Virtual Learning Accessibility Barriers Experienced by Engineering Students with Disabilities in the Wake of the COVID-19 Pandemic

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Abstract— **This Work in Progress, Research paper aims to address the well-documented discrimination against people with disabilities regarding the use of technology in education. Poor accessibility standards, a lack of administrative support, and numerous other barriers have contributed to the ever-present digital equity gap for students with disabilities. The digital equity gap has continued to widen as schools continue to increase the use of virtual or distance learning in the wake of the COVID-19 pandemic. This research aims to better understand students with disabilities' barriers in accessing online undergraduate engineering education by addressing the following research question: What barriers do engineering students with disabilities face in an online learning environment? The Universal Design for Learning (UDL) framework guides the research questions, data collection, and data analysis. A fixed item survey has been developed and is currently being used to capture the experiences of students with disabilities in engineering who participated in online learning at four-year colleges and universities across the United States. The identification of these students' barriers will be used to inform accessibility improvements and considerations to engineering online learning.**

Keywords— students with disabilities, COVID-19, equity, distance learning

I. Introduction

There is well-documented discrimination against people with disabilities regarding the use of technology in education. This discrimination creates digital inequities [1], which have continued to widen as schools have increasingly moved to virtual or distance learning due to the COVID-19 pandemic. More than two-thirds of classroom teaching globally are now taught virtually, prompting interest from educators to use the shift to expand flexible learning options (e.g., hybrid and distance) [2]. This has created an equity gap as accessibility and technical infrastructure were not prerequisites during the initial shift to virtual learning [2]. Ever-present digital inequities and the expansion of virtual classes post-COVID-19 suggest an urgent need to address existing barriers for students with disabilities in higher education to improve accessibility and inspect the impact these challenges have on perceived value of education.

This research uses Universal Design for Learning (UDL) to better understand students with disabilities' accessibility barriers in undergraduate and graduate engineering education. The following paper aims to address the following research question: What accessibility barriers do engineering students with disabilities most face in an online learning environment? Identifying these students' barriers will be used to inform accessibility improvements and considerations to online learning for students with disabilities.

II. Theoretical Framework

UDL uses three guiding principles for the design of inclusive learning: (1) providing several flexible modes for students to gather information, (2) allowing for flexible modes of student expression in acquiring knowledge, and (3) developing and retaining student interest through interactive engagement to ensure students are appropriately challenged by the material [3, 4]. The guiding principles categories of UDL were used to conceptualize barriers to access in virtual learning. This framework was also used to guide instrument and item development, data analysis, and data interpretation.

III. Methods

A. *Survey Design*

The Online Accessibility for students with Disabilities Scale (OADS) was developed to investigate students with disabilities' experiences in online learning and identify any subsequent digital equity gaps. Its design was informed by surveys exploring students with disabilities and online learning [5]; surveys related to UDL strategies [6]; surveys regarding perceived challenge and self-concepts [7, 8]; and a scale on control and relevance of schoolwork [9]. The OADS survey consists of 58 items examining: (1) accommodations for virtual learning (7 items), (2) accessibility (21 items), (3) perceived course difficulty (11 items), (4) perceived value of learning (7 items), and demographics (12 items). This paper focuses on student responses to items regarding accessibility. See Table I for the portion of the survey dedicated to accessibility.

TABLE I. ACCESSIBILITY SECTION OF THE ONLINE ACCESSIBILITY FOR STUDENTS WITH DISABILITIES SCALE (OADS)

Instructions: *Think about a particular online course you have or are currently taking. Now, please indicate your level of agreement with the*	
Scale: 1: strongly disagree, 2: disagree more than agree, 3: agree more than disagree, 4: strongly agree	
Q1	The instructor presents information in multiple formats to ensure information is accessible for all their students.
Q2	The course syllabus clearly describes the learning objectives of this course.
Q3	The instructor's expectations are consistent with syllabus learning objectives.
Q4	The instructor ties the most important points of the individual class session to the larger objectives of the course.
Q5	The instructor begins each individual class session with an outline of what will be covered.
Q6	The instructor summarizes key points throughout the individual class session.
Q7	The instructor provides electronic equivalents (e.g., Word, PDF) of paper handouts.
Q8	The required reading assignments are available online.
Q9	The key points from instructional videos for this class are easy to grasp.
Q10	The instructor uses instructional technologies (e.g., clickers, Rams) to enhance learning.
Q11	The course learning management systems (e.g., Canvas, Blackboard, or Moodle sites) are clearly organized and easy to use
Q12	Students are allowed to demonstrate their comprehension of material in alternate ways.
Q13	The instructor provides useful feedback on all assignments.
Q14	The instructor provides timely feedback on all assignments.
Q15	In this course, I feel interested and motivated to learn.
Q16	The instructor provides meaningful assignments.
Q17	The instructor is accessible outside of class time.
Q18	The instructor is highly approachable to all students.
Q19	The instructor creates a class climate in which student diversity is respected.
Q20	The instructor explains the real-world importance of the topics taught in this course.
Q21	The instructor supplements lecture and reading assignments with visual aids.

B. *Validity Evidence*

Face validity and content validity were used to test the initial set of items and inform potential changes. A focus group was conducted with two engineering students with disabilities who have participated in online learning to examine validity associated with use. Focus groups allowed the researchers to better understand the perceptions, beliefs, and values of culturally diverse groups in quantitative research [10]. Two subject matter experts with expertise in creating fixed item surveys and/or studying students with disabilities were also recruited to provide additional validity evidence. The subject matter experts were used to determine the domain relevance and representativeness of the survey items for each construct.

Focus group participants and subject matter experts were asked to individually rate each survey item on a 5-point Likert Scale: "5" the test is extremely suitable for the given purpose, "4" the test is very suitable for that purpose, "3" the test is adequate, "2" the test is inadequate, and "1" the test is irrelevant, therefore unsuitable [11]. The focus group participants' average item rating was 4.84, with an 83.93% agreement. Items were determined to be comprehensible for the target group based on an average rating of 4.84 and 83.93% agreement from the focus group; the percent agreement is well over the 41% minimum threshold [12]. The subject matter experts' average item rating was 3.11, with the lowest ratings being in the Accessibility construct. Items were removed or altered based on the suggestions of the subject matter experts.

C. *Data Collection and Participants*

Approximately 1,500 engineering department heads, diversity office leaders, disability office leaders, and professional engineering student organization leaders from U.S. colleges and universities were contacted to distribute this survey to their engineering students during the Spring 2022 semester. Survey respondents were entered in a raffle for $20 gift cards. A total of 1,078 students responded to the survey; 450 students indicated that they are a current engineering student with disabilities. The sample of participants identifying as a current engineering student with disabilities was used for this study. Additional demographics included gender - 34.5% male, 50% female, and 10.5% transgender or nonbinary (5% chose not to respond) – and race and ethnicity - 12% Asian, 3% Black or African American, 10% Hispanic or Latino, 3% Middle Eastern or North African, 1% Native American or Alaskan Native, <1% Native Hawaiian or Pacific Islander, 10% Two or More Races, and 61% White.

IV. DATA ANALYSIS

The scale for the items in the accessibility construct ranged from "0 – Strongly disagree" to "3 – Strongly agree." Respondents also had the option to respond, "Not applicable or prefer not to respond." Respondents that answered fewer than half of the questions were automatically removed from the analysis.

An exploratory factor analysis (EFA) was conducted to identify prominent accessibility barrier themes. Kaiser-Meyer-Olkin (KMO) and Bartlett's tests were conducted to determine the sample's adequacy. The KMO measure was 0.9, which meets the minimum threshold of 0.6 to determine sample adequacy [13]. The Bartlett's test of sphericity was significant ($p \leq 0.001$), indicating sufficient correlation between variables to proceed with the analyses [13]. Three factors reflecting the three UDL guiding principles were extracted using principal axis factoring (PAF), and the solution was rotated using an oblique rotation (Promax method) with Kaiser normalization. No cross-loading or high load on any factor occurred following two rounds of extraction and rotation. All remaining variable values satisfied the acceptable range of one item being ≥ 0.32 [14].

V. Results and Discussion

A. EFA Barriers to Online Learning

The EFA (Table 2) revealed that barriers in online learning can be conceptualized into three main categories providing multiple means of: (1) Action and Expression, (2) Representation, and (3) Engagement. These categories reflect the three guiding principles of Universal Design for Learning. Action and Expression encompassed items referring to the course's delivery. The items that loaded onto this factor describe instructor accessibility, feedback, and comprehension of the material. Representation items referred to how the course's learning objectives are presented. The items that loaded onto this factor describe the clearness of instructor and syllabus expectations for the student's learning. Engagement included items referring to the classroom environment that the instructor creates. The items that loaded onto this factor describe students' comfort with the classroom climate, approaching the professor for help, and instructor access outside of class.

TABLE II. EFA Barriers to online learning

Factor	Item Information	
	Question	***Factor Loading***
Provides Multiple Means of Action and Expression	The instructor presents information in multiple formats to ensure information is accessible for all their students.	.517
	The instructor begins each class session with an outline of what will be covered.	.573
	The instructor summarizes key points throughout the individual class session.	.778
	The required reading assignments are available online.	.409
	The key points from the instructional videos for this class are easy to grasp.	.512
	The instructor uses instructional technologies (e.g., clickers, Rams) to enhance learning.	.578
	The course learning management systems (e.g., Canvas, Blackboard, or Moodle sites) are clearly organized and easy to use.	.335
	Students are allowed to demonstrate their comprehension of material in alternate ways.	.714
	The instructor provides useful feedback on all assignments.	.686
	The instructor provides timely feedback on all assignments.	.543
	In this course, I feel interested and motivated to learn.	.508
	The instructor explains the real-world importance of the topics taught in this course.	.483
	The instructor supplements lecture and reading assignments with visual aids.	.588
Provides Multiple Means of Representation	The course syllabus clearly describes the learning objectives of this course.	.772
	The instructor's expectations are consistent with syllabus learning objectives.	.831
	The instructor provides electronic equivalents (e.g., Word, PDF) of paper handouts.	.350
Provides Multiple Means of Engagement	The instructor is accessible outside of class time.	.929
	The instructor is highly approachable to all students.	.774
	The instructor creates a class climate in which student diversity is respected.	.632

The summary of items for each factor presented in Table 2 shows the EFA factors, associated items, and factor loadings. Results from items in Action and Expression suggest that the format of assignments, presentation of material, and feedback from the instructor all contribute to how a student views their online course's accessibility. There is also a connection between the perceived accessibility and their interest in the course. Participant responses to Representation suggest that a clear explanation of learning objectives and outcomes contributes to how students view the accessibility of their online courses. Finally, the items from Engagement suggest that instructor availability and class climate contribute to students' accessibility.

B. Barriers Most Faced in Online Learning

We conducted a reliability analysis, which provided the mean scores and Cronbach's alpha values for each factor, to find the barriers that students with disabilities most face in the engineering classroom. We examined the average scores for each factor and individual items to identify the accessibility items with the lowest mean scores. The five items with the lowest mean scores ($M < 1.4$) were identified as the barriers most frequently encountered in online learning. These items were:

1. Students are allowed to demonstrate their comprehension of material in multiple ways.
2. The instructor provides useful feedback on all assignments.
3. The instructor provides timely on all assignments.
4. The instructor uses instructional technologies (e.g., clickers, RamCT) to enhance learning.
5. In this course, I feel interested and motivated to learn.

All items are a part of the factor Action and Expression. This suggests that barriers most faced in online learning stem from how instructors present material and provide feedback to students; all of which relate to students' interest and motivation in the course.

VI. Implications and Future Work

The ability to engage in classwork virtually is crucial for student success, especially now due to the influx of virtual learning opportunities resulting from COVID-19. The development and use of the OADS survey is part of an ongoing study measuring engineering students with disabilities' experiences in online courses. A better understanding of these experiences will inform future accessibility improvements in virtual engineering courses. The identification of barriers to online learning for students with disabilities resulting from this work will be used to initiate the conversation around accessibility in online learning.

VII. Conclusion

This study adds new information to the growing body of research for students with disabilities in online learning environments. Our results show that accessibility for engineering online learning can be conceptualized by the Universal Design for Learning principles. The accessibility barriers most faced relate to providing means for action and expression. More research is needed to understand these barriers and their specificity to engineering online learning environments.

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References

[1] Konur, O. (2007). Computer-assisted teaching and assessment of disabled students in higher *education: The interface between academic standards and disability rights*. Journal of Computer Assisted Learning, *23*(3), 207–219. https://doi.org/10.1111/j.1365-2729.2006.00208.x

[2] International Association of Universities [IAU]. (2020). In *The Impact of COVID-19 on Higher Education Around the World*. UNESCO.

[3] Rose, D.H., and Gravel, J.W. (2010). Universal design for learning. *International Encyclopedia of Education*, 119–124.

[4] Rose, D.H., and Meyer, A. (2006). A Practical Reader in Universal Design for Learning. *Harvard Education Press*.

[5] Roberts, J., Crittenden, L., & Crittenden, J. (2011). Students with disabilities and online learning: A cross-institutional study of perceived satisfaction with accessibility compliance and services. *Internet and Higher Education*, *14*, 242-250.

[6] Sánchez Fuentes, S., Castro, L., Antonio Casas, J., Vallejo, V., & Zuñiga, D. (2016). Teacher Perceptions based on Universal Design for Learning. *Communications Disorders, Deaf, and Hearing Aids*, *4*(1). 10.4172/2375-4427.1000155

[7] Wilson, H., Siegle, D., McCoach, B., Little, C., & Reis, S. (2014). A Model of Academic Self-Concept: Perceived Difficulty and Social Comparison Among Academically Accelerated Secondary School Students. *Gifted Child Quarterly*, *58*(2), 111-126.

[8] Baker, K., Boland, K., & Nowik, C. (2012). A Campus Survey of Faculty and Student Perceptions of Persons with Disabilities. *Journal of Postsecondary Education and Disability*, *25*(4), 309-329.

[9] Appleton, J. J., Christenson, S. L., Kim, D., & Reschly, A. L. (2006). Measuring cognitive and psychological engagement instrument. *Journal of School Psychology*, *44*, 427-445.

[10] Calderón, J., Baker, R., & Wolf, K. (2000). Focus Groups: A Qualitative Method Complementing Quantitative Research for Studying Culturally Diverse Groups. *Education for Health*, *15*(1), 91-95.

[11] Nevo, B. (1985). *Face Validity Revisited*. Journal of Educational Measurement, *22*(4), 287-293.

[12] McHugh, M. (2012). *Interrater Reliability: The Kappa Statistic*. Biochem Med. *22*(3), 276-282.

[13] Sharma, S., (1996). *Applied Multivariate Techniques*. John Wiley and Sons, Inc., New York.

[14] Tabachnick, B.G. & Fidell, L. (2001). *Using Multivariate Statistics, Fourth Edition*. Needham Heights, MA: Allyn & Bacon. ISBN 0-321-05677-9. Hardcover.