2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #33769

A UDL-Based Large-Scale Study on the Needs of Students with Disabilities in Engineering Courses

Dr. Jennifer R. Amos, University of Illinois at Urbana - Champaign

Dr Amos joined the Bioengineering Department at the University of Illinois in 2009 and is currently a Teaching Associate Professor in Bioengineering and an Adjunct Associate Professor in Educational Psychology. She received her B.S. in Chemical Engineering at Texas Tech and Ph.D. in Chemical Engineering from University of South Carolina. She completed a Fulbright Program at Ecole Centrale de Lille in France to benchmark and help create a new hybrid masters program combining medicine and engineering and also has led multiple curricular initiative in Bioengineering and the College of Engineering on several NSF funded projects.

Mr. Zhilin Zhang, University of Illinois at Urbana - Champaign

Zhilin Zhang is a 5-year BS-MS student in Computer Science at the University of Illinois at Urbana-Champaign (UIUC), co-advised by Professor Lawrence Angrave and Professor Karrie Karahalios. His research interests are in Human-Computer Interaction and Learning Sciences. He studies, designs, and builds intelligent systems to support scalable and accessible teaching and learning through a computational lens.

Prof. Lawrence Angrave, University of Illinois at Urbana - Champaign

Lawrence Angrave is an award winning Fellow and Teaching Professor at the department of computer science at the University of Illinois at Urbana-Champaign (UIUC). His interests include (but are not limited to) joyful teaching, empirically-sound educational research, campus and online courses, computer science, engaging underrepresented students, improving accessibility and creating novel methods that encourage new learning opportunities and foster vibrant learning communities.

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

Hongye Liu joined the Illinois Department of Computer Science after years of research experience in Biomedical informatics primarily in the Boston Longwood Medical area including Harvard Medical School and its affiliated hospitals. She received her B. E. in Precision Machinery and Instrumentation from the Univ of Science and Technology of China and her PhD from MIT in the area of computer aided design for 3-D Printing. Dr. Liu was driven by the interest of helping cure diseases and have done research in diverse Data Science related areas such as Bioinformatics, Computational Biology, Biostatistics, and Machine learning.

Over a 4-year period of encountering/interacting with students, reviewing academic works and college teaching, she discovered her passion for teaching undergraduate students and training next generation of computer scientists and data-centered professionals. She is compassionate about helping undergraduate students do research and mentoring underrepresented students. Her research interests are Biomedical applications that involve large high dimensional data analysis and machine learning and data-driven education improvement for underrepresented students.

Ms. Yiyin Shen

A UDL-based large-scale study on the needs of students with disabilities in engineering courses

Abstract

Among all college students, students with disabilities are particularly at risk due to a high percentage of underreporting. We conducted a survey across many undergraduate courses in engineering and computing at the University of Illinois to identify course components that engage students with and without disabilities. We were motivated to find not only opportunities for future course improvements for all students but also greater equity for students with disabilities. Therefore in the survey, we asked for both students' disability and demographics info and their usability and satisfaction with more than ten types of course modalities including live Zoom lectures, recordings of lectures, small group discussions, instructor notes, transcripts of lecture videos, discussion boards, etc. The study spanned 13 different departments with a total enrollment of 1800 students during Fall 2020 and Spring 2021. Preliminary results from 303 responses from 49 different courses showed that students with disabilities preferred recorded lectures videos with transcripts, course textbook and instructor notes/slides that they could engage with offline, while students without disabilities were more satisfied with office hours and lecture videos in addition to lecture notes. In addition, female students appeared to be less satisfied with instructor Powerpoint slides, live Zoom lectures and discussion/lab sessions than male students. These results demonstrated the importance of multiple resources, supporting Universal Design Principles.

Introduction

This paper presents the findings from a UDL-based survey on the needs of students with disabilities in engineering courses in Fall semester 2020 and Spring semester 2021 in the University of Illinois at Urbana Champaign. The survey collected data about different learning modalities including course textbooks, instructor handwritten notes, instructor lecture notes, instructor Powerpoint slides, course lecture videos, video transcripts, videos with captions in other languages, live Zoom lectures, and office hours. Students were asked about their usage of course content modalities, satisfaction of course content modalities, MUSIC expectancy factors, demographics of students, disability status and disclosure status. Statistical analysis was conducted on the survey data to understand the differences in the needs of students with and without disabilities. A statistical analysis also found significant differences based on gender for a subset of modalities.

This paper is organized as follows. The background section provides a broad context of the work presented in this paper: the current status of under-reporting of students with disability, an introduction to the Universal Design for learning (UDL), and how UDL can help to promote

engineering education. The methods section gives details on the survey, data collection and analysis. The results section presents findings on students' needs, with a special focus on students with disabilities and female students. We then discuss the implications and limitations of the study, and conclude with possible future directions.

Background

Under-Reporting of Students with Disability

The National Center for Education Statistics reported 19% of undergraduates reported a physical or cognitive disability (see Table 2-6 of [1]). Students with 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; speech or language impairment; learning, mental, emotional, or psychiatric condition (e.g., serious learning disability, depression, ADD, or ADHD); or other health impairment or problem. However most disabilities are not reported to the institution or course instructors. For example, Previous research showed 75% underreporting of students with a wide spectrum of disability, i.e. only a quarter of the respondents who reported a disability chose to inform the instructor or the institution [2].

In 2019, the University of Illinois performed a senior exit-survey that was sent to all graduating seniors on campus. The survey collected information on all aspects of campus life including access to-, and satisfaction with-, disability resources. The results of the senior survey provided similar preliminary evidence for the need to better support students in engineering with disabilities both disclosed and undisclosed. Among the respondents, 8% students reported a disability, among whom 27.8% replied that their disability needs were unmet. More than 56% of the students with disability did not register for support services. Surprisingly, for most of the "How well have you improved..." self-assessment questions in the survey, the students with disability responded significantly ($p=0.004$ for response of "very well improved" and $p=0.048$ for "extremely well improved") more positively than the majority. Moreover, the group of students who transferred or the group of students who were international, we found these two groups of non-majority students also gave more positive responses than the majority. We found these three student groups shared a commonality: their common areas are the ability to communicate and explore from viewpoints of more than one academic field. Lastly, greater percentages of students with disability found "Course(s) outside my major" had the most impact on their improvement than students without disability. Similarly, greater percentages of students with disability found "Informal interaction with other students" had the most influence on their improvement than the students without disabilities. Such findings lead to our question: what motivating factors are underlie the successes of students with disabilities?

Universal Design for Learning

Universal Design for Learning (UDL) is a conceptual framework and associated set of educational principles and practices designed to improve learning outcomes for all students by recognizing that single methods of delivery, assessment and engagement are insufficient and may cause unnecessary hardships to minority students, especially students with disabilities. UDL further posits that items and activities designed to assist specific disabilities and improve equity, may further help all students to be better learners [3]. Briefly, the three principles of Universal Design for Learning (UDL) are that a course should provide; 1) multiple methods of representation that give learners a variety of ways to acquire information and build knowledge; 2) multiple means of student action and expression that provide learners alternatives for demonstrating what they have learned; and 3) multiple modes of student engagement that tap into learners' interests, challenge them appropriately, and motivate them to learn. For this work we focus on multiple representations of content i.e. the first principle of UDL.

Although research has found that students enjoy courses that adhere to UDL principles [4] and that they perceive their instructor's teaching abilities to be better [5], the impact on learning outcomes has been mixed. For example, previous study found no significant difference in both disabled and non-disabled students' learning between a course taught using UDL principles compared to a course taught in a regular manner [6]. Conversely, the introduction of searchable video lectures in an undergraduate-level system programming course which complemented the equivalent online book content caused an increase in course performance for all students [7]. Similarly in an introduction to electronics class, searchable translated class videos led to improved course scores [8].

With the demonstrated (described in more details below) improved performance in these courses, we are curious how this may generalize to other Engineering courses which have already used multiple representations of content, such as video lectures, recorded videos and online course book, lecture Powerpoint slides with or without handwritten notes, and the set of recitation materials. Furthermore we want to investigate what dominant influences on the student improvement in learning are and what specific learning pathway(s) is/are underlying the students with disabilities so that we can help them flourish and succeed.

The element of choice is popular amongst students and also benefits the non-majority such students with disabilities. Choice is often linked to motivation in engineering education literature. In fact, modern expectancy-value theories argue that individuals' choice, persistence and performance can be explained by their beliefs about how well they will do on the activity and the extent to which they value the activity [9, 10]. For example, a student chooses to engage with different course materials because they believe it will increase their performance or overall understanding. Likewise, interest in a topic and empowerment to make choices in their learning engagement can determine whether or not a student performs well in a course. To better

understand the expected value of different course materials, the project leveraged a popular, validated survey methodology known as the MUSIC Inventory. The MUSIC Inventory measures the five primary components of the MUSIC Model of Motivation: eMpowerment, Usefulness, Success, Interest, and Caring (see Table 1). The components of the MUSIC model have been used for the past decade in multiple contexts to identify factors that motivate students [9, 10].

Table 1. The MUSIC Model.

MUSIC Model Construct	Definition
eMpowerment	He or she has control or her learning environment in the course
Usefulness	The coursework is useful to his or her near future
Success	He or she can succeed in the coursework
Interest	The instructional methods and coursework are interesting
Caring	The instructor cares about whether or not a student can succeed in coursework and cares about student well-being

Adoption of ClassTranscribe, a UDL tool, in Engineering Education at University of Illinois
In addition to standard modalities used to deliver content, 16 engineering classes at the University of Illinois have adopted ClassTranscribe, a new accessible video platform based on UDL principles, to provide students with multiple pathways to access video content. Using ClassTranscribe, students can view and review recorded live content asynchronously (compared to live lecture), optionally read the captions and live transcriptions, read transcriptions in alternative languages, and search for relevant content across an entire course. Though captions are beneficial to deaf students, the equivalent text representation of the audio stream benefited the class as a whole. In recent semesters ClassTranscribe has been used in 38 classes across the University of Illinois (18 classes in Spring 2020, of which 13 were in computer science). Highlights of peer-reviewed course performance models and student feedback showed that searching as a new modality is correlated with positive perceptions and improved student performance [7, 8].

With the evidence described above on the success of UDL-based approaches, we aim to study how students engage with course components with a focus on multiple representations of course material and multiple ways of interacting with the representations. For the design of the survey, we included the framework of expectancy value in order to determine the interplay between cognitive and affective attribute influences on use of a given representation. Further, we tested our hypothesis that providing multiple representations of course content in engineering courses, can benefit all students, especially students with disabilities.

We conducted this research with the hypothesis that providing multiple representations of course content in engineering and CS courses, can benefit all students and especially students with disabilities. We asked the following research questions:

1. What are students' usage, satisfaction, and MUSIC evaluation of different learning modalities?
2. What is different in usage, satisfaction, and MUSIC evaluation towards modalities between students with disabilities and without disabilities?
3. What is different in usage, satisfaction, and MUSIC evaluation towards modalities between female students and male students?

Methods

Survey Design

The research team created a survey that used a motivation framework to collect information about the usage of course content modalities, satisfaction of course content modalities. The research team used the MUSIC® Model of motivation [9, 10]. The MUSIC Model's emphasis on the design and assessment of instructor-facilitated classroom activities makes it a good choice for studying student motivation in the context of course modalities. Furthermore, the conceptual basis of the MUSIC Model—that the actions of instructors have been shown in the literature to influence student motivation to learn—reinforces the need to study UDL learning in the context of teaching. For our study, we focused on the empowerment, usefulness, and success elements as they related most closely to the course materials. The survey and study were approved by the university IRB and a lottery incentive was used to recruit participants. At the end of the collection period, the researchers used a random number generator to select five $100 gift card winners.

Survey Sections

The survey consisted of 3 sections, described below.

1. Usage and satisfaction from for each modality: Course textbook, Course lecture notes, Course Powerpoint slides, lecture notes, handwritten notes, Course lecture videos, captioned videos, Live Zoom lecture, Piazza or other online discussion forums resources, Information on Course website, Discussion/recitation, Office hour, etc.
2. MUSIC Survey elements for empowerment, usefulness, and success
3. Demographics (gender identity, international/domestic, disability disclosures, anonymous disability service status)

At the end of the collection period, 303 undergraduate students from 49 different courses completed the survey, with 48 (16%) students with disabilities and 255 students without disabilities. Among the 48 students, 44 disclosed mental or cognitive disabilities and 4 with

physical disabilities. Table 2 shows the demographic statistics of disclosed gender and disability status; students with disabilities (SWD) and students without disabilities (SWOD). Students had the option to not disclose their disability status or gender. We consider the few students who chose not to disclose their disability status as SWOD. The 7 students who didn't disclose gender, were considered as female in the subsequent analysis.

Table 2. Demographic statistics of Disability Status and Gender.

SWD	SWOD	Female	Male	Female SWD	Total
48 (16%)	255 (84%)	127 (42%)	176 (58%)	32 (11%)	303

Data Analysis

Analysis was performed without personal identifiable information. Unfinished and duplicate responses by the same participant were excluded. We checked the internal consistency of the responses by calculating the Cronbach alpha. The MUSIC questions had the highest Cronbach ~0.93 and the satisfaction questions at ~0.72, and the usage questions at ~0.63. To test for inter-group differences we conducted a chi-squared test for all the usages, satisfaction and MUSIC questions between SWD and SWOD students. Using numerical codes for the Likert-scale responses, we also conducted Wilcoxon tests to analyze the differences between the two groups of students. The same analyses were performed between the female students and male students. In this paper, when a p value is quoted without a name of test, the default will be the Wilcoxon test. In addition, we calculated the correlation coefficients between the usage and satisfaction for each of the modalities of course content. The visualization of the Likert-scale response data is conducted using the R package “Likert”.

Results

Usage, Satisfaction, and MUSIC

In the survey, we asked students to evaluate their usage and satisfaction of different modalities, such as instructor powerpoint slides, course lecture videos, live Zoom lectures, instructor lecture notes, office hours, discussion/lab section, online discussion forum, course textbook, instructor handwritten notes, ClassTranscribe/transcripts of videos, and caption in other languages. For usage, students can choose from “Use always - weekly or more often”, “Use sometimes - a few times during semester”, “Never use”, “Never use/Not available”, and “I wish this were available in my course.” For satisfaction, students can choose from “Very satisfied - wish every class offered it”, “Satisfied - will use it if available”, “Unsatisfied - consider it useless”, “Did not use/Not available in this course.”

According to the survey results from all 303 undergraduate students from 49 different courses, for usage of modalities (Figure 1), generally, students had a relatively high usage of course lecture videos, instructor powerpoint slides, and live Zoom lecture, because more than 80% of the respondents chose “Use always” or “Use sometimes.” More than 50% of the respondents chose “Use always” or “Use sometimes” for instructor lecture notes, office hours, discussion/lab section, online discussion forum, course textbook, and instructor handwritten notes. On the other hand, less than 50% of the respondents reported often or sometimes usage of the transcripts of videos/ClassTranscribe and captions in other languages. Most reported that such modalities were not available or never used.

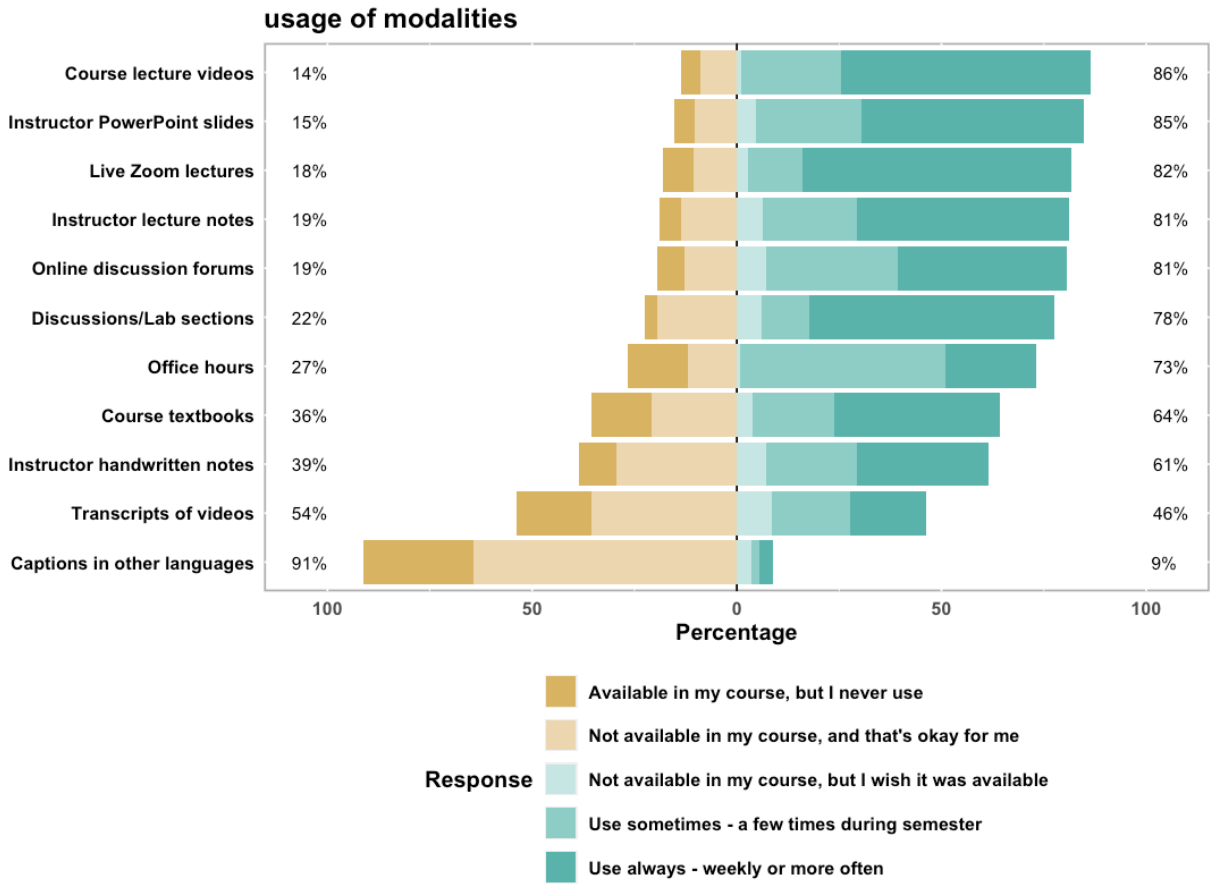

Figure 1. Usage of Modalities

For satisfaction of modalities (Figure 2), the same pool of respondents reported that course lecture videos, instructor Powerpoint slides, and live Zoom lecture were the three most satisfied modalities, with more than 75% of the participants choosing “Very satisfied” or “Satisfied”. Whereas more than 50% of the respondents chose “Very satisfied” or “Satisfied” for office hours, instructor lecture notes, online discussion forum, course textbook, and discussion/lab section. On the contrary, a majority of responses indicated that Transcripts of videos /ClassTranscribe and Captions in other languages were never used or not available in this course.

However, these modalities did exist in some of the courses that we surveyed, and we speculated that students might be unaware of them.

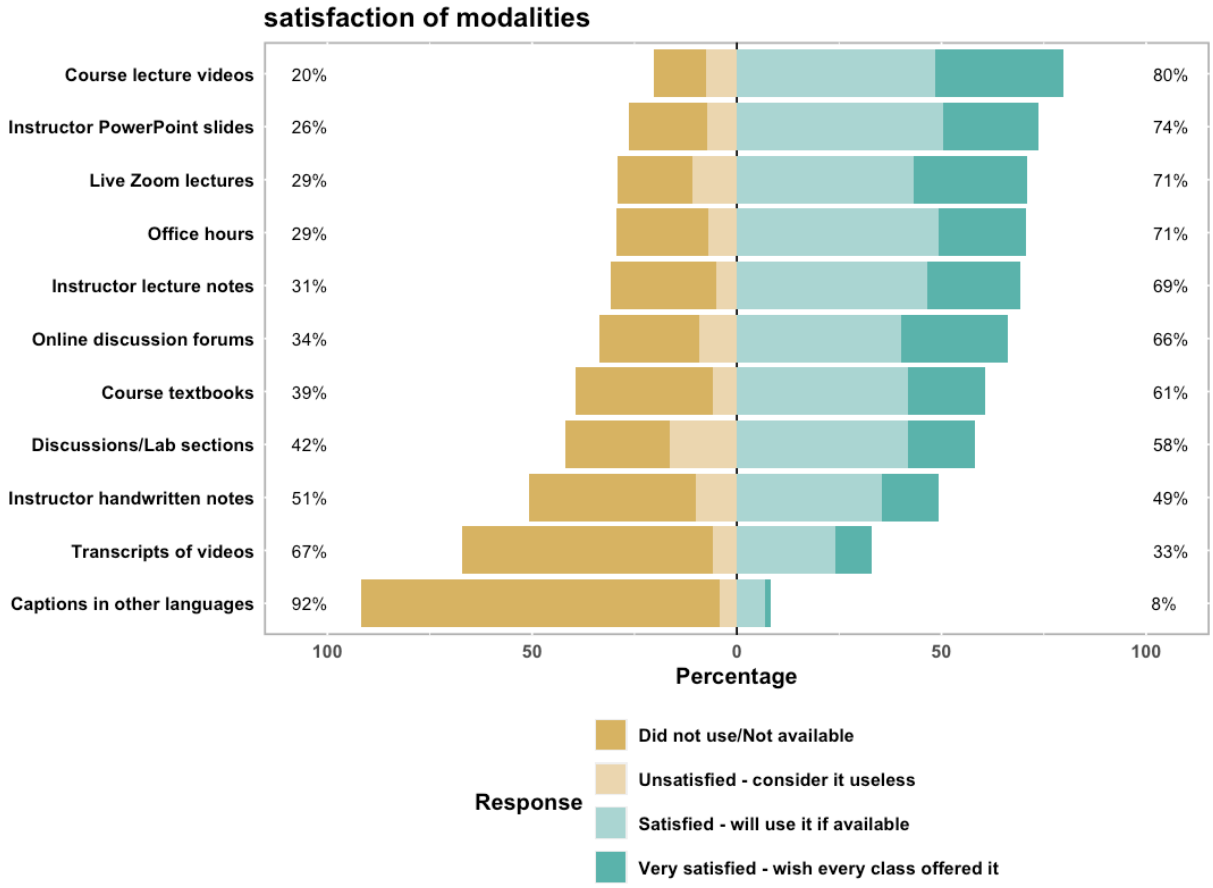

Figure 2. Satisfaction of Modalities

In addition, students were asked to evaluate their course based on the MUSIC model we discussed previously in this paper. We asked Likert-scale questions on students' feeling of eMpowerment, Usefulness, Success, Interest towards different modalities, where students rated from "Strongly disagree" to "Strongly agree" (Figure 3). Results showed that students generally evaluated the coursework high, with a slight exception for instructional methods 29% of the respondents revealed that they did not agree that the instructional methods used in the course held their attention.

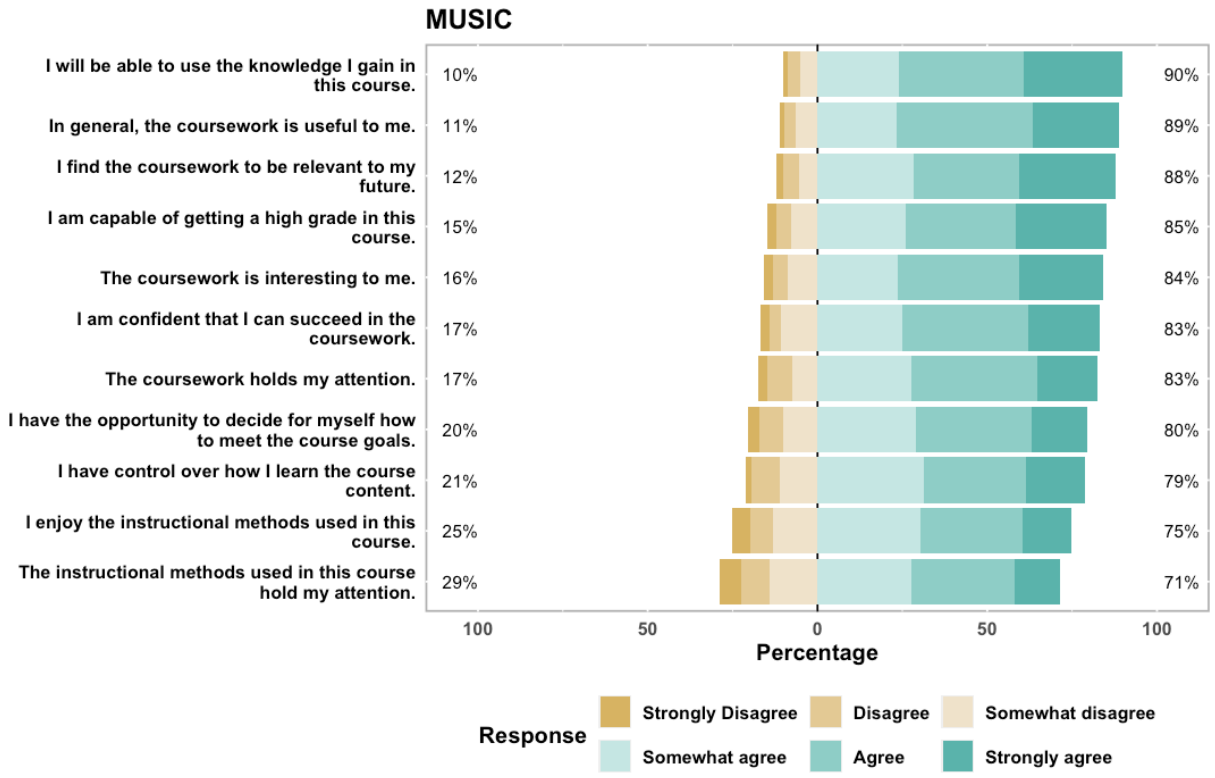

Figure 3. MUSIC Evaluation

Students with Disabilities (SWD) vs. Students without Disabilities (SWOD)
We compared and contrasted survey responses in terms of usage, satisfaction, and MUSIC evaluation for SWD and SWOD. We found significant differences in usage and satisfaction towards different modalities (Figure 4-5). The analysis showed no significant difference between the two student groups for all the MUSIC factors, which is an encouraging result.

For usage, given the large percentage of responses of "Never use/Not available" for some modalities, we did the comparison between the two student groups by filtering those responses. We found there is a difference for "Live Zoom Lectures" usage ($p<0.07$) and a significant difference for "Transcripts of videos/ClassTranscribe" usage ($p<0.002$) between SWD and SWOD. SWD used less live Zoom lectures (88% vs 92%) and used more ClassTranscribe (88% vs 64%) . The top two most-used modalities in terms of percentages for SWD were "Instructor powerpoint slides" and "Instructor lecture notes" while for SWOD "Discussion/Lab section" and "Course lecture videos" were the top two. Both SWD and SWOD used Powerpoint slides and lecture notes more than textbooks, and there was no significant difference between live Zoom and recorded video lectures for both groups.

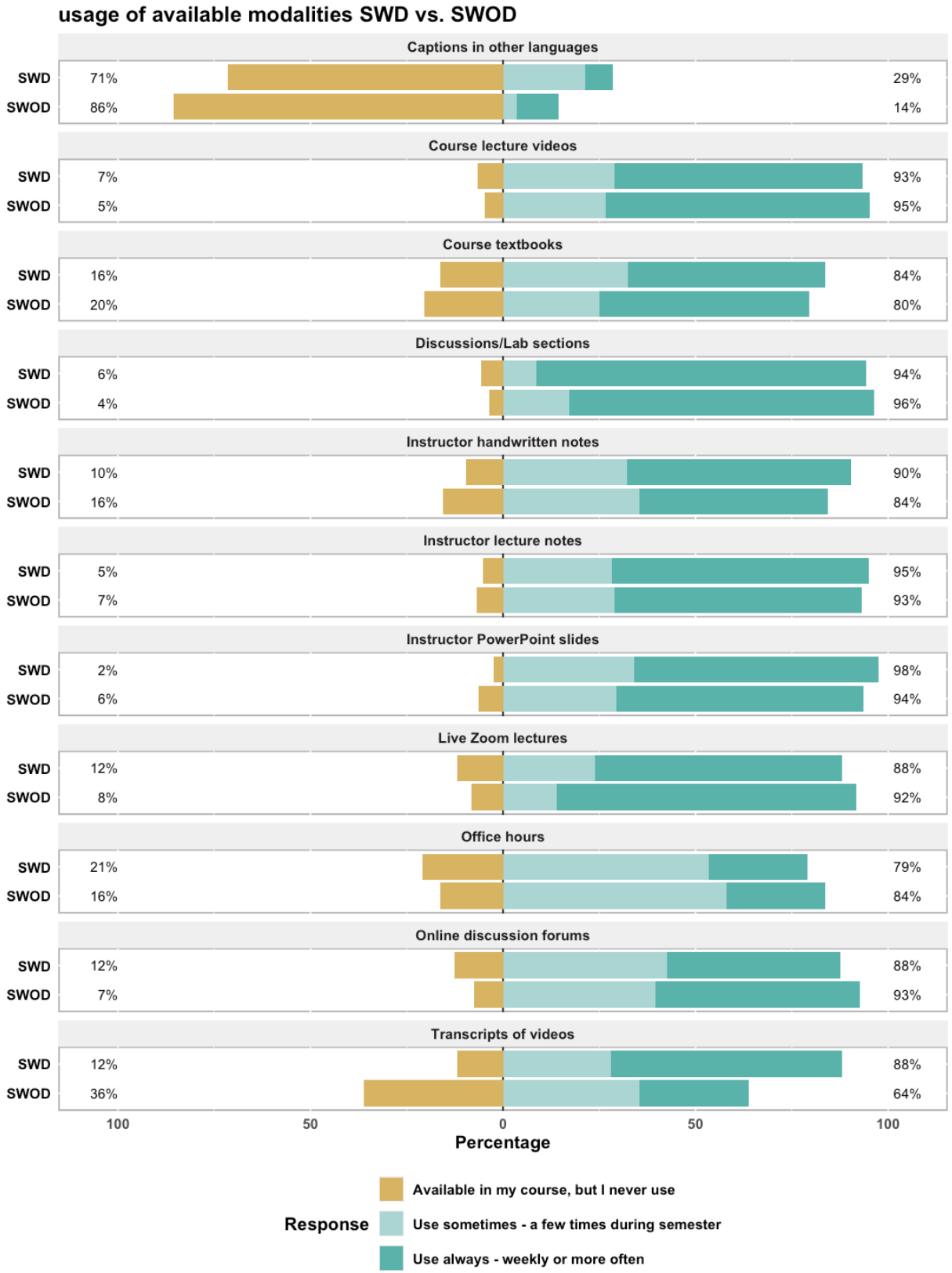

Figure 4. Usage of modalities SWD vs SWOD after filtering out "not available" option

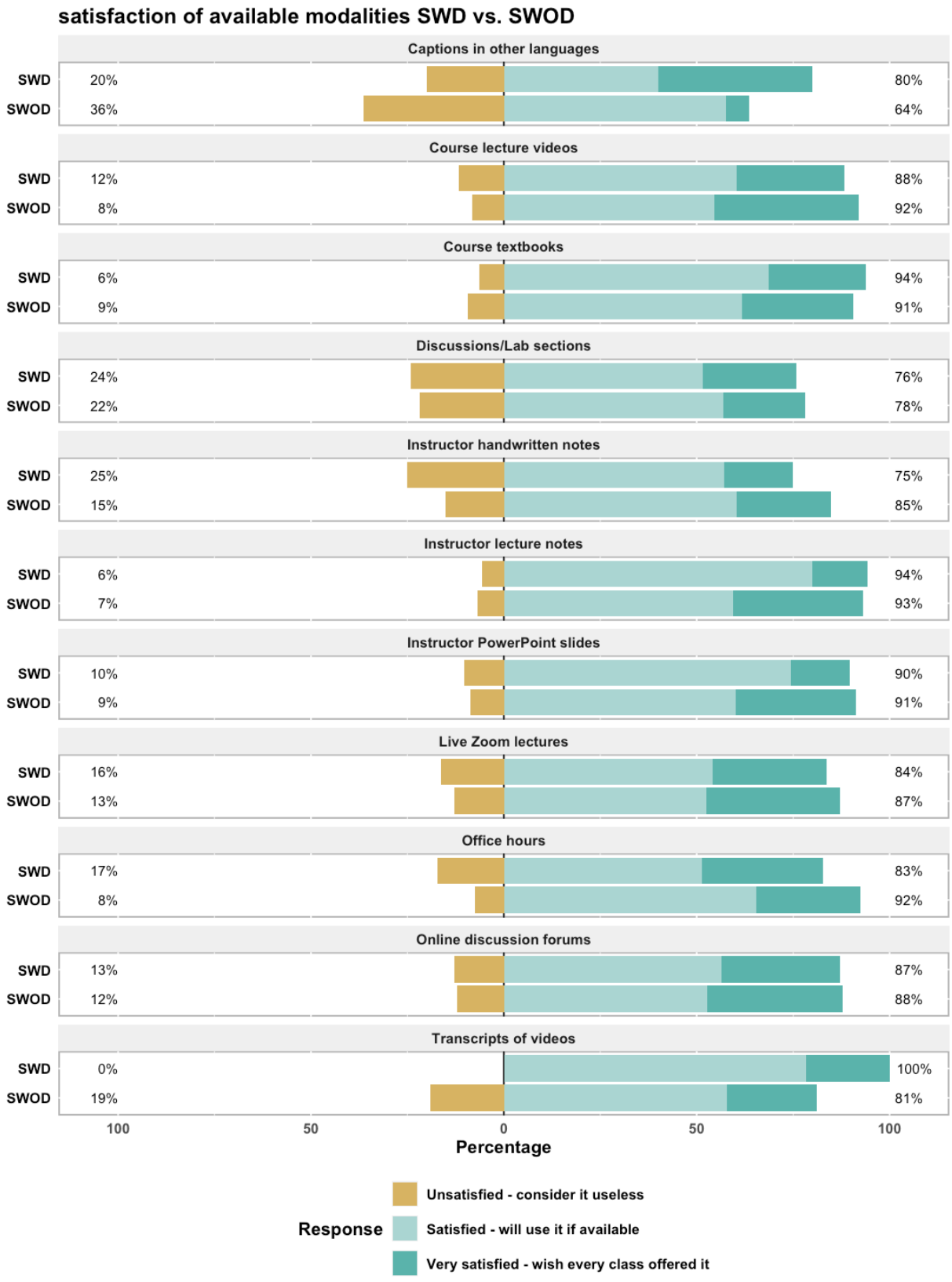

Figure 5. Satisfaction of modalities SWD vs SWOD after filtering out "not available"option

After we excluded “Not available” responses, there was an ~ 8% greater increase in usage of ClassTranscribe and captions in other languages for SWD compared to SWOD, for example the SWD usage of ClassTranscribe increased from 60% to 88% while SWOD usage of ClassTranscrive increased from 44% to 64% .

The percentage of responses for satisfaction and the p-value of Wilcoxon tests comparing SWD with SWOD are listed in Table 3. The top three modalities for satisfaction for SWD were “Transcripts of videos/ClassTranscribe”, “Course textbook” and “Instructor lecture notes” while “Office hours”, “Instructor lecture notes” and “Course lecture videos” were most satisfactory for SWOD. SWD were more satisfied with ClassTranscribe than SWOD ($p<0.024$, the test was done with data of two levels of responses- “unsatisfied” vs “satisfied” & “very satisfied” combined). Inclusion of “I wish to have " responses can strengthen this difference even more. There were no unsatisfactory responses from SWD for ClassTranscribe. In addition, no significant difference was found for satisfaction between live Zoom vs. recorded video lectures, or videos vs. Powerpoint slides for both groups of students.

Table 3. Percentages of responses for satisfaction from SWD and SWOD and the Wilcoxon tests p-value.

	Percentages								Wilcoxon p-value (remove unavailable)	Wilcoxon p-value (remove unavailable; combined)
	Did not use/Not available in this course		Unsatisfied - consider it useless		Satisfied with resource - will use it if available		Very satisfied with resource - wish every class offered it			
	SWD	SWOD	SWD	SWOD	SWD	SWOD	SWD	SWOD		
Course textbooks	33.333	33.333	4.167	6.275	45.833	41.176	16.667	19.216	0.9	0.568
Instructor lecture notes	27.083	25.49	4.167	5.098	58.333	44.314	10.417	25.098	0.056	0.809
Instructor PowerPoint slides	18.75	19.216	8.333	7.059	60.417	48.627	12.5	25.098	0.076	0.763
Instructor handwritten notes	41.667	40.784	14.583	9.02	33.333	35.686	10.417	14.51	0.214	0.206
Course lecture videos	10.417	12.941	10.417	7.059	54.167	47.451	25	32.549	0.201	0.455
Transcripts of videos	52.083	62.745	0	7.059	37.5	21.569	10.417	8.627	0.251	0.024*
Captions in other languages	89.583	87.059	2.083	4.706	4.167	7.451	4.167	0.784	0.145	0.495

Live Zoom lectures	22.917	17.255	12.5	10.588	41.667	43.529	22.917	28.627	0.486	0.574
Online discussion forums	18.75	25.49	10.417	9.02	45.833	39.216	25	26.275	0.63	0.903
Discussions/ Lab sections	31.25	24.314	16.667	16.471	35.417	43.137	16.667	16.078	0.969	0.753
Office hours	27.083	21.569	12.5	5.882	37.5	51.373	22.917	21.176	0.745	0.066

Female Students vs. Male Students

On a separate note, we compared responses from female students and male students. Results showed that for usage of modalities, female students have used instructors' handwritten notes ($p< 0.017$) and transcripts of videos ($p<0.042$) more than male students after we filtered out the "not available" responses. In terms of satisfaction and MUSIC evaluation, female students appeared to be less satisfied with instructor powerpoint slides ($p< 0.059$; $p<0.010$ if we use the combined levels), live Zoom lectures ($p<0.022$) and discussion/lab sessions ($p<0.028$), and less satisfied with the instructional methods used in their courses ($p< 0.025$) than male students (Figure 6 - 8). The percentage of responses for satisfaction and the p-value of Wilcoxon tests comparing female with male students are listed in Table 4.

Table 4. Percentages of responses for satisfaction from Female and Male and the Wilcoxon tests p-value.

	Percentages								wilcoxon p-value (remove unavailable)	wilcoxon p-value (remove unavailable; combined)
	Did not use/Not available in this course		Unsatisfied - consider it useless		Satisfied with resource - will use it if available		Very satisfied with resource - wish every class offered it			
	Female	Male	Female	Male	Female	Male	Female	Male		
Course textbooks	31.496	34.659	7.874	4.545	44.882	39.773	15.748	21.023	0.098	0.265
Instructor lecture notes	29.134	23.295	5.512	4.545	48.031	45.455	17.323	26.705	0.102	0.588
Instructor PowerPoint slides	18.898	19.318	11.811	3.977	48.819	51.705	20.472	25	0.059	0.009*
Instructor handwritten notes	39.37	42.045	10.236	9.659	38.583	32.955	11.811	15.341	0.436	0.971

Course lecture videos	14.173	11.364	7.874	7.386	48.819	48.295	29.134	32.955	0.585	0.813
Transcripts of videos	57.48	63.636	5.512	6.25	27.559	21.591	9.449	8.523	0.812	0.529
Captions in other languages	89.764	85.795	3.937	4.545	3.937	9.091	2.362	0.568	0.716	0.708
Live Zoom lectures	11.811	22.727	15.748	7.386	48.031	39.773	24.409	30.114	0.022*	0.056
Online discussion forums	27.559	22.159	8.661	9.659	41.732	39.205	22.047	28.977	0.419	0.92
Discussions/ Lab sections	34.646	18.75	18.11	15.341	37.795	44.886	9.449	21.023	0.027*	0.124
Office hours	22.047	22.727	7.874	6.25	48.819	49.432	21.26	21.591	0.752	0.595

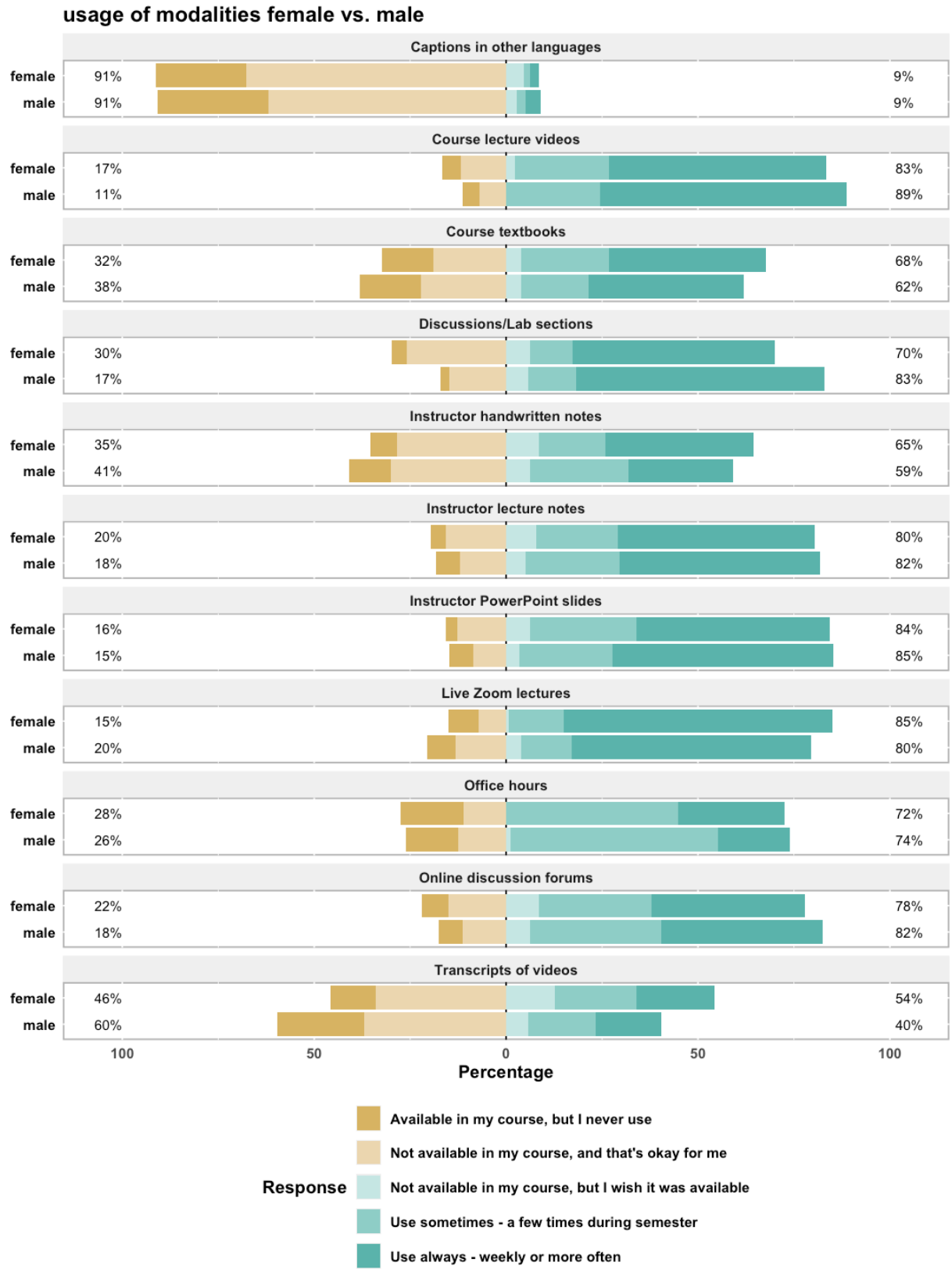

Figure 6. Usage of Modalities FS vs. MS

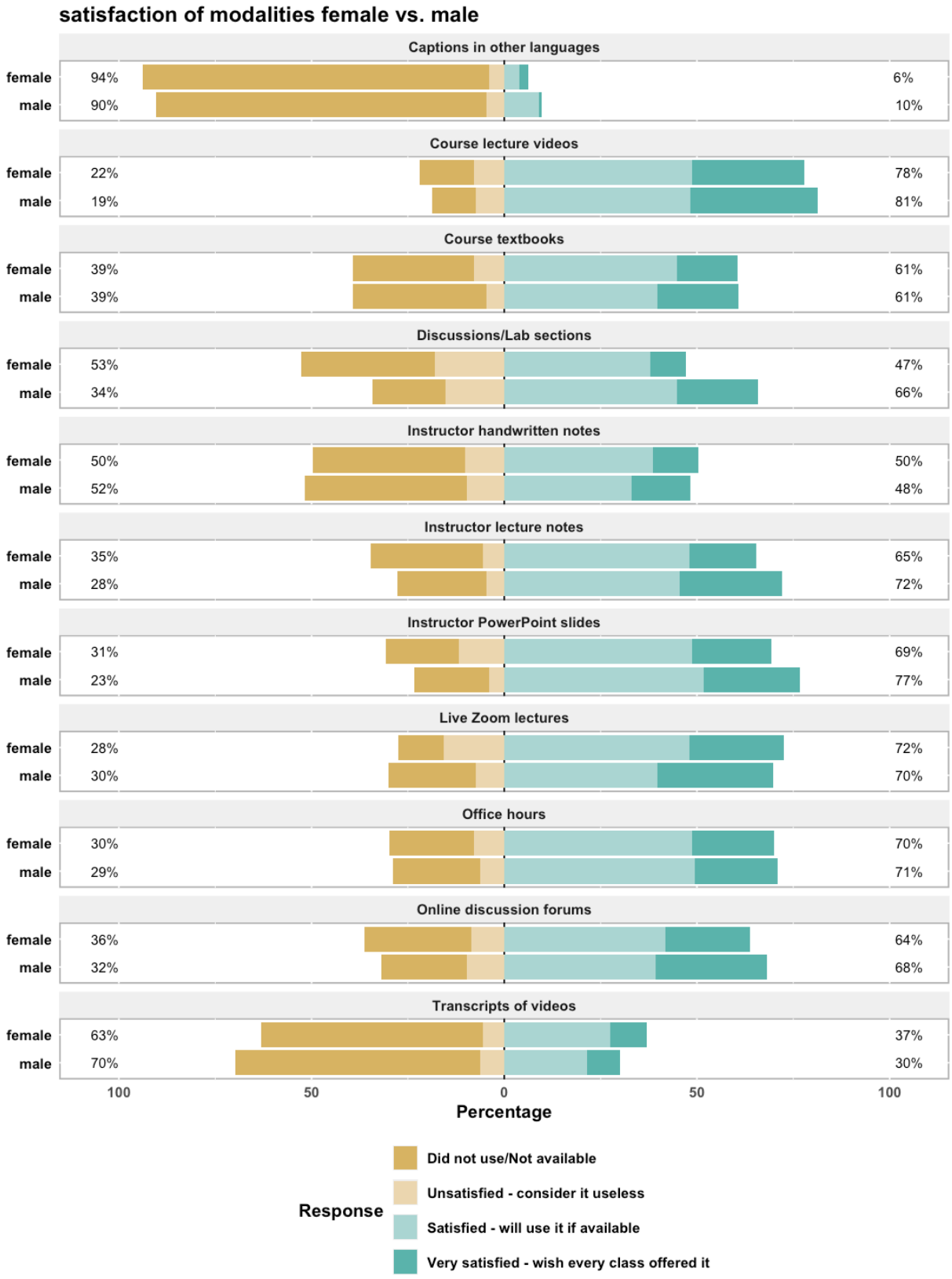

Figure 7. Satisfaction of Modalities FS vs. MS

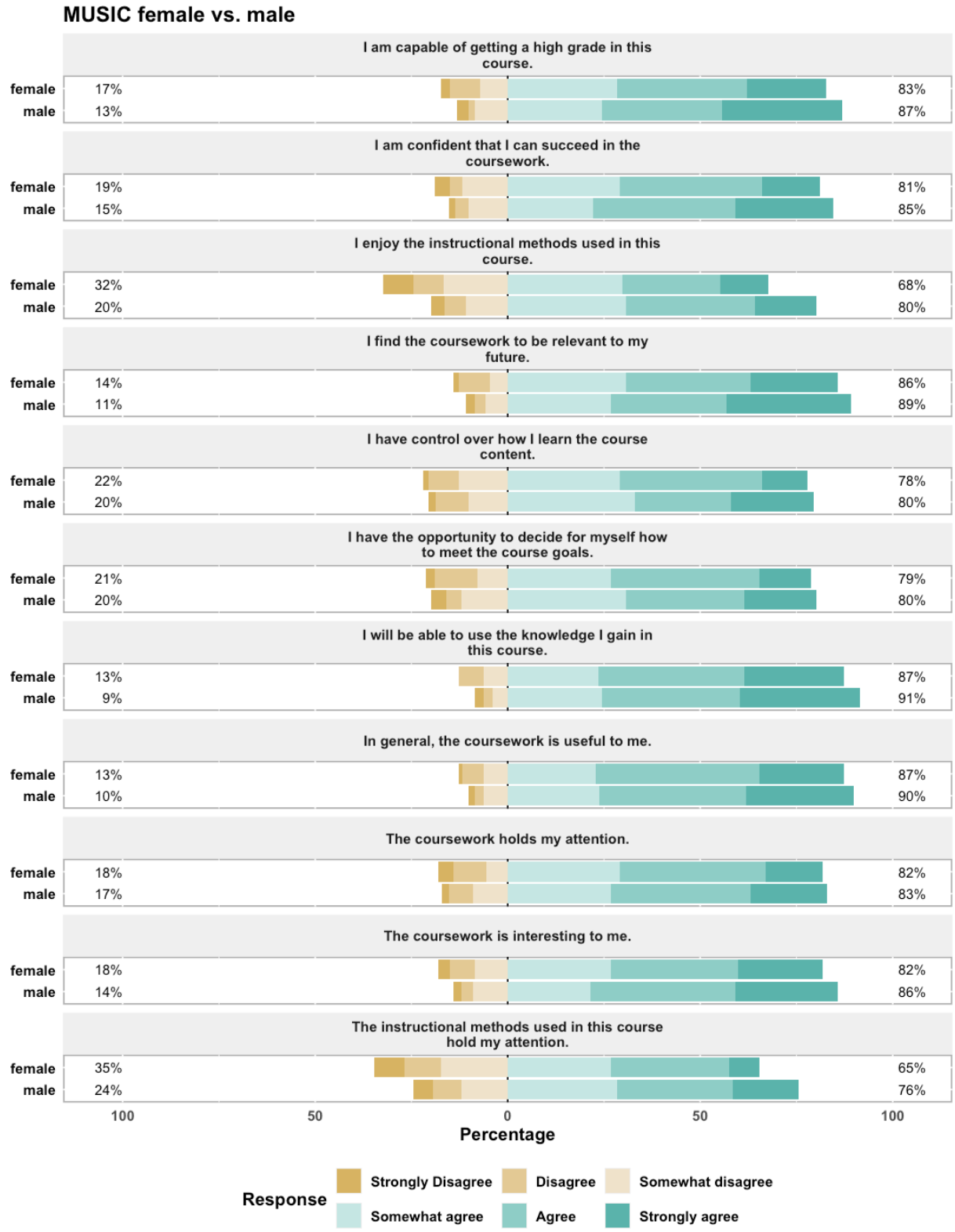

Figure 8. MUSIC Evaluation FS vs. MS

Discussion

To understand the unique needs or students' learning pathways especially for students with disabilities (SWD), we surveyed the students' perspectives on multiple course modalities. Our survey included not only the usage, satisfaction but also the expectancy values through the MUSIC model. Even if the work is still in progress and we have limited data from SWD students, we could see some significant differences between SWD and SWOD in their usage and satisfaction. We found SWD had the highest satisfaction for ClassTranscribe and textbook which both included a text-based narrative. This result seems to lead to the impression that SWD is in need of both video and text-based modalities. We also see the majority of students were satisfied with lecture videos which ClassTranscribe provided as well. In addition, we found SWOD was satisfied with office hours. Therefore, our study shows the needs of both video and text based content delivery and other modalities in order to provide accessible content for everyone. Our study also found that there was a significant difference between female and male on their perspectives on instructor powerpoint slides, live zoom lectures and the discussion/lab section. The female students tend to use more instructor's handwritten notes and transcripts from video than male students. Compared with male students, female students were less satisfied with live zoom lectures and the discussion/lab section. Such a difference between gender seems to be not entirely surprising given the data is from online learning during the COVID pandemic. Literature has shown significant differences between female and male in online learning where female students have different acceptance for E-Learning [11]. Our study helps identify the specific differences in the area of live zoom or discussion/lab section of a course. In summary, using a UDL based approach, we discovered the significant differences between SWD and SWOD in their learning preferences and differences between different gender groups. Furthermore, our data shows there is at least one student for every modality who responded that they wish such modality, thus demonstrating that UDL aligns with students' needs. One specific recommendation could be the inclusion of transcription-enabled lecture video for every engineering course. Even if the COVID pandemic is under control, this is still very important for students with disabilities based on our findings. More broadly, our findings also empirically support the use of Universal Design for Learning as an appropriate educational framework by new engineering educators to support inclusive and accessible education goals.

Limitations and future work:

Our study is in progress with the current data set from two semester's responses. We need more participants from SWD that have different types of disabilities. For example, currently we have 44 out of 48 SWD who responded to have Mental or Cognitive disabilities and 4 who reported to have physical disabilities. For these SWD students, we asked if they had reported to the school or instructors, but we have not analyzed if such a report status has correlation with their responses. We also found there were significantly more percentages of female SWD than male SWD in the survey (Chisq test p-value < 0.0004). We recognize that there are different adoption levels of

course modalities and the usage data is less consistent than other questions about satisfaction and the MUSIC questions. We have reached out to more courses from 7 courses in Fall 2020 to 49 courses in Spring2021 and a larger pool of SWD students and will continue to modify our survey to improve the consistency about usage responses for future surveys. We also plan to conduct analysis regarding potential bias caused by the discrepancies in instructional tools. In addition, we will analyze the results of semi-structured interviews, and conduct more detailed analysis of the existing survey data. Furthemore, we will do follow up interviews to identify the factors that could influence the gender differences. Finally, we will promote UDL in our institution and the awareness of SWD's needs among our engineering faculty, especially new instructors.

Acknowledgements: Our work was funded by a 2020 grant from the Strategic Instructional Innovations Program at the University of Illinois. The human subject study was permitted by an IRB #21183. ClassTranscribe and associated research is supported in part by a gift from Microsoft Corporation, as part of the Illinois Accessibility Lighthouse Program and Institute of Education Sciences, U.S. Department of Education through Grant R305A180211 to the Board of Trustees of the University of Illinois. We thank all the instructors, students and the Disability Resources & Educational Services (DRES) at U of I who participated in this project.

References

[1] NSF 19-304, National Science Foundation, National Center for Science and Engineering Statistics. 2019. Women, Minorities, and Persons with Disabilities in Science and Engineering: 2019. Special Report NSF 19-304. Alexandria, VA. Available at https://www.nsf.gov/statistics/wmpd.
[2] Love, Jacqueline Marie. (2017). Wording Matters: The Impact of Disability Identification in Post-Secondary Education. University of Wisconsin Milwaukee. https://dc.uwm.edu/etd/1662/.
[3] Rose, D. H., & Meyer, A. (2002). Teaching every student in the digital age: Universal design for learning. Association for Supervision and Curriculum Development, 1703 N. Beauregard St., Alexandria, VA 22311-1714 (Product no. 101042: $22.95 ASCD members; $26.95 nonmembers).
[4] Parker, D. R., Robinson, L. E., & Hannafin, R. D. (2007). “Blending” technology and effective pedagogy in a core course for preservice teachers. Journal of Computing in Teacher Education, 24(2), 49-54.
[5] Davies, P. L., Schelly, C. L., & Spooner, C. L. (2013). Measuring the effectiveness of Universal Design for Learning intervention in postsecondary education. Journal of Postsecondary Education and Disability, 26(3), 195-220.
[6] King-Sears, M. E., Johnson, T. M., Berkeley, S., Weiss, M. P., Peters-Burton, E. E., Evmenova, A. S., ... & Hursh, J. C. (2015). An exploratory study of universal design for teaching chemistry to students with and without disabilities. Learning Disability Quarterly, 38(2), 84-96.

[7] Angrave, L., Zhang, Z., Henricks, G., & Mahipal, C. (2020, February). Who Benefits? Positive Learner Outcomes from Behavioral Analytics of Online Lecture Video Viewing Using ClassTranscribe. In Proceedings of the 51st ACM Technical Symposium on Computer Science Education (pp. 1193-1199).
[8] Angrave, L., Jensen, K., Zhang, Z., Mahipal, C., Mussulman, D., Schmitz, C. D., Baird, R., Liu, H., Sui, R., Wu, M., Kooper, R. (2020). Improving student accessibility, equity, course performance, and lab skills: How introduction of ClassTranscribe is changing engineering education at the University of Illinois. In ASEE annual conference & exposition.
[9] Jones, B. D. (2018). Motivating Students by Design: Practical Strategies for Professors (2nd ed.). CreateSpace.
[10] Jones, B. D. (2009). Motivating Students to Engage in Learning: The MUSIC Model of Academic Motivation. International Journal of Teaching and Learning in Higher Education, 21(2), 272–285.
[11] Ramirez-Correa, Patricio E., Arenas-Gaitan, Jorge, Javier Rondan-Cataluna, F. (2015). Gender and Acceptance of E-Learning: A Multi-Group Analysis Based on a Structural Equation Model among College Students in Chile and Spain. PLOS One.