices received between 36% to 79% positive rate. Table 9 lists all the practices in descending order of usefulness ranked by students.

After aggregating the practices into the four types as before, we found students ranked these types regarding usefulness in the following descending order: representation, action-expression and engagement and accessibility features.

Question	Mean SACAN	Mean not SACAN	Positive SACAN %	Positive not SACAN %	p_val	corrected p_val
Flexible assignment/assessment deadlines	2.66	3.23	25	41	0.002	0.017
Anonymous polls on course content	2.34	2.86	21	31	0.002	0.017
Recorded lectures that students can search for content	3.42	3.89	51	70	0.004	0.024
Accessibility checker for webpages	2.52	3.00	18	37	0.006	0.026
Alternative learning formats to lectures (text-book, slides, etc.)	3.52	3.87	55	70	0.016	0.046
On-boarding form for accessibility	2.36	2.75	17	21	0.017	0.046

Table 6: Significant differences between SACAN and SACAN-complement responses regarding frequency

Aggregated Type	Feature Experience			Feature Usefulness		
	Mean	Median	Positive %	Mean	Median	Positive %
Representation	3.07	3	41	4.16	4	80
Action expression	2.57	2	25	3.87	4	66
Engagement	2.48	2	22	3.86	4	67
Offering for accessibility	2.34	2	14	3.42	3	48

Table 7: Experience/Usefulness of aggregated UDL practice types – SWD

The differences between all students and instructors

The top five useful UDL practices according to instructors are 1) Alternative learning formats to lectures (96% positive rate); 2) Transcripts/captions on course-related videos (92% positive rate); 3) Official discussion platform (92% positive rate); 4) Frequent low-stake tests (92% positive rate); 5) Anonymous polls on course content (92% positive rate). Among these 5 practices, *Frequent low-stake tests* and *Anonymous polls on course content* are considered useful by instructors but less so to students. Instructors did not consider *recorded lectures that students can search for contents* and *flexible assignment/assessment deadlines as useful* as the students.

After aggregating the practices into 4 types as before, we found instructors ranked these types regarding usefulness in the same descending order as students, that is: representation, action-expression, engagement, and accessibility features. Notably, more percentage of instructors consider *accessibility features* useful than that of SWD.

Question	Male Mean	Female Mean	Male Pos %	Female Pos %	p_val	corrected p_val
Auto-graders	4.36	3.78	89	67	<0.001	0.003
Anonymous polls on course content	2.9	2.11	34	11	<0.001	0.001
Alternative learning formats to lectures (text-book, slides, etc.)	3.92	3.41	75	48	0.001	0.005
On-boarding form for accessibility	2.9	2.24	26	13	0.001	0.003
Frequent low-stake tests	2.86	2.25	30	13	0.002	0.006
Gamification (points systems, Kahoot!, achievements, etc.)	2.4	1.81	22	6	0.004	0.01
Official discussion platform (Discord, GroupMe, etc.)	3.84	3.37	72	49	0.005	0.01
Recorded lectures that students can search for content	3.91	3.41	70	52	0.005	0.01
Accessibility checker for webpages	3.04	2.54	36	21	0.006	0.011
Flexible assignment/assessment deadlines	3.2	2.7	41	27	0.008	0.012
Utilizing props or physical objects in teaching	2.57	2.1	22	11	0.009	0.013
Alternative assessments (such as presentations)	2.61	2.25	22	11	0.025	0.034
Immersive Reader	2.68	2.32	22	11	0.03	0.036

Table 8: Significant differences between female and male student responses regarding frequency

Differences between SWD and SWOD responses

The top five useful UDL practices according to SWD and SACAN are the same as those from all students together.

SWD had significant differences from SWOD regarding the following three practices: SWD considered *On-boarding form for accessibility* higher in usefulness than SWODs. SWD considered *Auto-graders* lower in usefulness than SWODs. Likewise, SWD considered *Frequent low-stake tests* lower in usefulness than SWOD. Table 10 summarizes all the statistically significant comparisons between the two groups.

After aggregating the practices into 4 types as before, we found SWD differs significantly from SWOD. Overall, **SWD consider accessibility and engagement features more useful than SWOD**, (FDR $p < 0.049$, 48% SWD vs 36% SWOD) and (FDR $p < 0.049$, 67% SWD vs 64% SWOD) respectively.

The significant difference between SACAN and all other students was in Auto-graders which are considered less useful by SACAN. After aggregating the practices into the 4 types as before, we found SACAN differed significantly from all other students regarding usefulness in practices

Question	Mean	Median	Standard deviation	Positive rates %
Recorded lectures that students can search for content	4.61	5	0.62	95
Flexible assignment-/assessment deadlines	4.52	5	0.72	93
Transcripts-/captions on course related videos	4.25	4	0.74	88
Official discussion platform (Discord, GroupMe, etc.)	4.32	4	0.74	88
Alternative learning formats to lectures (textbook, slides, etc.)	4.26	4	0.82	86
Frequent low-stake tests	4.08	4	0.96	79
Auto-graders	3.96	4	1	71
Anonymous polls on course content	3.91	4	0.95	70
Instructors providing learning objectives or other motivational content	3.87	4	1.03	68
Utilizing props or physical objects in teaching	3.7	4	1.1	64
Alternative assessments (such as presentations)	3.71	4	1.04	62
Gamification (points systems, Kahoot!, achievements, etc.)	3.67	4	1.11	61
On-boarding form for accessibility	3.43	3	0.98	44
Accessibility checker for webpages	3.32	3	0.92	40
Text-to-Speech	3.2	3	1.03	40
Immersive Reader	3.24	3	0.99	36

Table 9: All the practices in descending order of usefulness ranked by students

Question	SWD Mean	SWOD Mean	SWD Pos %	SWOD Pos %	p_val	corrected p_val
Auto-graders	3.54	4.17	54	80	0.001	0.012
On-boarding form for accessibility	3.74	3.27	58	37	0.003	0.024
Frequent low-stake tests	3.8	4.22	66	86	0.009	0.047

Table 10: Significant differences between SWD and SWOD responses regarding usefulness

about **accessibility features** (FDR $p < 0.027$, 45% SACAN vs 35% NOT SACAN) and **engagement** (FDR $p < 0.027$, 66% SACAN vs 64% NOT SACAN). Table 11 summarizes these results.

Question	SACAN Mean	not SACAN Mean	SACAN Pos %	not SACAN Pos %	p_val	corrected p_val
Auto-graders	3.69	4.25	56	87	0.001	0.01

Table 11: Significant differences between SACAN and SACAN-complement responses regarding usefulness

Differences between female and male students responses

The top five useful UDL practices according to female students were the same as those from all students together and the same as that of male students. The significant difference between females and males was that female students did not consider *Auto-graders* as useful as the male students.

3) Findings about the knowledge/proficiency of instructors and barriers for the implementation of the UDL practices

Knowledge/level of proficiency in UDL practices among instructors

Instructors were surveyed about their knowledge or level of proficiency in implementing the list of UDL practices. The top five practices that instructors are most knowledgeable or proficient at are: 1) *Instructors providing learning objectives or other motivational content*; 2) *Transcripts/captions on course-related videos*; 3) *Alternative learning formats to lectures* (textbook, slides, etc.); 4) *Auto-graders*; 5) *Official discussion platform*.

Only slightly more than **28% instructors reported positively about their knowledge of the UDL framework and literature**. The five practices that instructors are least knowledgeable or proficient at are: 1) *Text-to-Speech*; 2) *Immersive reader*; 3) *On-boarding form for accessibility*; 4) *Gamification* (points systems, Kahoot!, achievements, etc.); 5) *Alternative assessments* (such as presentations). The results demonstrated instructors are less knowledgeable about accessibility related practices and engagement methods such as gamification. Table 12 shows results about the knowledge of instructors with UDL practices.

The barriers for UDL practices among instructors

Instructors were also surveyed about the barriers that hinder them from implementing a specific practice. We asked which type of barriers or related items applies to their implementation such as: “Lack of awareness”, “Not offered training”, “University procurement lacks expertise”, “Don’t have enough time to use this in teaching”, “Do not have sufficient technology to develop”, “Do not believe in the effectiveness of this practice”, “Learned by own initiative”, “No barriers” and an option of open ending comments on their barriers.

Table 13 shows the 25 instructors’ responses for each practice regarding barriers.

Question	Mean	Median	Standard deviation	Positive rates %
Instructors providing learning objectives or other motivational content	3.6	4	1	68
Transcripts/captions on course-related videos	3.28	4	1.24	60
Alternative learning formats to lectures (textbook, slides, etc.)	3.4	3	1.16	48
Auto-graders	3.32	3	1.25	48
Official discussion platform (Discord, GroupMe, etc.)	2.88	3	1.27	44
Flexible assignment/assessment deadlines	3.24	3	1.2	44
Frequent low-stake tests	3.12	3	1.27	40
Recorded lectures that students can search for content	2.68	3	1.46	36
Anonymous polls on course content	3.08	3	1.08	36
Accessibility checker for webpages	2.56	3	1.23	32
Utilizing props or physical objects in teaching	2.6	3	1.23	28
The three UDL guidelines (regarding the framework, literature on UDL)	2.52	2	1.16	28
Alternative assessments (such as presentations)	2.56	3	1.04	12
Gamification (points systems, Kahoot!, achievements, etc.)	2.16	2	1.11	12
On-boarding form for accessibility	1.64	1	1.04	8
Immersive Reader	1.68	1	0.99	4
Text-to-Speech	1.6	1	0.96	4

Table 12: Instructor Knowledge of of UDL practices

Our results show that instructors face “No barriers” in implementing most of the UDL practices (n=155). Sorted by number of responses, the top 5 “No barriers” practices were “Instructors providing learning objectives or other motivational content”, “Anonymous polls on course content”, “Official discussion platform”, “Alternative learning formats to lectures”, and “Auto-graders”.

The data shows that instructors encounter more barriers in the area of providing accessibility features in their course. The two top useful practices ranked by students “Recorded lectures that students can search for content” and “Flexible assignment/assessment deadlines” were also not considered easy to implement.

The item “Learned by their own initiative” received 80 responses. This demonstrated that **most instructors had strove to improve their courses by their own initiative.**

Overall, **instructors have the limited amount of time to implement features relating to**

Question	Lack of awareness	Not offered training	Learned by own initiative	University procurement lacks expertise	Do not have enough time to use this in teaching	Do not have sufficient technology to develop	Do not believe in the effectiveness of this practice	No barrier	Other
Transcripts/captions on course-related videos	3	2	7	2	6	4	0	9	0
Official discussion platform (Discord, GroupMe, etc.)	4	2	3	1	2	1	0	13	1
Recorded lectures that students can search for content	2	9	7	2	4	4	1	6	0
Flexible assignment/assessment deadlines	1	2	6	0	7	2	2	8	3
Alternative learning formats to lectures (text-book, slides, etc.)	0	1	8	1	2	1	0	13	0
Accessibility checker for webpages	6	7	3	0	1	3	0	8	0
Auto-graders	0	1	8	0	2	2	1	13	1
Immersive Reader	12	4	1	0	2	2	0	5	0
Text-to-Speech	6	7	1	0	4	4	1	4	1
Instructors providing learning objectives or other motivational content	0	2	6	0	2	0	0	17	0
On-boarding form for accessibility	11	8	1	0	2	1	0	6	0
Frequent low-stake tests	1	0	6	0	8	1	0	12	0
Alternative assessments (such as presentations)	0	0	9	0	5	3	0	8	4
Anonymous polls on course content	1	0	8	0	1	0	0	15	0
Gamification (points systems, Kahoot!, achievements, etc.)	5	5	3	2	3	1	3	7	1
Utilizing props or physical objects in teaching	1	2	3	1	4	0	1	11	4

Table 13: Instructors' responses for each practice regarding barriers

action-expression and accessibility. The item “Don’t have enough time to use this in teaching” received 55 responses and the top practices that present the most barriers are “Frequent low-stake tests”, “Flexible assignment/assessment deadlines”, “Transcripts/captions on course-related videos”, “Alternative assessments (such as presentations)” and “Recorded lectures that students can search for content”.

Instructors are least aware of and have received no training around accessibility features.

The item “Lack of awareness” received 53 responses and the item “Not offered training” received 52 responses. Instructors are least aware of and have received no training for: “Immersive Reader”, “On-boarding form for accessibility”, “Text-to-Speech”, and “Accessibility checker for web pages”. Overall,

Again, we see that **implementing and developing accessibility features is a large barrier for instructors.** The item “Do not have sufficient technology to develop” received 29 responses and the top practices that received more than 2 responses were “Recorded lectures that students can search for content”, “Transcripts/captions on course-related videos”, “Text-to-Speech”, and “Alternative assessments (such as presentations)”.

The barriers “University procurement lacks expertise” and “Do not believe in the effectiveness of this practice” were the least prominent among the list of barriers.

4) Students preferences regarding feedback methods and class format

We asked all students if they felt comfortable bringing up curriculum issues and/or giving course feedback to instructors and their rating of four potential feedback methods. Feedback is crucial for underrepresented groups of students to present their needs of UDL practices in a comfortable and timely fashion. Lack of such feedback would be a barrier for UDL implementations.

We found female students and SWD are significantly more uncomfortable giving direct feedback to instructors (chisq $p < 0.005$ female; chisq $p < 0.006$ SWD).

As for the feedback methods, we found that all students together ranked the following 4 options in descending order: *Anonymous Google forms to gather course feedback* (74%); *Instructors encouraging course feedback* (51%); *Intermediary groups* (TAs or other designated student groups to receive and transmit course feedback) (49%); *unofficial school wide forms to gather course feedback* (45%).

SWD, SACAN and Female students have the same ranking of the four feedback options as that of all students together. **SWD and SACAN felt less comfortable about having intermediary groups to transmit the feedback** (FDR $p < 0.035$ for SWD vs SWOD, FDR $p < 0.026$ for SACAN vs NOT SACAN). **There were no significant differences between female and male students for any individual feedback method.**

We also asked students what class format they preferred among the following 5 formats: 1) Lecture-based classroom (Students are first introduced concepts within lecture classes and are given practice materials afterwards); 2) Flipped classroom (Students are assigned lectures/readings to learn the material ahead of the class, while questions and practice materials are covered during the class); 3) Fully asynchronous; 4) Fully synchronous online classroom

(Lectures/discussion may be held over Zoom as an example); 5) Combinations of the rest.

The responses show that all students ranked the class formats in the following order: 1) **Lecture-based classroom** (76%); 2) **Combinations of the rest** (61%); 3) **Flipped classroom** (42%); 4) **Fully asynchronous** (34%); 5) **Fully synchronous online classroom** (33%). SWD and female students ranked them in the same order as all students together. SACAN ranked them slightly differently by swapping the last two formats.

Female students consider the usefulness of flipped classrooms lower than male students (FDR $p < 0.025$, 32% Female vs 51% Male).

5) Summary

The most frequently experienced UDL practices by all students and the most useful UDL practices by all students and instructors is shown in Table 14.

In general, students do not experience UDL practices as much as their usefulness may suggest. The results found students gave higher scores for usefulness than for frequency regarding each feature except for “Autograders” (Table 15). Some features showed a large difference between the two ranks. For example, “flexible deadlines” was considered useful (ranked second in usefulness) while experienced very infrequently (ranked 7th in frequency). The Top useful practices such as “Recorded lecture with searchable content” and “flexible deadlines” were not experienced very frequently.

SWD and SACAN reported significantly less frequent experience for half of the UDL practices than their counterparts and female students reported significantly less frequent experience for 81% of the practices than males. In comparison with SWOD, SWD ranked accessibility features and engagement features higher (i.e. on-boarding form for accessibility needs, anonymous polls, and discussion platforms).

Instructors agreed but also differed from students for the usefulness of the top UDL practices ranked by the students. “Frequent low-stake tests” and “Anonymous polls on course content” were unique to instructors’ top 5 list. The data showed instructors were less knowledgeable about accessibility related practices and engagement methods, two areas considered more useful by SWD. Notably, Instructors considered accessibility related practices even more useful than SWD and strived to learn to apply these practices by their own initiative. They encountered more barriers in applying accessibility features due to either not being offered training, a lack of awareness, or not having sufficient technology to develop the features.

Female students and SWD were significantly more uncomfortable giving direct feedback to instructors and most students preferred anonymous forms as a way for feedback. Regarding classroom format, most students preferred “lecture-based classroom” followed by “Combinations of the rest”.

Table 16 shows the order that students ranked the three UDL guidelines and accessibility. Students ranked their usefulness and frequency in the same order.

Rank	Frequent UDL practices (all students)	Frequent UDL practices (SWDs)	Frequent UDL practices (SACAN)	Frequent UDL practices (Females)	Frequent UDL practices (Male)	Useful UDL practices (All students)	Useful UDL practices (SWD)	Useful UDL practices (SACAN)	Useful UDL practices (Female)	Useful UDL practices (Male)	Useful UDL practices (Instructors)
1	Auto-graders	Auto-graders	Auto-graders	Auto-graders	Auto-graders	Recorded Lectures	Recorded Lectures	Recorded Lectures	Recorded Lectures	Recorded Lectures	Alternative Learning Formats to Lectures
2	Alternative Learning Formats to Lectures	Transcripts- /captions	Transcripts- /captions	Transcripts- /captions	Alternative Learning Formats to Lectures	Flexible assignment- /assessment deadlines	Flexible assignment- /assessment deadlines	Flexible assignment- /assessment deadlines	Flexible assignment- /assessment deadlines	Flexible assignment- /assessment deadlines	Transcripts- /captions
3	Transcripts- /captions	Alternative Learning Formats to Lectures	Alternative Learning Formats to Lectures	Alternative Learning Formats to Lectures	Recorded Lectures	Transcripts- /captions	Transcripts- /captions	Transcripts- /captions	Transcripts- /captions	Official discussion platform	Official discussion platform
4	Official discussion platform	Instructors providing learning objectives	Official discussion platform	Recorded Lectures	Official discussion platform	Official discussion platform	Official discussion platform	Official discussion platform	Official discussion platform	Alternative Learning Formats to Lectures	Frequent low-stake tests
5	Recorded Lectures	Official discussion platform	Recorded Lectures	Official discussion platform	Transcripts- /captions	Alternative Learning Formats to Lectures	Alternative Learning Formats to Lectures	Alternative Learning Formats to Lectures	Alternative Learning Formats to Lectures	Auto-graders	Instructors providing learning objectives

Table 14: The top five UDL practices that are most frequently experienced or most useful ranked by respondents

Aggregated Type	Feature Experience		Feature Usefulness	
	Mean	Pos%	Mean	Pos %
Auto-graders	4.10	79	3.96	71
Alternative learning formats to lectures (textbook, slides, etc.)	3.69	62	4.26	86
Transcripts/captions on course-related videos	3.57	61	4.25	88
Official discussion platform (Discord, GroupMe, etc.)	3.60	60	4.32	88
Recorded lectures that students can search for content	3.64	60	4.61	95
Instructors providing learning objectives or other motivational content	3.31	50	3.87	68
Flexible assignment/assessment deadlines	2.93	32	4.52	93
Accessibility checker for webpages	2.75	27	3.32	40
Anonymous polls on course content	2.59	26	3.91	70
Frequent low-stake tests	2.60	22	4.08	79
On-boarding form for accessibility	2.55	19	3.43	44
Alternative assessments (such as presentations)	2.47	18	3.71	62
Immersive Reader	2.50	17	3.24	36
Text-to-Speech	2.35	16	3.20	40
Utilizing props or physical objects in teaching	2.34	16	3.70	64
Gamification (points systems, Kahoot!, achievements, etc.)	2.12	15	3.67	61

Table 15: The comparison between UDL practices' frequency experienced and their usefulness ranked by students

Discussion

Throughout this study we discovered the most experienced and useful UDL practices ranked by students and investigated the difference between the instructors and students regarding the usefulness of these practices. Searchable lecture recordings and flexible deadlines were the top two useful practices ranked by students, but they were rarely experienced.

Lecture recordings are an accessible way for students to learn and review course content. SWD can benefit from recorded lectures. For example, students who are deaf/hard of hearing can utilize captions in recorded lecture videos in order to properly understand all the information presented. Additionally, students who are blind/low-vision, who may not be able to learn effectively in a traditional in-person lecture format due to being unable to see the material presented, can benefit from being able to enlarge the lecture content and use screen readers when utilizing recorded lectures. Providing multiple modes of representation was shown by our study to be preferred by all students. As a result, recorded lectures can be useful for all students, not just SWD. All

Rank	Aggregated UDL type	Questions
1	Representation	video cap, record, alternative format, motivation, props
2	Action expression	flexible deadline, low stake, anonpoll, auto grader, gamify, altassess
3	Engagement	discuss platform, anonpoll, motivation, gamify, props, altassess, onboard
4	Offering for accessibility	onboard, access check, tts, immersive

Table 16: Aggregated UDL types' usefulness/experience rank and corresponding questions

students can use recorded lectures to replay material they did not understand upon first pass, pause the lecture and take breaks as needed without having to miss content, and utilize searchable transcripts for review purposes.

We believe there is an opportunity to close the gap in the ranking of flexible deadlines between students and instructors by the use of frequent low stakes tests. Frequent low stakes tests given by instructors can be automatically graded. This makes it easier to set up flexible deadlines for these exams. This creates a middle ground between appealing to student preferences and ease of implementation for instructors. One strategy to implement flexible deadlines is the rolling deadline method; Instructors can set a "100%" deadline and students will receive less credit for the assignment as time from the 100% deadline passes. This incentive encourages students to finish assignments on time while also not overly-penalizing them for submitting slightly late work. It also reduces the burden of dealing with late submissions for instructors because submission deadlines are flexible and penalties for submitting late work are well defined.

Feedback mechanisms are also imperative for meeting and evaluating the needs of students. Our study found that female students and SWD were more uncomfortable giving direct feedback. This calls for us to reevaluate the methods that we use for collecting feedback. Students tend to avoid face-to-face interaction due to feeling uncomfortable or not wanting to disclose sensitive information in person. One way around this is to use anonymous web forms to collect student feedback. This mechanism was ranked as the most preferred mode of feedback (74%) in our study. The use of frequent anonymous web forms in courses can help instructors more accurately learn what they can improve on and what students like about their instruction. Additionally, course on-boarding forms for accessibility needs can remove the in-person stigma of asking for accommodations while also making the process of providing accommodations easier for instructors.

One limitation of our study was the higher number of SWD with mental/cognitive disabilities surveyed (41 respondents) versus physical disabilities (9 respondents). The voices of SWD with more specialized needs may thus be hidden in our results. SWD overall valued features such as flexible deadlines and multiple modes of representation. Students who needed other specific accessibility related features may not have had their preferences heard as a result. For example, blind/low-vision students who use screen readers may not be having their needs met or even heard. While the implementation of UDL practices in the classroom improves education for all

students (SWD and SWOD), instructors still need to be cognizant of students with other specialized needs and be willing to aid them.

Our study also had a limited number of responses from students who identify as non-binary or preferred not to disclose their gender (NBCDO). Due to the low sample size, the data may not show the general opinions of NBCDO and it may not reveal the actual differences between NBCDO and all other students. However, our results (Table A3) did show some significant differences which indicates that the opinions of NBCDO are distinctly different than all other students. These findings prompt future research around the opinions and experiences of non-binary students.

Another limitation of the study is the relatively small number of responses from instructors (25 responses). Although we reached out through new faculty training and professional meetings, the difficulty in getting instructor feedback may reflect a broader barrier of a general lack of time for learning and implementing UDL. It also indicates the lack of awareness of UDL and accessibility issues among engineering and STEM faculty at UIUC. The challenge we faced in collecting instructor feedback may pose a new research question of how to educate and engage faculty interest around UDL.

To aid in faculty education and interest about UDL, we are actively developing a training course in our institute using principles adopted from [15]. The course focuses on educating faculty about the struggles that students with disabilities go through in school as well as a curated set of UDL best practices that can be used as a template to be implemented and examples of designs that can be plugged into their courses. Modules are designed to give instructors practical skills and methods to effectively implement UDL practices. Modules scale from beginner to advanced levels of difficulty. Faculty can also participate in Canvas to discuss new developments of the library of UDL elements. Our goal with this course is to clearly show the ongoing issues that SWD face in order to motivate faculty while also giving them the tools that they need to fix such problems. We hope that our ongoing efforts will inspire a new generation of educators to strive to improve the accessibility of university courses for all students.

Conclusion

In this paper, we presented the results from two surveys designed to assess student and instructor opinions about and experience with UDL best practices.

The top five most useful UDL practices indicated by students were: 1) Recorded lectures that students can search for content, 2) Flexible assignment deadlines, 3) Transcripts and captions on course related videos, 4) An official discussion platform, and 5) Alternative learning formats to lectures (textbook, slides, etc.).

Our key findings were: 1) Students do not experience UDL practices as much as their usefulness may suggest. The top useful practices such as recorded lectures and flexible deadlines were experienced very infrequently; 2) SWD experienced significantly less frequently than SWOD for half of the UDL practices; 3) Female students experienced significantly less frequently than male students for almost all of the UDL practices; 4) SWD ranked accessibility and engagement features significantly higher than SWOD; 5) Female students and SWD are significantly more uncomfortable giving direct feedback to instructors. Anonymous Google forms are the most

preferred method of feedback for all students (74%); 6) Instructors face no barriers to implement most of the UDL practices. They are, however, least knowledgeable about accessibility features and face more barriers to implementing accessibility features; 7) Instructors are highly self-motivated to learn about UDL but are provided minimal training and are not aware of many accessibility issues or UDL features in general.

We hope that our findings will inspire current and future educators to rethink their course design to be more accessible for all students by using UDL.

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Appendix

Aggregated Type	Feature Experience			Feature Usefulness		
	Mean	Median	Positive %	Mean	Median	Positive %
Representation	3.31	3	50	4.14	4	80
Action expression	2.8	3	32	3.98	4	73
Engagement	2.71	3	29	3.8	4	65
Offering for accessibility	2.54	3	20	3.3	3	40

Table A1: Experience/Usefulness of aggregated UDL practice types – All students

Aggregated Type	Feature Experience			Feature Usefulness		
	Mean	Median	Positive %	Mean	Median	Positive %
Representation	3.19	3	45	4.16	4	80
Action expression	2.67	3	29	3.95	4	69
Engagement	2.59	2	26	3.86	4	66
Offering for accessibility	2.45	2	19	3.38	3	45

Table A2: Experience/Usefulness of aggregated UDL practice types – SACAN

Comparison Group(CG)	Question	NBCDO Mean	CG Mean	NBCDO Pos %	CG Pos %	p_val	corrected p-val
Male	Accessibility checker for webpages	1.78	3.04	0	36	0.002	0.019
Male	On-boarding form for accessibility	1.78	2.9	0	26	0.002	0.019
Male	Recorded lectures that students can search for content	3	3.91	33	70	0.007	0.037
Female	Anonymous polls on course content	3.33	2.11	56	11	0.003	0.042

Table A3: Significant NBCDO Differences Regarding Frequency

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