2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #39794

Is Poor Classroom Attendance a Virtual-Learning Hangover or the New Normal? A Qualitative Study

Dr. Matthew Cooper, North Carolina State University, Raleigh

Dr. Matthew Cooper is an Associate Teaching Professor in the Department of Chemical and Biomolecular Engineering at North Carolina State University. He served as a researcher at RTI International before joining the NC State faculty in 2011. Dr. Cooper's research interests include effective teaching, process safety decision-making skills, and best practices for online education. He also hosts the In The (Fume) Hood chemical engineering education podcast.

E. Daniel Cardenas-Vasquez, North Carolina State University, Raleigh

Is Poor Classroom Attendance a Virtual-Learning Hangover or the New Normal? A Qualitative Study

1. Introduction

Attending class in person has historically been considered an important factor leading to student success in undergraduate institutions [1,2]. However, in the spring of 2020, a nationwide shutdown due to the COVID-19 pandemic forced most schools (primary, secondary and tertiary educational institutions) to cancel in-person class sessions and move to remote instruction [3]. As a necessary remedy to keep classes in session, remote instruction became the norm and many strategies toward improving the effectiveness of synchronous and asynchronous remote instruction were devised and implemented [4–6]. Both parents and students were told by school administrators that these virtual classes were an appropriate replacement for in-person classes [7]. At the same time, tuition and fees were typically not changed even though classes were not held in person [8-10].

As higher education institutions became more comfortable with the risks associated with holding classes in person, as well as an increase in COVID-19 vaccination, institutions began holding in-person classes again [11]. However, classes were often still recorded and/or live streamed in some fashion [12, 13]. In many cases classes were not strictly held in person but rather in a hybrid mode; this hybrid structure meant students did not have to attend class during all class periods, but only for a portion or in alternate sessions [14, 15]. Additional school policies allowed students to miss class at any time to allow for self-quarantine due to potential COVID exposure or concern of contracting COVID in class [16].

Consequently, students may now feel viewing recorded lectures is a suitable replacement for in-person classroom attendance [17, 18]. Students can also view recorded lectures at increased speed (e.g., double speed), allowing students to save time if viewing recorded lectures. Additionally, current students have access to online tools (such as Google Docs) which make sharing course notes between students easy, perhaps even commonplace, making faculty rethink global cooperation in higher education [19, 20].

The unique nature of capstone engineering courses resulted in additional challenges toward effective delivery during the pandemic, with one faculty member commenting “lack of in-person discussions, team collaboration and time spent in the lab all have negative impacts on the project” [21]. Many adaptations were made during the pandemic to allow students to effectively work on chemical engineering capstone projects as part of a team, such as focusing on design tasks using simulation tools (e.g. ASPEN) and managing group meetings through video conferencing software (e.g. Google Meet) [22]. It is possible that knowledge of these practices necessarily implemented during the pandemic have impacted students’ perceived ability to complete capstone project tasks

without face-to-face interactions with teammates, further diminishing the value they place in in-person classroom attendance in capstone chemical engineering courses.

2. Methods and Data

2.1. Research Questions

The goal of this research is to understand the perceptions of senior undergraduate chemical engineering students on factors influencing their classroom attendance and engagement with the course. The approach of this study is guided by the following research questions:

1. What factors do students feel contributed to themselves or others deciding not to attend classes in person in the Fall 2022 semester?
2. How do students believe themselves or others may have been able to perform well on assignments without attending classes in person, nor reviewing recorded lectures?

2.2. Course Studied

The studied senior capstone design course covers many topics, including review of process flow diagrams (PFDs) and piping and instrumentation diagrams (P&IDs), applying information learned in previous courses toward the design of chemical processes, use of ASPEN, costing capital equipment / manufacturing, and engineering economics. The course is delivered as a twice-a-week 75-minute lecture with active learning activities (e.g. think-pair-share) led by the instructor approximately every 15-20 minutes. Classroom and syllabus policies remained unchanged from those prior to the onset of the COVID-19 pandemic, including a lack of an attendance policy. Course meetings were available to students in person, via livestream and as lecture recordings; lecture recordings were available to students from the moment they were recorded until the end of the semester.

In an effort to illustrate information that may be helpful to the reader in understanding the transferability of this study's results, one source illustrates the makeup of a recently-graduated BS class of the studied ChE program as roughly [23]:

- Sex: 59% Male / 41% Female
- Ethnicity: 67% White / 8% Hispanic / 8% Asian / 2% Black / 15% Other

These demographics should be considered when considering the perspectives contained in student responses in this study and to determine more broad implications toward other institutions, courses, ChE programs, majors, etc.

2.3. Methods

As is typical for many university courses, at the end of each semester the authors' university collects feedback from students on their courses through a class evaluation process. Students provide feedback to the university via an online survey on anonymous and voluntary bases. The results of these evaluations are then provided to instructors. In the Fall 2022 semester, two custom open-ended response questions were included by the authors as part of the online class evaluation survey. These questions were:

1. [the instructor] noticed that in-person classroom attendance this semester was far lower than the last time the course was offered in Fall 2021. What factors do you think contributed to students deciding not to attend class in person this semester?
2. [the instructor] noticed that some students who did not attend class in person also did not view recorded lectures posted to Classroom Capture, yet still performed well on homework and exams. Do you have any specific ideas on how this was possible?

A sample of 21 students out of a classroom population of 99 students who completed a senior capstone design course volunteered to provide anonymous written feedback on the custom open-ended responses above. Proper human subjects approval was secured as part of this study.

2.4. Data Analysis and Handling

The qualitative analysis strategy of thematic coding was used to analyze responses toward answering the study's two research questions. Thematic coding is used to determine common themes or topics which emerge from a number of open-ended responses [1, 24-26]. It is possible (even likely) that multiple themes may be identified within a single response. This coding strategy was selected since the resulting codes would provide a summary of factors and student beliefs regarding their perspectives on classroom attendance and engagement.

As part of the analysis procedure, each student response to the first custom course evaluation question listed above was read by both members of the research team. The use of multiple coders, while adding challenge to the study protocol, also improves research outcomes, quality and reliability [27]. While reading the responses, each researcher noted any themes they felt existed in the text; these themes represent nascent codes which may be common among student responses. This process was repeated for responses to the second custom course evaluation question listed above.

Once these initial qualitative assessments were completed, the research team met to compare and discuss the themes emerging from each of their analyses of the data. From this discussion a master code book was jointly produced which represents the themes present within the qualitative data. Finally, the research team individually repeated the described analysis of each custom course evaluation question, but this time using the master code book to determine

prevalence of themes existing within the data as well as representative student responses. Once each researcher used this master code book to re-code the responses, the senior investigator resolved any intercoder discrepancies.

Regarding data handling, all codes (whether preliminary, in-progress or finalized) considered in this study were recorded by the research team. Initially, two different code books – one secured by each of the researchers as they performed the initial read-through of the students responses – were kept. Later, once the research team met to compare and discuss the themes emerging from each of their analyses, a master code book was produced for each custom class evaluation question transcript which was shared between the researchers.

2.5. Positionality

The first author of this study is a middle-aged white male who has been teaching university chemical engineering courses for over a decade, and their department's capstone design course for four years. They approach this study from the perspective of an educator who tries their best to create an active learning environment in the classroom, and admit disappointment over their observed lack of student attendance in their Fall 2022 capstone design course. Lack of attendance had not been a problem in the past, even during the Fall 2021 semester when in-class masking was required and the course was taught in the same way as Fall 2022. Their resulting confusion over reasons for this change led them to perform this study. The second author is a Hispanic male in his late 20s who served as a TA for the studied course. He is participating in this research effort as part of a university program geared toward preparing promising Ph.D. students for careers in academia. Exposure to the qualitative social science research methods used in this study, performing coding of student responses, etc. served to broaden their understanding of engineering education scholarship.

2.6. Limitations

The first author of this study was the instructor of the studied course, so it is possible that unconscious bias due to the author's feelings regarding the course and its students impact their interpretation of collected qualitative data. Similarly, since the author was the course instructor, they are privy to information not relevant to this study (e.g. classroom performance, academic misconduct, etc.) which may cloud analysis. Since student responses to the custom course evaluation questions were collected on a voluntary, anonymous basis and not read until after grades were submitted, only a portion of students involved with the course provided responses and there was no opportunity for follow-up questioning. The practice of the senior investigator resolving intercoder discrepancies may introduce bias.

3. Results and Discussion

3.1. Research Question #1

The first research question addressed in this study regards student perspectives on factors which led to diminished in-person classroom attendance during the Fall 2022 semester. This question was worded in a way to compare the observed lower attendance rates in Fall 2022 against the observed higher attendance rates in Fall 2021. This comparison was drawn, rather than comparing Fall 2022 attendance against a pre-pandemic semester, to avoid confounding issues with students perhaps feeling uneasy about attending class in person due to COVID-related health risks (which would be present in both the Fall 2021 and 2022 semesters, but not in a pre-pandemic semester). The most prevalent theme emerging from thematic coding of student responses was **"Recorded Lectures"** which appeared 17 times across the data set. This theme was coded when a student specifically or implicitly referenced the availability of recorded lectures in their response. Two examples of such student responses were:

> *"The main reason students did not attend class in person was because they knew the lectures would be livestreamed, recorded and accessible later."*
>
> *"I knew I could catch up on lectures later on (...)"*

It should be noted that of these 17 responses which resulted in a theme of "Recorded Lectures", five of these responses also specifically mentioned the time savings associated with watching recorded lectures since there was an option to view recorded lectures at accelerated speed:

> *"Watching the recordings at 2x speed was much more beneficial (...)"*
>
> *"This let students take the same notes but in half the time (...)"*

The second-most prevalent theme emerging from the data was **"Course Conflict"**, which was identified eight times in the data set. This theme arose when students referenced some kind of course conflict which prevented them from regularly attending class; an example of such a response was:

> *"I would have preferred to attend in person every class but working full time M-F created a lot of conflicts and I was very grateful for the recorded lecture option (...)"*

Another main theme was **"No Attendance Policy"** which was identified seven times in the data set. This theme was coded when a student directly or indirectly referenced the course's lack of an attendance policy as a reason students might not attend class. Examples of comments with this theme were:

"I think not requiring an excuse for absence allowed students to skip class since technically they would not be penalized."

"I would assume attendance not being required (...) contributed to this the most"

From these results it is evident that students consider watching lecture recordings to be a suitable replacement for in-person attendance. This perspective which has been identified here has also been identified in other literature as well [17, 20] regarding students who returned to in-person classes after regularly attending virtual classes during the pandemic. However, the availability of lecture recordings also represents a valuable tool to assist in student learning [18], and is particularly important for a senior capstone design course since many students may have course conflicts with internships, job interviews, etc. This idea is further corroborated by the finding here that course conflicts are a main factor in students not attending class. With this in mind, though recorded lectures seem to contribute to students not attending class in person, it may not be appropriate to remove them from course delivery.

It is clear that the lack of an attendance policy for the studied course also played a large role in students deciding not to attend class in person. It should be noted that in this context, the term "attendance policy" is used to connote that penalties exist when attendance which does not meet a certain threshold, rather than a statement which simply provides expectations for attendance without associated penalties for non-compliance. In previous offerings of this class, attendance policies have historically not been put in place for a number of reasons, including to allow senior students the flexibility to work other responsibilities into their course schedule, as well as the common idea that "they are adults, they do not have to attend class if they do not want to" [28, 29]. Moreover, associating behaviors (i.e. attendance) with assessments can have negative effects, particularly for students who struggle with factors such as financial pressure or disability [30]. However, since the lack of an attendance policy appears to be a main driver of poor attendance, it is suggested that faculty who wish to encourage in-person attendance include an attendance policy as part of the course with allowances for flexibility in inequitable student circumstances.

3.2. Research Question #2

The second research question addressed in this study regards student perspectives on how students may be able to successfully earn passing or "good" grades even if not attending class nor reviewing lecture recordings in the studied course during the Fall 2022 semester. The most prevalent theme emerging from thematic coding of student responses to the second course evaluation question was **"Enough Resource Materials"** which appeared 15 times across the data set. This theme was coded when a student response referenced the presence of resource

materials (screencasts, coursepack, textbook, links to supplemental information) made available as part of the course and/or its website. Examples of responses coded to this theme were:

> *"My best guess is that some students studied the coursepack and uploaded slides and still performed well on exams and homework without watching the lectures."*

> *"The ASPEN screencasts and coursepack allowed students to complete the homework and Exam 2 without reviewing lectures."*

The second-most prevalent theme emerging from the data was **"Straightforward Content / Prior Knowledge"**, which was identified 11 times in the data set. This theme arose when students stated that course content was straightforward enough that they could figure it out without attending class, or that the course content was easy enough for them to accomplish it because they had encountered it in previous courses or work experiences. Examples of such responses were:

> *"(...) previous experience with ASPEN helped (...)"*

> *"Some of the course material seemed intuitive."*

> *"ISE 311 (Engineering Economic Analysis) teaches almost exactly the same material as what was on Test 3 (...)"*

Based on the analysis of responses to the second course evaluation question, it is possible that the instructor's effort to provide high-quality resources such as the coursepack prepared for the course or the custom-recorded screencasts detailing use of ASPEN, while helpful to students, may unfortunately have a detrimental impact on classroom attendance since students may feel that they can succeed using only these supplemental resources. Since a goal of the course is for students to achieve mastery of course learning objectives, it is unclear if providing these helpful resources is actually a problem; does this success outweigh the value of students attending class and/or reviewing course lectures? Or should this decision be left to the students? Similar to the drawbacks of attendance policies discussed previously, additional resources are also helpful to many subgroups of students who due to inequities may greatly benefit from their use compared to a stereotypical student [31], which further impacts this issue.

A number of students felt that the course content is somewhat straightforward and/or similar to content they have learned elsewhere. With this in mind, it is clear that the content of this particular course should be reviewed and material which appears to be prerequisite knowledge or overly straightforward should be eliminated from the course, or at least should not form a large basis of assessment.

A final consideration to discuss based on the results of this work relates to the difference between attendance and engagement. Modern students are clearly willing and able to engage with online materials, whether that be recorded lectures, additional resources, etc. An "engagement policy" which would award points for simply reviewing/engaging with course content would seem to be a reasonable alternative for in-person attendance on a per-student level, but it should be cautioned that research in the area of student growth in online vs. in-person classes is ongoing. For example, one study suggests that while learning gains are similar between a well-done online course and an in-person course, in-person classes offer valuable bio-psycho-social developmental advantages to students over online learning [32].

4. Conclusions

This study applied qualitative analysis of open-ended student responses to survey questions toward better understanding the perceptions of senior undergraduate chemical engineering students on factors influencing their classroom attendance and engagement. It was found that students consider watching lecture recordings to be a suitable replacement for in-person attendance, perhaps exacerbated by these students' experiences with recorded lectures commonplace during the COVID-19 pandemic. However, students also cited course conflicts as a reason for lack of attendance, so eliminating recorded lectures may not be an ideal way to counteract diminished in-person attendance. Students also repeatedly cited the lack of an attendance policy for the studied course as playing an important role in students deciding not to attend class in person. Though this finding may be straightforward, it is suggested that faculty who wish to encourage in-person attendance include an attendance policy as part of the course's syllabus.

When inquiring about how students may be able to successfully earn passing grades even if not attending class nor reviewing lecture recordings in the studied course, students cited that the instructor's effort to provide a number of helpful resources for the course may unfortunately have a detrimental impact on classroom attendance since students feel that they can succeed using only these supplemental resources. In addition, students indicated that they felt confident they could succeed in the course without attending lectures since they felt that the course content was straightforward and/or material they had learned elsewhere; this finding supports the importance of continually reviewing course content to avoid redundancy with content from prerequisite courses and expected student experiences.

To close, let us return to the title of this study: is poor classroom attendance a virtual-learning hangover or the new normal? The pandemic seems to have opened a "Pandora's box" of expectations for modern learning such as the availability of lecture recordings, high-quality online resources, etc. This study has shown that students have become comfortable engaging

with these online materials, and that access to these materials has impacted their decisions to attend class due to tangible benefits such as time savings and convenience. It would appear that these expectations and factors are unlikely to change – indeed, this is likely the new normal. With this in mind, if faculty wish to encourage in-person attendance toward facilitating classroom rapport, student social growth, etc., then we must be aware of the influences discussed in this study and consider adjusting classes (whether policies, content, delivery, etc.) as needed for the reality of post-pandemic modern learning.

References

[1] M. Credé, S. G. Roch, and U. M. Kieszczynka, "Class Attendance in College," *Rev Educ Res*, vol. 80, no. 2, pp. 272–295, Jun. 2010, doi: 10.3102/0034654310362998.

[2] M. Schneider and F. Preckel, "Variables associated with achievement in higher education: A systematic review of meta-analyses," *Psychol Bull*, vol. 143, no. 6, pp. 565–600, Jun. 2017, doi: 10.1037/BUL0000098.

[3] K. Weise, "Remote Learning Comes to America as Coronavirus Shuts Schools," *The New York Times*, 2020. https://www.nytimes.com/interactive/2020/03/10/us/covid-19-seattle-washington-home-schooling-remote.html (accessed Jan. 17, 2023).

[4] A. A. Oloyede, N. Faruk, and W. O. Raji, "COVID-19 lockdown and remote attendance teaching in developing countries: A review of some online pedagogical resources," *African Journal of Science, Technology, Innovation and Development*, vol. 14, no. 3, pp. 678–696, Apr. 2022, doi: 10.1080/20421338.2021.1889768.

[5] R. Sunasee, "Challenges of Teaching Organic Chemistry during COVID-19 Pandemic at a Primarily Undergraduate Institution," *J Chem Educ*, vol. 97, no. 9, pp. 3176–3181, Sep. 2020, doi: 10.1021/acs.jchemed.0c00542.

[6] Z. H. Khan and M. I. Abid, "Distance learning in engineering education: Challenges and opportunities during COVID-19 pandemic crisis in Pakistan," *The International Journal of Electrical Engineering & Education*, p. 002072092098849, Jan. 2021, doi: 10.1177/0020720920988493.

[7] K.-P. Chua, M. DeJonckheere, S. L. Reeves, A. C. Tribble, and L. A. Prosser, "Factors Associated With School Attendance Plans and Support for COVID-19 Risk Mitigation Measures Among Parents and Guardians," *Acad Pediatr*, vol. 21, no. 4, pp. 684–693, May 2021, doi: 10.1016/j.acap.2020.11.017.

[8] D. J. Deming, C. Goldin, L. F. Katz, and N. Yuchtman, "Can online learning bend the higher education cost curve?," *American Economic Review*, vol. 105, no. 5, pp. 496–501, May 2015, doi: 10.1257/AER.P20151024.

[9] S. W. Hemelt and K. M. Stange, "Why the move to online instruction won't reduce college costs," *Brookings*, 2020. https://www.brookings.edu/blog/brown-center-chalkboard/2020/07/28/why-the-move-to-online-instruction-wont-reduce-college-costs/ (accessed Jan. 17, 2023).

[10] S. Hubler, “As Colleges Move Classes Online, Families Rebel Against the Cost,” *The New York Times*, 2020. https://www.nytimes.com/2020/08/15/us/covid-college-tuition.html (accessed Jan. 17, 2023).
[11] R. Tulaskar and M. Turunen, “What students want? Experiences, challenges, and engagement during Emergency Remote Learning amidst COVID-19 crisis,” *Educ Inf Technol (Dordr)*, vol. 27, no. 1, pp. 551–587, Jan. 2022, doi: 10.1007/S10639-021-10747-1/FIGURES/5.
[12] L. Lafleur, “Students’ Experiences of Emergency Remote Teaching,” *JALT Postconference Publication*, vol. 2020, no. 1, p. 125, Aug. 2021, doi: 10.37546/JALTPCP2020-16.
[13] J. M. Hawdon and J. P. Bernot, “Teaching Parasitology Lab Remotely Using Livestreaming,” *Am Biol Teach*, vol. 84, no. 5, pp. 312–314, May 2022, doi: 10.1525/abt.2022.84.5.312.
[14] T. Cochrane *et al.*, “A collaborative design model to support hybrid learning environments during COVID19,” in *ASCILITE’s First Virtual Conference. Proceedings ASCILITE 2020 in Armidale*, Dec. 2020, pp. 84–89. doi: 10.14742/ascilite2020.0119.
[15] S. Singh and A. Arya, “A hybrid flipped-classroom approach for online teaching of biochemistry in developing countries during Covid-19 crisis,” *Biochemistry and Molecular Biology Education*, vol. 48, no. 5, pp. 502–503, Sep. 2020, doi: 10.1002/BMB.21418.
[16] G. Nathwani, A. Shoaib, A. Shafi, T. A. Furukawa, and N. T. Huy, “Impact of COVID-2019 on school attendance problems,” *J Glob Health*, vol. 11, p. 03084, Jul. 2021, doi: 10.7189/jogh.11.03084.
[17] M. J. Tomasik, L. A. Helbling, and U. Moser, “Educational gains of in-person vs. distance learning in primary and secondary schools: A natural experiment during the COVID -19 pandemic school closures in Switzerland,” *International Journal of Psychology*, vol. 56, no. 4, pp. 566–576, Aug. 2021, doi: 10.1002/ijop.12728.
[18] I. Williams, L. Williams, S. Mauthner, and J. Das, “Impact of recorded lectures on classroom attendance in PharmD didactic courses,” *Journal Of Advanced Pharmacy Education And Research*, vol. 11, no. 1, pp. 1–10, 2021, doi: 10.51847/PIpDbrS.
[19] S. Buitendijk, H. Ward, G. Shimshon, A. H. Sam, D. Sharma, and M. Harris, “COVID-19: an opportunity to rethink global cooperation in higher education and research,” *BMJ Glob Health*, vol. 5, no. 7, p. e002790, Jul. 2020, doi: 10.1136/bmjgh-2020-002790.
[20] K. A. Godber and D. R. Atkins, “COVID-19 Impacts on Teaching and Learning: A Collaborative Autoethnography by Two Higher Education Lecturers,” *Front Educ (Lausanne)*, vol. 6, p. 291, Jul. 2021, doi: 10.3389/feduc.2021.647524.
[21] O. Murray, ‘COVID causes issues for capstone projects,’ *Dominion Post*, November 2, 2020, https://www.dominionpost.com/2020/11/02/covid-causes-issues-for-capstone-projects/ (last accessed April 15, 2023).
[22] N. G. Khouri, M. Fontana, I. L. Dias, M. R. Maciel, R. M. Filho and A. P. Mariano, ‘Chemical Engineering Teaching in COVID-19 Times: Successfully Adapting a Capstone

Design Course to a Remote Format,' *Journal of Chemical Education*, Nov. 2021, doi: https://doi.org/10.1021%2Facs.jchemed.1c00445.
[23] College Factual, "Chemical Engineering at North Carolina State University," 2022, located at https://www.collegefactual.com/colleges/north-carolina-state-university-at-raleigh/academic-life/academic-majors/engineering/chemical-engineering/#diversity (last accessed April 15, 2023).
[24] M. Andrasik, S. Frey, and M. Meheret Endeshaw, 'Qualitative Methods: Coding & Data Analysis CFAR SPRC Qualitative Methods Workshop Series'. https://depts.washington.edu/cfar/sites/default/files/uploads/core-program/user70/Qualitative Methods Workshop_Coding_05-2014.pdf (accessed Feb. 23, 2023).
[25] G. Gibbs, 'Analyzing Qualitative Data', 2007, doi: 10.4135/9781849208574.
[26] H. Bernard, 'Social Research Methods', 2013, ISBN: 9781412978545.
[27] S. Church, M. Dunn, and L. Prokopy, 'Benefits to Qualitative Data Quality with Multiple Coders: Two Case Studies in Multi-coder Data Analysis', *J Rural Soc Sci*, vol. 34, no. 1, Aug. 2019, Accessed: Feb. 23, 2023. [Online]. Available: https://egrove.olemiss.edu/jrss/vol34/iss1/2
[28] K. L. st. Clair, 'A case against compulsory class attendance policies in higher education', *Innov High Educ*, vol. 23, no. 3, pp. 171–180, 1999, doi: 10.1023/A:1022942400812.
[29] L. Zhu, E. Huang, J. Defazio, and S. A. Hook, 'Impact of the Stringency of Attendance Policies on Class Attendance/Participation and Course Grades', *Journal of the Scholarship of Teaching and Learning*, vol. 19, no. 2, pp. 130–140, Jan. 2019, doi: 10.14434/josotl.v19i1.23717.
[30] S. Bond, 'Strict attendance policies adversely impact students,' *Daily Illini*, October 18, 2022, https://dailyillini.com/news-stories/longform/2022/10/18/attendance-policies-mental-health/ (last accessed April 15, 2023)
[31] N. A. Stites, E. Berger, J. DeBoer, and J. F. Rhoads, 'Are resource-usage patterns related to achievement? A study of an active, blended, and collaborative learning environment for undergraduate engineering courses,' *European Journal of Engineering Education*, vol. 46, no. 3, pp. 416-440, 2021, doi: 10.1080/03043797.2020.1783208.
[32] K. E. Canada, R. A. Freese, R. M. Bailey, and D. Fitch, 'Evaluating Learning Outcomes and Assessing Social Work Skill Development: Comparing Online vs. In-Person Education,' *J. Technology in Human Services*, vol. 40, no. 1, pp. 47-57 2022, doi: 10.1080/15228835.2021.1997693.