

Article

STEM Students' Perceptions on Emergency Online Learning during the COVID-19 Pandemic: Challenges and Successes

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Abstract: Declaration of the COVID-19 pandemic by the World Health Organization in 2020 forced many schools to switch to emergency virtual instruction. This situation provided an opportunity to explore the effectiveness of online learning from students' perspectives. To discover best practices for online learning, 584 STEM students at California State Polytechnic University Pomona (Cal Poly Pomona) were surveyed about their Spring and Fall 2020 experiences. Some of the obstacles students faced were adapting to a new lifestyle, feeling disconnected, managing schedule and workload, and overcoming distractions. Despite difficulties, 61% of students benefited from the flexibility, convenience, and increased productivity. The time students normally spent commuting to and parking on campus was instead spent getting more sleep, studying, working extra hours, spending time with family, and practicing self-care. Another major benefit was the increased accessibility to course materials posted online. Major themes from students' responses were belonging, organization and transparency, and the need for real-world applications. Incorporating these strategies enhance the effectiveness of teaching methods. Responses along with some problem-solving suggestions that can improve the effectiveness of both online and in-person learning are discussed.

Keywords: COVID-19; emergency eLearning; eLearning; higher education; student survey; course organization; belonging; effective instruction



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1. Introduction

COVID-19, caused by novel coronavirus SARS-CoV-2, became a concern in December 2019; on 11 March 2020, the World Health Organization [1] declared it to be a pandemic. As scientists rushed to understand and control the virus, social distancing and stay-at-home orders were issued and schools around the world closed. Early during the pandemic there was a hope that the closure was temporary, but as weeks and months passed, it was clear that the emergency online learning would not end soon. In Spring 2020 it became clear that many university instructors were unprepared for teaching online [2,3].

Acknowledging that the faculty were under-prepared to teach online [3–5], the Center for the Advancement of Faculty Excellence (CAFÉ) at Cal Poly Pomona [6] offered workshops and faculty learning communities to prepare for the continuation of virtual learning in Fall 2020, with a focus on effectively using the campus Learning Management System (LMS). This unique situation provided an opportunity to explore the impact and effectiveness of virtual learning from students' perspectives. Rather than wait for life to return to "normal," there was an effort to learn from and adapt to the situation. According to Shapiro [7], it is possible to design a quality online course, but the suddenness of the transition to online instruction did not allow for it [4,5]. In addition to faculty struggling to adjust course curricula and teaching methods, students' mental health declined. These were a few of the many barriers to effective remote learning [5,8].

Prior to the pandemic, there were several articles detailing best practices in online teaching and learning [9–12]. The characteristics of the most effective courses include course design, course delivery, and attention to learner needs. Although this literature existed before everyone had to teach remotely, most instructors were not familiar with these articles or ideas mostly because they were not willing participants in designing an online course.

Effective course design for an online course differs from the typical face-to-face design [10,12]. More faculty time is required to reimagine and design an effective online course because an online course is quite different from one previously taught in person [10]. Learning is enhanced when the course increases critical thinking and reinforces lifelong learning [13]. Including real-life problems and active learning are strategies that can make the course more thought provoking and engaging [13]. Included in course design are learning objectives, reading material, assessments, and stating clear and explicit student expectations [10].

Course delivery involves deciding on the length of learning segments, inclusion of listening breaks (e.g., active participation in discussion/problem solving/group work), student-to-student interactions, and faculty-to-student interactions [8]. Unlike good movies that have interesting plots, lectures rarely have plots or are as engaging. One way to avoid students “tuning out” is to chunk class time material into segments of no longer than 20 min to match the adult attention span [14]. Missing key points is not just an attention span problem; Kestin et al. [15] found that students learned more in watching a video demonstration than they did with an in-person demonstration by reducing distracting features in the video which is consistent with cognitive load theory [16].

One primary learner need for learning success is belonging to a community [8,11,12,17–21]. Fostering a sense of community, especially in online courses, is critical to students’ well-being as well as learning success. One way to foster community is to create well-structured student groups that work on assignments both in class and out of class. During the pandemic, when all instruction was taking place at a distance, this was even more critical [2,5,8,19,22,23].

To learn about the experiences of university students during the COVID pandemic, a survey was distributed to students at Cal Poly Pomona, a large, public university in the US. Cal Poly Pomona is a Hispanic serving institution with over 26,000 students on a primarily commuter campus. The survey was administered during Fall 2020 while all courses were still offered virtually to hear students’ perspectives about the best teaching practices in emergency online learning during Spring 2020 and Fall 2020. The responses of the students in STEM majors are reported here.

2. Materials and Methods

A survey was created on Google Forms to gain a comprehensive understanding of students’ experiences with virtual learning with the aim of discovering ways to increase the effectiveness of online learning (see Supplemental Materials: Survey Questions [24]). The survey consisted of non-standardized, researcher-generated, free-response, multiple choice, and yes or no questions that asked about students’ experiences in Spring 2020 and Fall 2020, their preferences for effective teaching methods, factors important to their academic success, and the pros and cons of virtual learning. Upon approval from Cal Poly Pomona’s Institutional Review Board ((IRB) IRB-20-134), the survey invitation was sent via email to students throughout the campus; student participation was completely voluntary. Although there were no measurements or reliability tests taken to ensure the results were not skewed, responses were obtained from ~4–5% in each college; the response numbers by college correspond to the population of each college. Students could provide responses and not be included in the reported results; their agreement (or not) was recorded in the Informed Consent question at the beginning of the survey. The trends observed in the data including all students were consistent with the trends observed in the data from only STEM majors who comprised 74% of respondents.

Questionnaire

The questions queried the characteristics of responding students, their perceptions of what was helpful (or not) for a variety of teaching techniques, and what they felt contributed to their success during emergency online instruction. Given that most of the campus instructors participated in professional development during Summer 2020, students were asked to provide information about online instruction during both Spring 2020 as well as in Fall 2020. The complete survey can be found in the Supplementary Materials: Survey Questions [24].

3. Results

A total of 584 STEM students completed the survey. The survey results can be found in the Supplemental Materials: Survey Responses [24]. The response rate was ~4%, with the majority (58%, N = 339) of respondents being juniors and seniors (see Table 1). Most students were from the College of Engineering, followed by the College of Science, College of Agriculture, College of Business, College of Education and Integrative Studies, College of Letters, Arts, and Social Sciences, and Collins College (see Table 2).

Table 1. A breakdown of the 584 responding STEM students by academic standing. Most respondents (N = 339, 59%) were upper division students.

Which Describes Your Academic Standing?		
Senior	181	31%
Junior	158	27%
Freshman	116	20%
Sophomore	76	13%
Incoming Transfer	46	8%
Graduate	7	1%

Table 2. The number of survey respondents from each college and major.

College	Major	Number of Students	Percentage of Respondents
College of Science	Biology	74	36.8%
	Chemistry	41	
	Computer Science	45	
	Geology	6	
	Kinesiology	15	
	Mathematics	22	
	Physics	12	
College of Engineering	Aerospace Engineering	22	45.9%
	Chemical Engineering	31	
	Civil Engineering	38	
	Computer Engineering	29	
	Construction Engineering and Management	6	
	Electrical Engineering	26	
	Electromechanical Systems Engineering Technology	21	
	Industrial Engineering	16	
	Manufacturing Engineering	8	
	Materials Engineering	2	
Mechanical Engineering	69		
Don B. Huntley College of Agriculture	Agricultural Science	9	16.6%
	Animal Health Science	10	
	Animal Science	53	
	Food Science and Technology	13	
	Nutrition	7	
	Plant Science	5	

Table 2. Cont.

College	Major	Number of Students		Percentage of Respondents
Collins College of Hospitality Management	Hospitality Management	2	2	0.3%
College of Letters, Arts, and Social Sciences	Psychology	5	5	0.9%

Students were asked about which factors were important to their academic success. Their responses were grouped into four categories: relationships, learning, campus resources, and external support. Relationships included interactions with faculty, staff, and classmates, connections with the campus community, and schedule flexibility. Effective learning included hands-on learning, course organization, applications of theory, access to course materials, manageable workloads, motivation, and self-learning. Campus resources included study spaces, access to resources, career advising, and tutoring. External support included financial stability, childcare, and a support system.

Although 69% of the respondents had previously taken classes at the campus, only 47% of them indicated feeling part of the campus community (see Table 3).

Table 3. Student responses regarding taking classes on campus and feeling part of the campus community.

	Yes	No
Have you taken classes on campus?	N = 404 (69%)	N = 180 (31%)
Do you feel part of the campus community?	N = 274 (47%)	N = 309 (53%)

The number of students that described adjustments to online courses as moderate (N = 258, 44%) were only three percentage points less than the number of students that described it as difficult (N = 272, 47%). The remaining students (N = 54, 9%), described the transition as easy. This level of dissatisfaction is greater than found by Means and Neisler [8]. Students also reported that in-person courses were more effective than virtual courses (see Figure 1).

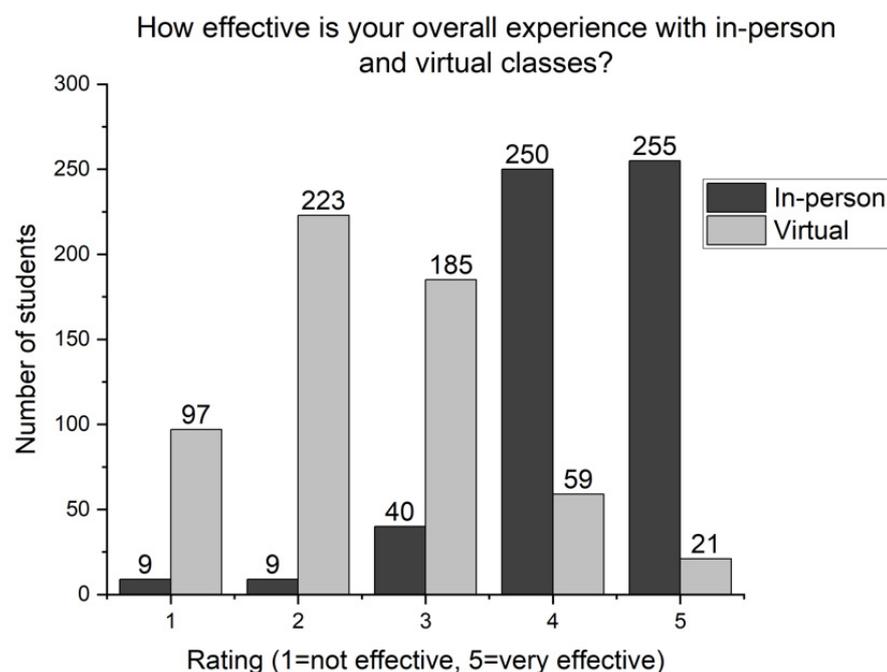


Figure 1. Students' ranking of the effectiveness of in-person and virtual courses.

3.1. Instruction during Spring 2020

The respondents who experienced a sudden shift to online classes in Spring 2020 were asked about their experience. All responses collected in this portion were independent comments. Using the inductive thematic analysis method of Braun and Clarke [25], the researchers read through the free response comments multiple times and came up with a list of topics that best described the common themes. The comments were then categorized, and the themes agreed upon. The most common responses regarding the worst or hardest aspects of switching to virtual learning were sorted into the following categories: quality of education, adapting, feeling disconnected from people and learning, and managing workload and schedule (see Table 4). These findings are consistent with some of the findings of Miller [26]. Students that described a decrease in the quality of education reported a lack of concern for learning from professors, checking for student understanding, engaging and effective lectures, hands-on learning, ease in asking questions, communication and guidance, organization and preparation, an educational atmosphere, appropriately and effectively addressing cheating, clear expectations, and feedback on assignments.

Table 4. Themes of responses to the questions, “What was the worst/hardest aspect of switching to virtual learning in Spring 2020? What was the best aspect of virtual learning in Spring 2020?”.

Category	Number of Responses	Percentage of Responses
Best Aspects:		
Flexibility, convenience, and increased productivity	301	61.4%
Nothing	58	11.8%
Increased accessibility to course materials	45	9.2%
Saving money	42	8.6%
Classes were made easier	29	5.9%
Safety	18	3.7%
Smooth transition	12	2.4%
Ease of communication with classmates	10	2.0%
Worst Aspects:		
Quality of education	169	33.7%
Feeling disconnected from people and learning	108	21.6%
Adapting	105	21.0%
Managing workload and schedule	93	18.6%
Distractions	54	10.8%
Lack of resources	44	8.8%
Technology	41	8.2%
Difficulty finding motivation	40	8.0%
Unrealistic expectations	35	7.0%

Comments about adapting included the need to adjust to having different structures (e.g., modes of communication and electronic submission programs) for each course, new teaching styles, a virtual learning setting, being home all day, changing their personal environment, having to move, schedule changes, and loss of opportunities. Students felt disconnected from people and learning due to ineffective communication, not seeing professors, the loss of interactions with classmates and other students, the difficulty in managing group work, not being able to show the effort they are putting into the course, not engaging in class, the lack of discussions, and not knowing where to go for help. In terms of managing workload and schedule, students had difficulty keeping track of

assignments and deadlines, completing assignments by due dates, managing their time, adjusting to the workload, balancing family life and academics, and being productive.

Students also responded to an open-ended query about the best aspect of virtual learning. Flexibility, convenience and/or increased productivity were mentioned in 61% of the responses. The other benefits that were reported were increased access to course materials, saving money, easier classes, and safety from COVID-19 (see Table 4).

Course flexibility allowed students to complete coursework at times of their choosing, go through the material at their own pace, study from the comfort of their home, customize their schedule, experience less stress, take classes that are normally offered at inconvenient times, and continue their education when their life situation would normally not allow it. The time students normally spent commuting and going from one class to another was spent eating proper meals, getting enough sleep, fitting in more hours of work, studying more, and spending more time with family. Increased accessibility to course materials allowed students to replay and pause lectures, take notes the first time around and watch with full attention the second time, have access to more detailed notes and materials, and reference past lectures for review.

3.2. Instruction during Fall 2020

In response to open-ended questions about instruction during Fall 2020, 54% of students indicated that virtual learning improved over Spring 2020. Both students and professors were better prepared for remote learning. Faculty and staff were more comfortable and familiar with Zoom and the LMS. Headphones, microphones, and tablets also were more widely used, enhancing the virtual experience. Students reported more effective communication and interactions, including live, weekly office hours, polling during synchronous classes, and discord servers. There were more recorded class sessions, workloads became more manageable, more course resources were provided, and assignments and exams were better adapted to virtual learning. All these improvements, in addition to clearer course expectations and increased emphasis on student success made Fall 2020 a more effective learning experience.

Students who indicated that virtual learning did not improve in Fall 2020 shared a very different experience. Many course LMS sites were disorganized; students could not keep track of due dates or their grades. Another issue was that students did not receive feedback on assignments from their professors. They believed that more difficult exams were administered without proper time or preparation. Students lacked necessary resources to keep up with their professors' expectations. There was less flexibility and understanding from faculty and staff, including mandatory attendance and class sessions not being recorded or posted. While some students preferred asynchronous courses, they can create a feeling of isolation. Burnout was common among students; they had difficulty retaining material, resulting in a disconnect between the material covered and students' understanding. This was in part due to students having trouble holding themselves accountable for focusing during class, the inability to create a productive learning environment, and the reliance on self-learning. The difficulty and workload increased, yet the inconsistency among courses made it hard for students to keep up.

One area of focus during summer faculty professional development was course instructions. A total of 91% of responding students received instructions on how to access course materials at the beginning of the semester and 58% of those students described the instructions as somewhat helpful and 5% described them as unhelpful. The top three recommendations on how to improve the instructions were about making explanations more detailed and clearer and having better organization (see Figure 2).

Students selected teaching methods they felt were effective for lecture and lab courses in both virtual and in-person settings. For virtual lecture courses, 351 students voted for synchronous courses while 355 students voted for asynchronous courses, indicating no clear preference. Responses about specific methods were quite varied. For labs and activities, 264 (52.4%) students expressed a preference for synchronous courses compared

to the 204 (40.5%) for asynchronous courses. Hands-on learning was greatly favored for in-person settings whereas video demonstrations received the largest number of responses for virtual settings (see Figure 3).

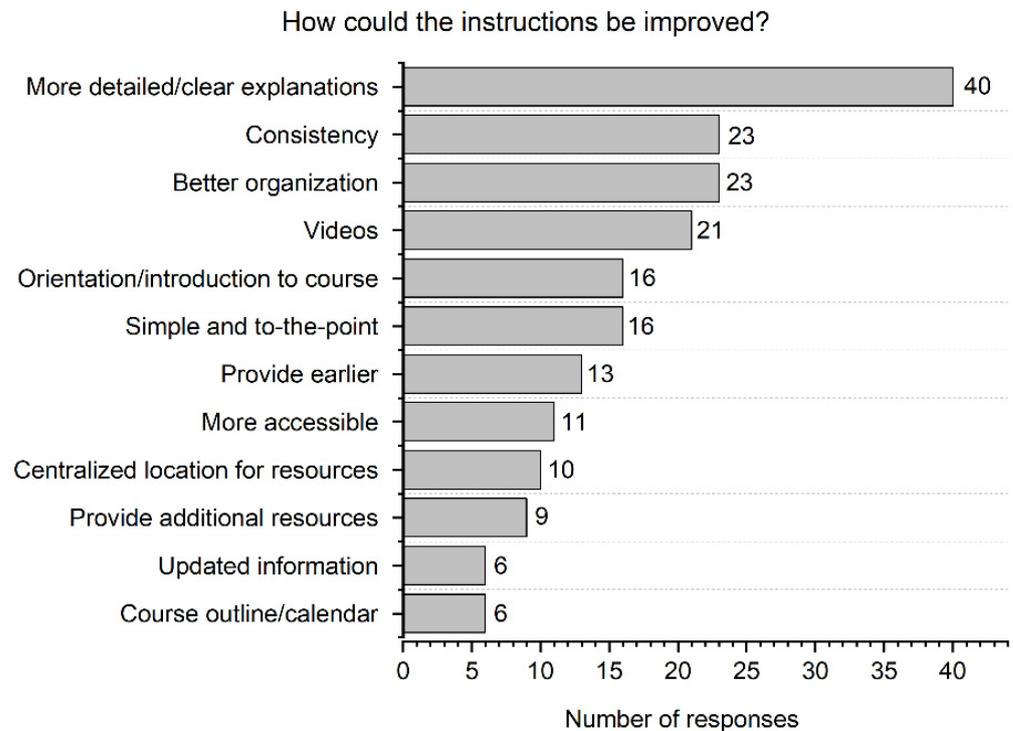


Figure 2. Recommendations on how to improve course instructions.

When asked about their preference about having classmates' videos on during live Zoom classes, most students (363) indicated not having a preference, while almost the same number of students preferred that their classmates have their videos on (100) as those that preferred that videos stay off (114). Of the students that prefer cameras on, 94 mentioned that seeing their classmates creates a sense of community. One student explained that their preference is due to not wanting to be the only one in the class with their camera on. Three students preferred webcams be turned on while students are in breakout rooms and doing group work. Three students specified that cameras should only be on if they are not distracting. Eight students felt that cameras should be on out of respect for professors and two stated that it encourages focus. Of the 114 students that prefer videos to be off, 113 of them complained about classmates being distracting. Three gave the reasoning that video affects bandwidth.

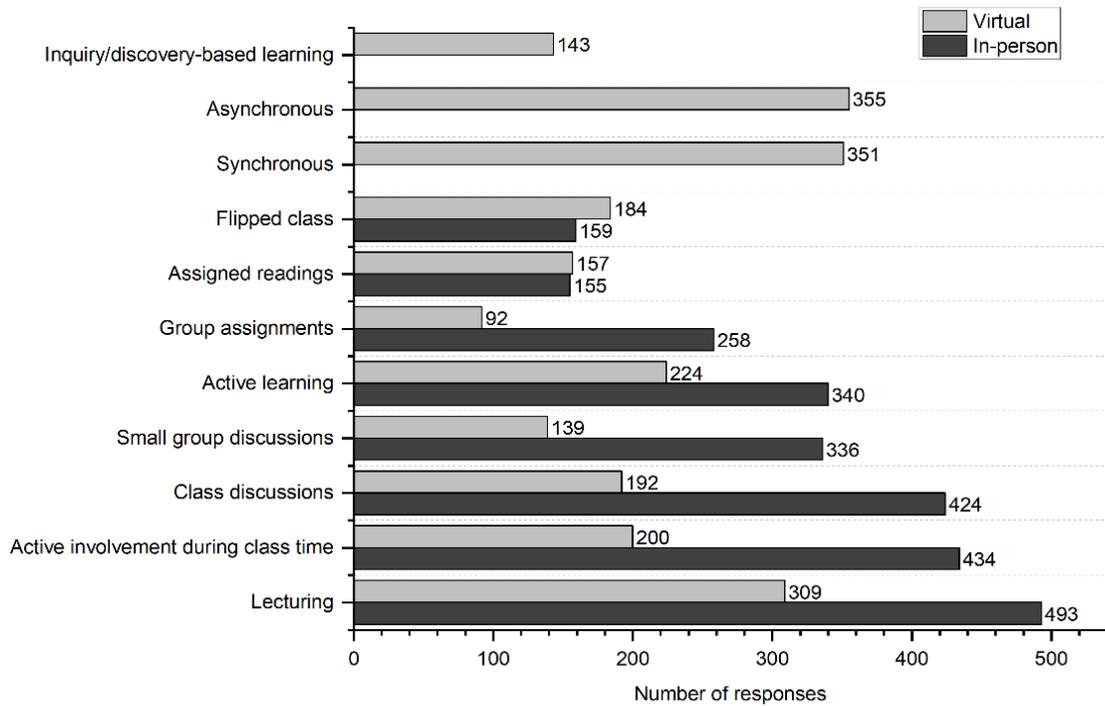
Students who took a lab or activity course through virtual learning were asked if hands-on learning was incorporated. Those who experienced hands-on learning (N = 465, 79%) were asked if it helped them better understand the course content and to give examples. The results are illustrated in Figure 4. From the responses students indicated that hands-on learning helps them better understand the content, yet there appeared to be little hands-on work in the virtual classes/labs.

Some examples of hands-on work experienced included performing experiments with household items, creating mathematical models on computers, building circuits with purchased equipment, examining rock samples from loaned kits, creating instruments to collect data, designing experiments, testing physics theories with common objects, dissecting plants and nuts, and creating compost.

Students were asked to select the academic assessments they felt were effective for in-person and virtual courses (see Figure 5). Open-note assessments were the most popular

for virtual learning while closed-note assessments were the least popular. The results for all the in-person assessments were similar, with multiple choice being the most popular.

Which of the following are effective teaching methods for lecture courses?



Which of the following are effective teaching methods for lab courses?

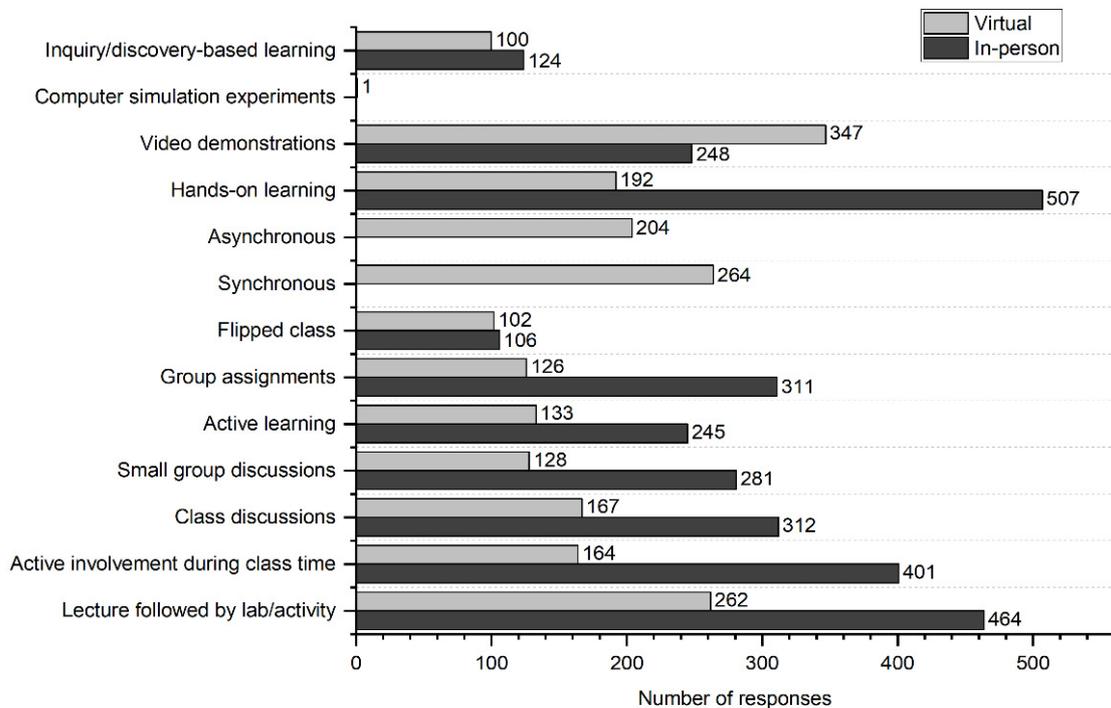


Figure 3. Number of students that feel each teaching method is effective for in-person and virtual lecture (top figure) and lab/activity (bottom figure) courses.

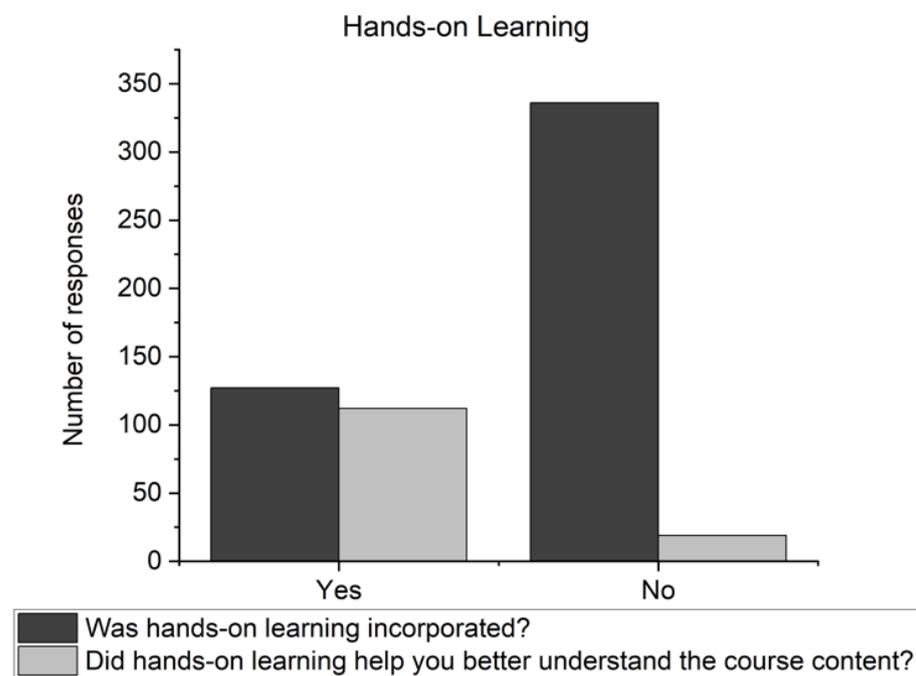


Figure 4. The incorporation of hands-on learning and its effectiveness in helping students understand course content.

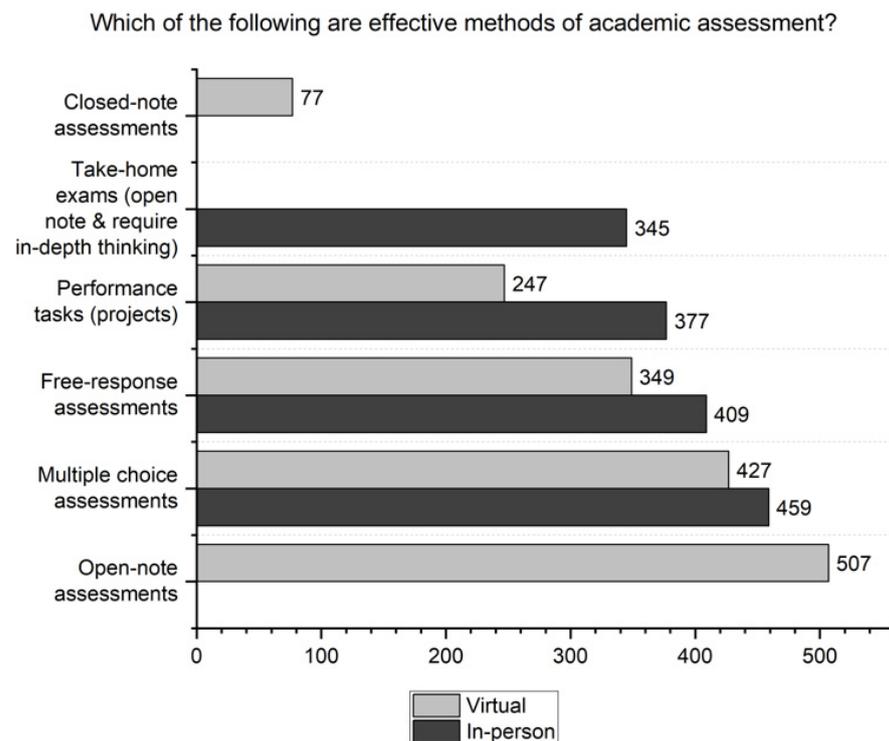


Figure 5. The selection of effective in-person and virtual methods of academic assessment.

When asked about how they were affected by their instructors’ abilities to detect cheating, 77% of students (442) responded that their instructors’ ability to detect dishonesty and cheating does not directly impact their academic performance. Many students struggled with the increased difficulty of assessments, time restrictions, and stress and anxiety of possibly being falsely accused. Students’ open responses are presented in Table 5. One representative student’s response was, “[The focus on cheating] makes me overly cautious

of my work and makes me more nervous to complete my work. Even though I do not cheat, I still feel like I am not trusted which makes me feel unwelcome in the course”.

Table 5. The effect of instructors’ abilities to detect cheating on students’ learning and academic performance.

How Does Your Instructor’s Ability to Detect Dishonesty/Cheating Affect Your Learning and Academic Performance?		
Category	Number of Responses	Percentage of Responses
I don’t cheat and am not affected by those who do.	163	53.62%
The focus on detecting cheating gives me stress and anxiety because I may be falsely accused.	37	12.17%
Some measures that are taken to prevent cheating encourage effective learning and honesty.	25	8.22%
Cheating creates unfair advantages.	28	9.21%
Courses have been made more difficult as an attempt to prevent cheating.	25	8.22%
Some measures that are taken to prevent cheating are exaggerated and unnecessary.	17	5.59%
Receiving warnings about cheating increases discipline, responsibility, and accountability.	14	4.61%
Some measures that are taken to prevent cheating are ineffective.	14	4.61%
The attempt to prevent cheating by rushing students during exams and quizzes causes stress and anxiety.	15	4.40%
Being falsely accused of cheating is belittling and disappointing.	16	4.93%
A cheating-free environment increases motivation.	5	1.64%
Some measures that are taken to prevent cheating are an invasion of privacy.	6	1.97%
Some measures that are taken to prevent cheating are distracting.	7	2.30%

4. Discussion

The original intent of the survey was to identify the best teaching methods used for online instruction, but the data analysis revealed recurring themes that shifted our focus to factors to consider when choosing online teaching methods and those that enhance the effectiveness of teaching methods. Although separate models were created for each group of factors, there are many overlapping areas between the two.

Circumstances, learning outcomes, and real-world applications should be considered when deciding which teaching methods should be used for a particular course (see Figure 6), consistent with the findings of others [8,25].



Figure 6. Factors to consider when deciding teaching methods to use for a course.

Circumstances include significant challenges and access to resources, among many others. The pandemic has made this aspect more relevant than ever. While some students remained close to campus, others traveled to different cities, states, and countries. Some students struggled to earn money and support their families. Others had no access to a quiet workspace and were forced to share a small space with many younger siblings. Many were grieving for those who died. Every person had a unique situation and was challenged in different ways. Identifying the pros and cons of virtual learning can help to create more effective teaching methods. This can be done by incorporating the benefits, including flexibility and increased accessibility to course materials, and addressing the challenges, including feeling disconnected from people and learning [8,27]. It is worth knowing that over half of the responding students reported benefiting from the flexibility of online learning. While it is not possible to personalize every course, there are certain measures that can be taken to maximize the effectiveness of students' learning experiences.

Each course has different learning outcomes, but the teaching methods should be structured to allow students to attain the expected knowledge and skills [8,12,13]. This was particularly challenging for virtual labs. Many of the learning objectives in labs include proper use and handling of equipment, especially in foundational courses where students learn basic skills. Providing practical demonstrations, either by videos, computer simulations, or even sketches of instrumentation and processes, has proven to be the most effective way to make up for the loss of learn by doing.

The last consideration is appropriate assessments. The teaching methods used should prepare students to successfully complete assessments. If the teaching method and assessments are not aligned, students will be unable to rely on just course resources to do well on them. Many students put in the minimum amount of work required to pass the class, so use of teaching methods and assessments that focus on understanding and applying knowledge rather than memorization result in students working harder to understand the material and higher scores on the assessments [12,13,27].

Student responses about factors that enhance the effectiveness of teaching strategies were categorized into three groups: belonging, organization and transparency, and real-world application, (see Figure 7) which are consistent with the findings of others [11–13,17,19,21,22].

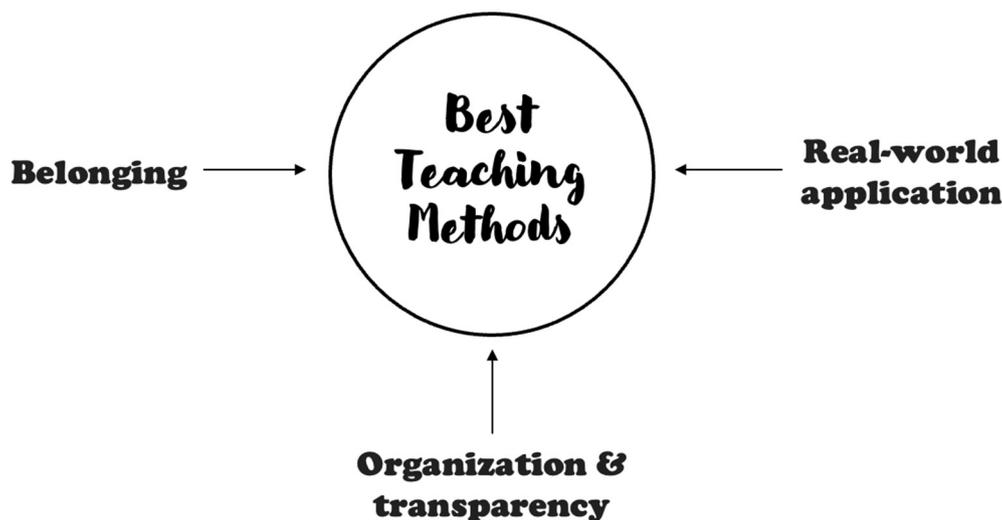


Figure 7. Factors that enhance the effectiveness of teaching methods.

4.1. *Belonging: Relationships and Interactions*

Faculty can incorporate interactions in a course by adding practice questions throughout the lesson and encouraging questions. Students do not retain information about all the covered course material; by focusing more on learning rather than just performance, students will benefit more from the course. Faculty also should provide feedback on

assignments before assessments occur so students know what they did wrong and how to improve [4]. By initiating effective communication, faculty can develop relationships with students [11,13,17,19]. Students are often unaware that professors are overwhelmed by the changed workload and that virtual teaching is more time intensive than it is in-person. If students were aware of the challenges faculty are facing (e.g., increased workload), they would be much more understanding.

Faculty can create a sense of community by helping students connect with their classmates through creating effective groups with specific guidelines regarding individual contribution and accountability [12,20,21]. The final recommendation for improving relationships and interactions is for faculty to notice and appreciate student effort. For students putting in a lot of effort to complete assignments and understand the material, feeling that their effort is noticed and appreciated means a great deal. It motivates them to work harder and continue to excel. When professors are aware of the effort students are expending to succeed, they will trust that the students have integrity. The focus on cheating makes students feel otherwise.

Ian Thacker, in a seminar entitled, “Social Connectedness in Physical Isolation” [20], explained that belonging is important in academia because according to the Self-Determination Theory [28] students are more likely to engage and learn if they feel autonomous, competent, and feel a sense of social belonging. Prior research concluded that belonging, interest, and persistence are facilitated by online instruction that emphasizes social interaction [21]. Thacker shared that breakout groups and interactive lectures were found to support feelings of belongingness, positive emotion, and engagement, whereas noninteractive lectures negatively predicted students’ sense of belonging and interest in STEM [20].

4.2. *Belonging: Cheating and Fairness*

Based on student responses, one recommendation to reduce cheating and increase fairness is to allow students to demonstrate their knowledge through performance tasks. Another recommendation is to use new, creative assessments that could not have been posted online previously. An example for a chemistry exam question was to provide a table of fictitious symbols with molar masses and ask students to calculate the molecular molar mass of a compound created using those symbols [29]. This question would accurately reflect student’s understanding of the topic as the method would have been taught in class using the periodic table and yet the answers could not be found online. Giving partial credit for correct work is one of the students’ main requests when it comes to perceived fairness. Students feel more connected to the course and have more motivation to work hard when they know that their effort and work is evaluated fairly and proportionally to the knowledge they demonstrate. In addition, providing a variety of assessments gives students many opportunities to show what they have learned. Cheating and fairness in groupwork can be addressed through assigning private journal entries that ask about group member contributions. Journal entries can also ask how students are doing in their personal life and a reflection on their progress in the course to create a greater sense of belonging.

4.3. *Organization and Transparency: Course Organization*

Students find it much easier to manage their workload and schedule when they are provided with a course calendar and consistent due dates. Easy-to-find deadlines and explicit instructions for assignment completion allows them to complete the expected work on time [4]. Course organization also includes the time and way in which students receive a grade and feedback on their work. Making sure that students have sufficient time to complete their assignments and review instructor feedback prior to assessments ensures that students are prepared and can succeed.

4.4. *Organization and Transparency: Expectations*

To enhance students’ learning experience in a course, it is important for professors to have realistic expectations of what students can do under the given circumstances. Faculty

should expect that students have challenges outside of their control; simply being mindful of that (with some flexibility) can help students manage those challenges [8]. Faculty should set clear expectations about what students need to do and when assignments are due. This can be achieved through an organized LMS site that makes deadlines easily visible and by providing rubrics for each assignment. Recognizing that students have many obligations to other courses, work, and real life, faculty should try to assign more meaningful, less frequent assignments. This allows students to submit higher quality assignments that reflect their understanding of the material.

Just as professors have expectations of students, students have expectations of their professors. Students are expected to submit clear, legible work, and professors are expected to post good quality videos that are easy to follow. Students are expected to put effort into assignments, and professors are expected to put effort into reviewing and grading student work. Students are expected to turn in assignments on time, and professors are expected to grade assignments and provide feedback in a timely manner. Communicating these expectations is beneficial for both students and professors.

4.5. Real-World Applications

Real-world applications refer to teaching students the importance of the knowledge they are learning and how it may be used in their careers or real lives [12,13]. As many topics are addressed and explored in different departments and across colleges, interdisciplinary collaboration is a great way to incorporate diverse styles of teaching, points of view, and to allow students to appreciate and apply the theories they are learning to many fields. This will help the entire university community excel and provide the highest quality education possible.

5. Limitations

Although the sample size was large (584 STEM students), this was a response rate of ~4%. It is unclear whether the respondents were a random sample of the target population, since they self-selected to participate. The survey was designed by the researchers and not based on any previous survey. The survey has not yet been validated, and its reliability has not yet been tested.

6. Conclusions

The majority (62%) of students benefited from the flexibility, convenience, and increased productivity of virtual classes. At the same time, students felt the worst aspects of virtual learning were the quality of their education (34%), that they were disconnected from people and learning (22%), and the difficulties adapting to the “new normal” (21%).

Many respondents indicated they had some difficulties with instructions on how to access course materials at the beginning of the term. They requested more explicit details, easier-to-find deadlines, a course calendar, and a more organized LMS site. In designing virtual courses, careful attention needs to be paid to providing flexibility to students—especially during the pandemic when each person is experiencing a multitude of difficulties and challenges. This flexibility includes not just deadline flexibility, but posting directions, resources, and videos to the course website for viewing at any convenient time.

Instruction should be aligned with assessments and learning goals, not just learning outcomes [27]. A helpful planning tool is “Understanding by Design” [30]. This process contains three stages: (1) identifying desired results, (2) determining assessment evidence, and (3) planning instruction to enable students to succeed on the assessments. While faculty were concerned with the possibility that students would cheat on assessments in a virtual setting [23], student comments indicated that the focus on measures to prevent and detect cheating were ineffective, made assessments more difficult, and caused additional stress and anxiety. Many students indicated a desire for real-world contexts to be included in the lessons and topics, consistent with the findings of Means and Neisler [8].

While there was no clear preference for either asynchronous or synchronous class session delivery, there was an indicated preference for lectures in both virtual and in-person courses. For in-person lab courses there was a definite preference for hands-on learning, active involvement during class time, and lectures followed by laboratory activities. In the case of virtual laboratory courses, there was a slight preference for synchronous delivery of class sessions as well as video demonstrations. Strikingly, many students indicated that hands-on learning helped them better understand course content in both lectures and laboratories, yet there were very few virtual courses that included any hands-on learning.

Special attention needs to be paid to student well-being and belonging. These recommendations were present in the literature before the pandemic [11,17,18], and our data along with the data of others [19–21] reinforce the idea of paying attention to the social and emotional wellness of students. Responses we received indicated that relationships between students and other students, faculty, and staff were important and valued, yet many students did not feel they were part of the campus community.

A synthesis of what has been learned from the student responses are presented in the “Top 10 Take-Aways from the Survey” (see Table 6).

Table 6. Top 10 takeaways from student surveys to enhance the effectiveness of teaching methods.

No.	Students Find It Effective When Professors:
1	Focus on learning and knowledge gain, rather than performance. Encourage questions, provide feedback, and create interactive environments.
2	Provide a variety of assessments so students can demonstrate what they learned; appreciate student effort with partial credit and timely feedback.
3	Keep due dates consistent; create a course calendar with easy to find assignments, resources, and due dates.
4	Record and post class session recordings in a timely manner.
5	Provide explicit directions and set realistic expectations for assignments and deadlines.
6	Assign more meaningful, less frequent assignments.
7	Find ways to build community. Create guidelines for effective groups; hold all students accountable for group work.
8	Incorporate diverse styles of teaching that ask students to apply their knowledge to many fields and careers.
9	Provide clear videos, computer simulations, or drawings with detailed explanations for activity and lab courses.
10	Be flexible! Keep in mind that all of us experience challenges and technical difficulties, most of which are beyond our control.

Supplementary Materials: The following are available online at <https://www.mdpi.com/article/10.3390/educsci11120799/s1>, File S1: Survey Questions, File S2: Survey Results.

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