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How Have High School Students Experienced the Transition to Remote Mathematics Learning?

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In Spring of 2020, many US students switched to remote learning in response to the COVID-19 pandemic. A key research question is the extent to which best practices in remote education are being followed currently, and to the extent they are not, what can be done to remedy this. Given its key role in influencing future success, students' experience in remote mathematics education is of particular significance. To answer this, we conducted a survey of US high school students at the end of the 2020 school year soliciting their thoughts on remote learning in mathematics. We used this data as the basis for qualitative analysis. Our results strongly suggest that in order to improve students' learning experiences in the future, we must increase opportunities for both student to teacher interactions and student to student interactions.

Introduction

In Spring of 2020, schools across the US shut down in response to the COVID-19 pandemic. As a result, students studied remotely for the last few months of the school year. Understanding the consequences of such a drastic transition is a vital project in educational research.

Though we are only just beginning to grapple with these recent developments, preliminary research is coming out on the effects on student learning of the transition to remote learning. The results are largely dispiriting, with students learning significantly less than would normally be expected in this timeframe, and low income and minority students suffering disproportionately.

According to work by Kuhfeld et. al (2020) "students are likely to return in fall 2020 with approximately 63-68% of the learning gains in reading relative to a typical school year and with 37-50% of the learning gains in math." Data from Opportunity Insights (2020) shows that student progress in math has declined dramatically, on average down 92% relative to the previous school year, and in addition that results were much worse for low income students. Further analysis by Dorn et al. (2020) suggests that remote learning is likely to disproportionately hamper the education of black and Hispanic students.[1]

Given that in the 2020-21 school year, the majority of students in the US are spending at least part of their time learning remotely and may well continue to do so in the future, understanding what went wrong and what can be improved is essential.

Though the current situation is unprecedented in many ways, many students in the US have been learning remotely for a long time. There is a well-established body of research on such remote learning, which shows that following certain best practices can greatly improve its effectiveness. The key lesson of this research is the significance of *interaction* in effective remote learning. Swan (2003) outlines how this includes interactions between student and teacher, student and student, and student and technology. Additional studies show this general

[1] McKinsey (2020)

rule applies to both video learning (Zhang 2006) and dedicated online learning applications (Liaw 2008).

One key question then is the extent to which these practices are being followed currently, and to the extent they are not, what can be done to remedy this.

To contribute to this project, we conducted a survey of US high school students at the end of the 2020 school year, soliciting their thoughts on remote learning in their mathematics courses. We used this data as the basis for qualitative analysis to draw some systematic conclusions about their experiences. In line with other research, we found that students had negative experiences of remote learning – especially in comparison to the classroom. Our results strongly suggest that in order to improve students' learning experiences in the future, we must increase opportunities for both student to teacher interactions and student to student interactions.

Methodology and Research Question

Our goal with this project is to examine our practices from this past year and try to make sense of the experiences and dispositions of students who engaged in remote learning. To this end our research questions are as follows:

1. How did students experience learning mathematics in a remote setting?
2. What were the biggest challenges students faced as a result of receiving mathematics instruction in a remote setting?
3. What changes would most improve students' remote mathematics learning experience?

By providing some insight into these questions we hope to help educators and researchers have a little more clarity about students' experiences, addressing challenges and capitalizing on benefits with the aim of both understanding and improving remote learning.

The unit of analysis for this paper is each student's response to a series of survey items related to remote learning. The main form of data analysis was a classification of each unit of analysis and an assessment of its valence.

The survey asked students four open-response questions about their remote learning experiences:

1. Can you describe your experience learning [course name] remotely during the past couple of months?
2. In what ways has remote learning been more difficult than learning in the classroom?
3. Are there any ways remote learning has been better than classroom learning?
4. Are there any additional resources or support that would have improved your remote learning?

A total of 67 students answered these questions. Respondents were high school students taking a course in financial applications of mathematics. This group was majority minority, with 37% of respondents identifying as Black, and 30% as Hispanic. Therefore, the data provides insight into particularly vulnerable demographic groups. Respondents come from six high schools located in New York City; Newark, New Jersey; and the Los Angeles Area. The schools were mix of pubic, private and charter schools, and all had a majority of students on free school lunches. The researchers had a prior relationship with these schools due to joint work on the aforementioned financial mathematics course. The questions on remote learning were included in their broader end of year data gathering process.

The two researchers used a preliminary analysis of the responses to create a classification rubric for the analysis. Doing so provided the following metrics for each question. The categories are summarized in table 1 below:

Question	**Code**	**Criteria**	**Values**
1	1a	Valence of response	Positive/negative/neutral
1	1b	Uses emotional Language	True/False
1	1c	Mentions finding work difficult	True/False
1	1d	Mentions interactions with teacher	True/False

1	1e	Focus on remote learning or course	Remote/Course
2	2a	States there were no problems	True/False
2	2b	Lack of teacher responsiveness	True/False
2	2c	Missed classroom or "physical" learning environment	True/False
2	2d	Home is bad learning environment	True/False
2	2e	Struggled with learning	True/False
2	2f	Struggled with concentration and focus	True/False
3	3a	States that there were no advantages	True/False
3	3b	Schedule flexibility	True/False
3	3c	Pacing flexibility	True/False
3	3d	Better learning environment at home	True/False
3	3e	Better use of technology	True/False
3	3f	Improved focus	True/False
4	4a	States there are none	True/False
4	4b	More teacher availability	True/False
4	4c	Additional learning materials	True/False

Two of the study authors, both with research backgrounds and training, were responsible for coding the dataset. The coders initially met and collaboratively coded 20 of the survey items used in the study using the provided rubric. Coders worked collaboratively to reach agreement on each survey item. Based on feedback and discussion, the coding rubric was revised.

The coders then independently coded an additional 20 items with 80% agreement, coding 16 of the 20 items of analysis the same. The coders discussed the first round of independent coding, reaching agreement on each item of analysis. The coders then divided the remaining items between them and coded them independently.

Results

A full description of the results of the qualitative analysis is provided in table 2 below:

Code	Criteria	Results
1a	Valence of response	Positive: 31% Negative: 37% Neutral: 31%
1b	Uses emotional Language	True: 13%
1c	Mentions finding work difficult	True: 32%
1d	Mentions interactions with teacher	True: 7%
1e	Focus on remote learning or course	Remote: 30% Course: 15%
2a	States there were no problems	True: 12%
2b	Lack of teacher responsiveness	True: 25%
2c	Missed classroom or "physical" learning environment	True: 24%
2d	Home is bad learning environment	True: 6%
2e	Struggled with learning	True: 21%
2f	Struggled with concentration and focus	True: 19%
3a	States that there were no advantages	True: 40%
3b	Schedule flexibility	True: 18%
3c	Pacing flexibility	True: 13%
3d	Better learning environment at home	True: 6%
3e	Better use of technology	True: 4%
3f	Improved focus	True: 10%

4a	States there are none	True: 67%
4b	More teacher availability	True: 7%
4c	Additional learning materials	True: 6%

Table 2

The results show a range of negative responses to the remote learning environment. A plurality of students (40%) felt there were no advantages at all to remote learning, while only a small fraction (12%) experienced no difficulties with the format. Many felt their teacher was insufficiently responsive (25%) and many others struggled with learning (21%) and maintaining focus (19%). There was also a sense of pessimism in the students as out of those who had nothing positive to say about remote learning, all but one said they couldn't think of any way to improve it. If students are to continue learning remotely in the following year, it is essential to give them some hope and belief in the learning format in order to engage them.

Going beyond the numbers, the individual responses provide further insight into student feeling. Many used evocative language saying of remote learning "It's horrible", "I hate it", and "It's been very stressful and overwhelming" Many responses suggested that the students felt a lack of support in one way or another in their learning – one student commented that "it was a very difficult times understanding some of the new material without being [shown] or talked through it" while another simply said "we don't have the help of the teacher".

Other responses focus on the learning experience. One said "I cannot learn as much as I would usually do. Remote learning made the topics very difficult and confusing". Others specifically mentioned the benefits of the classroom noting "You aren't able to truly discuss these topics with your peers which I believe is essential to deepen your understanding of a topic" and "I wanna go back to school since my teacher knew how to connect with the students and make the class more engaging."

Summing up the sense of despondency, students said that "I personally believe that remote learning is not in any way better than classroom learning" and "From my experience with remote learning, nothing can improve it."

Discussion and Limitations

These results emphasize just how much needs to be done if future remote learning is to be a success. We can answer our research questions as follows

1. How did students experience mathematics learning in a remote setting? *Students had negative experiences and generally perceived both their learning and enjoyment levels decline.*
2. What were the biggest challenges students faced as a result of receiving mathematics instruction in a remote setting? *Students struggled to gain the interactions with teachers and peers that would allow them to learn effectively; they also struggled to maintain concentration levels while working alone*
3. What changes would most improve students' remote mathematics learning experience?

The final question requires a more detailed response:

- Students need regular, reliable interactions with their teacher, that provides timely feedback on their work and additional explanation when they are stuck.
- Students need to interact and learn with their peers: it's essential that group activities are not abandoned in the remote environment.
- Many students need more of a structure to their working habits, resembling what the experience in the school day.
- Many students struggle to find an adequate space to learn in their homes. Such students should be a priority when considering partial school re-openings.

Interestingly, students' responses on the subject matter itself were much more positive. Around 85% of students said they would recommend the course to a friend. Further, students on average

said they found the course more interesting than a regular math course, found it more useful and learned more than in a regular math course. This suggests students were able to separate their experience of the content they were taught from the remote setting and that their negative experiences applied only to the latter.

A key limitation of this study is the size and specificity of the sample of respondents. For this reason, care must be taken when drawing conclusions about the wider student population. It would be valuable additional data to gather information on the experiences of a greater number of high school students taking a range of types of math course. This study provides some valuable early information though, in capturing the responses of students in detail, in their own words, and sheds light on the thoughts of minority students who we know to be particularly vulnerable to the transition to remote learning. In addition, the fact that respondents had an overall positive impression of the math course they were taking suggests we shouldn't expect remote experiences to be more positive when looking at different kinds of math courses.

Conclusion

The results of this study align with existing research in painting a troubling picture as to the effects of the transition to remote learning in mathematics. As well as showing that students are struggling to learn, it also suggests that known best practices in remote learning are not being followed in math classes. This is not particularly surprising, given the extremely difficult circumstances in which the transition occurred, with teachers switching mid-semester with limited training and time to prepare. Therefore, additional preparation and professional development for teachers is essential for improving student experiences in future remote learning.

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