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## Addressing Access and Equity in Mathematics Education: The Role of Technology in the Twenty-First Century Classroom

## ABSTRACT

Educational research has firmly established best practices for the teaching and learning of mathematics. In recent decades, research has evolved to address practices for teaching and learning with technology. This focus on technology has been complemented with a focus on addressing issues of equity in mathematics education. Within this context, I am proposing to conduct multiphase qualitative research on teachers' perceptions and students' experiences regarding the teaching and learning of mathematics in virtual and in-person classes. Data will be produced from secondary mathematics teachers and their classrooms in International Baccalaureate schools from three countries using questionnaires, interviews, and observations. This research on technology utilization invokes an access and equity lens and is particularly timely, as the reliance on technology will only increase in future mathematics classrooms.

## **PERSONAL STATEMENT**

From a young age I knew that I wanted to be a teacher. I come from a long line of educators in Australia; those who taught within the classroom, from the sideline, or in the arts. My mother had taught at the school where I received all of my education, so I had known many of my teachers outside of school since birth. My career choice was never a question, as I found myself teaching and learning with my friends early on in my life and formal education. The only question that remained was what subject I would teach. My mother had been a classroom teacher, instructing Physical Education, Mathematics, and English classes, whereas my grandmother was a renowned Oboe teacher. The answer became clear when I naturally gravitated towards the harder mathematical questions within my Year Seven class. From there, I was placed in extension Mathematics classes until I was able to decide my subjects in Year Eleven and Twelve, where I chose the two top level Mathematics classes. My family's background and these decisions made my transition into tertiary education quite clear, with an obvious decision to pursue Mathematics with Teaching Licensure major at Elon University.

Being a part of Generation Z has allowed me to experience many turning points within broader education. In my reception class, my teacher used both a blackboard and whiteboard for classroom instruction, now some of my classes are solely over video stream. Comparing my Year Ten and Eleven mathematics experiences shows a stark shift in relationship to technology for students and teachers alike, changing from using exercise books to using laptops. These different forms of teaching with technology not only changed the way I learnt but how the teacher approached each topic, with clear disparities between those who were and those who were not comfortable utilizing technology. Like many students, my Spring semester of 2020 finished on Zoom; however, not many could say that a drastic time zone difference caused their class to start at 10 pm. Being an international student definitely made online learning a difficult task; thus, I have personally dealt with both the assets and liabilities of technology within education. This continued into my Sophomore courses, especially in observation hours of local elementary classes where I watched students struggle to maintain concentration in the seemingly endless Zooms. These classroom changes are not unique to our COVID-19 affected society, it has been a gradual buildup to the implementation of personal computers in almost every classroom and this has altered our relationship with education. The question that stands is how this evolution of implementing more technology has affected the space for high-impact teaching practices.

As a future educator, I want to create an effective and efficient classroom where all students have equal access and opportunity to succeed in all subjects. It is with my future students in mind, that I must question how to create this environment, and with what technology. With a Lumen prize acceptance, I would be able to capitalize on my intellectual curiosity, immerse myself in mathematics education literature, gather data from current International Baccalaureate mathematics teachers, and attend conferences varying in focus from curriculum to technology implementation. It is with this research that I intend to inform the next generation of mathematics teachers on the best combination of standard practices and future innovations.

#### **PROJECT DESCRIPTION**

The field of mathematics education must develop ways to support teachers in utilizing technology to address the issue of equity, specifically regarding access. Gutierrez (2012) defines equity as having four dimensions: access, achievement, identity, and power. She explains that equity does not equate to sameness, but fairness, and access relates to the availability of resources for students (Gutierrez, 2012). Without access and equity, implementing the high-impact mathematics teaching practices provided by the National Council of Teachers of Mathematics (NCTM) in conjunction with technology is unproductive (NCTM, 2014). This council expresses that the education system cannot ensure access and equity without providing "challenging mathematics curriculum" to all students, "ensuring that all attain mathematics proficiency", supplying future teachers with an education that generates "skilled and effective" capabilities, and ensuring students from all "racial, ethnic, linguistic, gender, and socioeconomic groups" are represented in the highest levels of mathematics achievement (NCTM, 2014, p. 1). In Schoenfeld's (2016) Teaching for Robust Understanding (TRU) framework, the third element, Access to Mathematical Content, focuses on accessibility within the classroom, ensuring that no student is being "ignored" (p. 12-13). My research will utilize the eight high-impact mathematics teaching practices from NCTM and the five elements of the TRU framework to investigate the quality of opportunities for the teaching and learning of mathematics. At the core of equity issues in mathematics education lies student access to high quality teaching and available technology. NCTM's practices and the TRU framework will guide this research process in forming research questions for both the questionnaire and interview phases, creating data collection instruments, and interpreting my findings. The focus of this research is to understand teacher's perceptions of their ability to teach with available technology and address access and equity in virtual and in-person classes.

In addition to the establishment of best practices for the teaching and learning of mathematics, the field of mathematics education has narrowed its focus, exploring and documenting powerful ways teachers and students use technology (e.g. Goos, et al., 2000; Koehler, et al., 2014). Technology is an asset to the classroom and should promote success for teachers and students (Wolf et al., 2011). The Replacement,

Amplification, and Transformation (RAT) Framework supports this thinking from Wolf (2011), highlighting that technology may serve as "a different means" for instruction (Replacement), should develop "efficiency and productivity without fundamental change" (Amplification), and allows for old concepts to be demonstrated in "previously inconceivable" forms (Transformation) (Hughes et al., 2006, p. 1616-1619). In Drijvers et al. (2010) research, a teacher reflected that the use of technology within classrooms must align with teachers' views on learning; "an interactive process in which students should have a voice" and technology provides "new possibilities" with how they teach mathematics (p. 222). Technology orchestrations such as discuss-the-screen, and spot-and-show provided by Drijvers et al. (2010) will assist with the observation phase, as these orchestrations are "an evolution of teaching techniques" and will provide a structure for data collection and interpretation (p. 230). The TRU framework will also supply assistance with creating a foundation for which elements of teaching practices I see during the observation phase. It will be key throughout each phase to reflect on the mathematics aims from the International Baccalaureate (IB) Curriculum. This curriculum should allow students to: develop mathematical knowledge, concepts, and principles; develop logical, critical, and creative knowledge; and employ and refine their powers of abstraction and generalization (International Baccalaureate, 2021). The overarching objective of this research is to find what implementation strategies for teaching mathematics with technology result in the highest accessibility, equity, and achievement for both the students and teachers in virtual and in-person classes. Although some limited research exists on effective mathematics teaching in virtual and hybrid classes at the collegiate level, very little exists addressing secondary mathematics.

This research will use qualitative thematic analysis as suggested by Creswell (2013) and will comprise three sections: a questionnaire, interviews with a subgroup from the questionnaire phase, and field notes from observations with the same teachers as the previous phase. I will adhere to the process that Creswell (2013) refers to as the data analysis spiral, where qualitative data collection consists of the following: data managing; reading and memoing; describing, classifying and interpreting; and representing. The final phase results in a package of thematic findings and will be represented in visual form. Qualitative data analysis will allow for systematic examination and summarizing within each phase to inform data collection methods in each subsequent phase.

All aspects will consist of working with secondary mathematics teachers, who I have begun to contact, from IB programs in three selected countries: the United States, New Zealand, and Australia. These teachers will provide data needed to make comparisons across countries and address all subquestions. This process will advance my personal knowledge of the current educational climate within mathematics classes, improve my ability to communicate with professionals within my chosen profession, experience a multitude of ways to teach, and analyze how these differences impact students. I will continue to read and develop expertise in these qualitative methods as I write the research protocol for Institutional Review Board approval and complete the research.

The initial phase of sending out questionnaires should secure approximately twenty IB teachers and establish what typical practices occur under virtual and in-person classes. Understanding the language used by these teachers when they reflect on their teaching and the students' learning will allow for easier association of similar ideas across the three countries. Using questionnaires will allow me to collect longer, more in-depth responses from the teachers and these details will enable quality interview questions to be crafted that further unpack the nuances of teaching and learning mathematics in both classroom settings.

Purposeful sampling will be used to form the interview pool of two teachers from each country, with consideration of process level and what Marshall and Rossman (2010) define as actors. The small sample size will allow me to develop a more intimate relationship with each teacher as I interview them and observe their classes. These interviews will be designed to prompt participating teachers to reflect on the daily work of their classroom and how the technology they use affects their teaching and student learning. Interview questions will target the high-impact mathematics teaching practices from the NCTM (2014), frameworks for utilizing technology (Drijvers et al., 2010; Hughes et al., 2006) to teach mathematics, definitions of access and equity (Gutierrez, 2009), and dimensions of mathematically powerful classrooms (Schoenfeld, 2016). Interview data will reveal the degree to which the teachers have implemented research-informed practices to address access and equity, and how technology has impacted their ability to do so.

Tentative to possible traveling restrictions, the final phase of my active research will be completed in the classroom, observing mathematics teaching and learning, and gathering field notes. I will observe each teacher who participated in the interview phase for at least six hours. Further, I will already have a general idea of their teaching styles and how they employ technology in the classroom from information gained in interviews. My time in classrooms will predominantly be observational; however, possible interactions with the students will provide primary sources on how the use of technology affects individual access to high-impact practices. Observing and interacting with students will allow me to assess what students actually learn and experience relative to what teachers report. Support from the Lumen Prize will allow me to carry out this exhaustive qualitative research and gather data at the point of contact between students and their experiences in mathematics. I will be able to document how and to what extent access and equity has been addressed for secondary mathematics students during virtual and in-person instruction. Lessons learned from this research will inform the field of mathematics as we seek to provide equitable learning experiences in the future.

I plan to present my research findings at conferences concerning mathematics education, including the state, regional, and national conferences associated with the National Council of Teachers of Mathematics. I also plan to present at the national conference MathFest for the Mathematical Association of America, and the international conference for the Society for Information Technology and Teacher Education. These three conferences also publish the research reports associated with the presentations. Finally, I look forward to presenting at Elon University in the SURF event. Presenting my findings at these conferences and forums will further develop my ability to communicate in academic circles and allow interaction with professionals within my future career field.

I will utilize any findings during my student teaching whilst still at Elon, and in my future education career. As I hope to become a teacher in the IB program, the specificity of this research will be invaluable and informative to my fellow educators.

## FEASIBILITY

Through my contacts in the education sphere both here in the US and at home in Australia, the first step of this research has already begun by making contact with IB secondary mathematics teachers. Some of these teachers will be utilized in all three components, whilst others will just be a part of the questionnaire group. Finding the participating teachers for the questionnaire is one of the first steps, which I plan to finish over this summer, along with writing my application for Elon's Institutional Review Board, and learning more about research methodology. I will also participate in some professional development, including through the Association of Mathematics Teacher Educators, National Council of Teachers of Mathematics, Qualitative Research Summer Intensive at UNC, and MathFest seminars. From this studying, I will have completed a draft of the research design before the beginning of Fall Semester, including the creation of data collection instruments, and an established participant pool for all aspects of the research. This will allow for questionnaires to be sent out during Fall Semester, making me prepared for the interviews and observations in New Zealand in the Spring, and then in Australia during the summer.

Funding from the Lumen Prize will support the extensive conference travel, registration fees for numerous conferences, seminars and online courses, recording devices, and incentives for participating teachers. This will be outlined in more detail in the Budget. My travel to New Zealand and Australia will be covered by the Teaching Fellows; however, there will be domestic travel to perform the observations in all three countries that will need to be funded. It is imperative to be physically present in the observation classrooms to gain firsthand experience of the teachers' instruction and interact with students. Many of the teachers I will be working with are full-time; therefore, it is only considerate to provide incentives for their participation, which will be acquired through Lumen funds. During both the interview and observation stages, I will need recording equipment to triangulate my notes to make sure that the information aligns with the recording. To ensure that I effectively utilize my time spent creating the questionnaire and interview questions, completing these tasks as well as the observations, I will also use Lumen funds to receive training regarding research methodology. This will include enrolling in online courses, buying educational materials such as journal articles and textbooks, attending conferences specifically on data collection, and other talks and seminars.

Due to the current COVID-19 situation, my travel plans are tentative based on individual country's travel restrictions, and each component of this research can be completed online if necessary. The distribution of the questionnaire will be through emails, so this aspect will not change. The increased use of online video conferencing can enable the interviews to be performed either over a Zoom/Webex call if necessary. Whilst the best data collection method would include me being in the classroom, the observations could also occur over a Zoom/Webex call. It is possible that the setting of some conferences I plan to attend will change depending on the COVID-19 situation, and they all have the contingency plan to transition to an online format. These changes may affect the allocation of funds, but this may make room for unforeseen costs.

## TRAVEL OUTSIDE THE US

PROPOSED TRAVEL: New Zealand and Australia

I will spend Spring Semester 2022 in New Zealand as my study abroad program with Teaching Fellows. I will be attending two univeristy courses at the University of Otago as well as participating in student observation in the Dunedin area. This time will be spent obtaining primary sources with NZ teachers.

I will spend Summer 2022 at home in Australia where I plan to observe IB Mathematics classes at a local school.

#### GEC PREASSESSMENT: YELLOW

Student and adviser will need to be aware of any travel restrictions imposed by the NZ and AUS governments due to COVID at time of travel. Please see: https://travel.state.gov/content/travel/en/traveladvisories/traveladvisories/new-zealand-travel-advisory.html and

https://travel.state.gov/content/travel/en/traveladvisories/traveladvisories/australia-traveladvisory.html Assessed by: Mark Dalhouse

## BUDGET

Equipment/Miscellaneous: Transcription services - \$500 Recorder and microphone - \$200 Books for professional development - \$500 Membership to professional organizations - \$400 Total: \$1,600 Schools: Incentives for participating teachers - \$1200 Domestic travel to schools - \$1000 Total: \$2,200 Conference/Professional Development Expenses: - 18th Annual Qualitative Research Summer Institute - Online at UNC (2021) Registration: \$530 Total: \$530 - MAA Nation Conference, MathFest - Online (2021) Registration: \$200 Total: \$200 - NCTM Annual Research Meeting - Online (2021) Registration: \$400 Total: \$400 - NCTM Regional Conference - Arizona, AZ (2021) Registration: \$200 Travel: \$700 Lodging: \$600 Total: \$1,500 - NCTM Regional Conference - New Orleans, LA (2022) Registration: \$200 Travel: \$600 Lodging: \$800 Total: \$1,600 - NCTM Annual Research Meeting - Los Angeles, CA (2022) Registration: \$400 Travel: \$600 Lodging: \$700 Total: \$1,700 - Society for Information Technology and Teacher Education Registration: \$300

Travel (TBD): \$500 Lodging (TBD): \$500 Total: \$1,300 Total: \$7,230

Tuition: \$8,970

## **PROPOSED EXPERIENCES and PRODUCTS**

	Experiences	Products
Summer 2021	Professional Development	IRB Protocol Approval
	- View and reflect in writing on selected	
	AMTE webinars (e.g. Examining student	Data collection instruments and
	practices on technological tasks through a	detailed research plan
	lesson of professional noticing)	
	- View and reflect in writing on selected	Send out questionnaire (round 1)
	NCTM webinars (e.g. See It, Move It, Grasp	
	It: Math with Virtual Manipulatives)	
	- Attend the 18th Annual Qualitative	
	Research Summer Institute	
	(http://www.researchtalk.com/qrsi-2021/)	
	Attend the MAA Nation Conference,	
	MathFest	
	Write IRB Protocol application	
	Martine states and the states of the states are stated	
	write data collection instruments and	
<b>Fall 2021</b>	Attend the NCTM Annual Desserve	Sand out superior size (nound 2)
Fall 2021	Attend the NCTW Annual Research	Send out questionnaire (round 2)
	person) TRD	Summany report of questionnaire data
		Summary report of questionnaire data
	Attend the NCTM Regional Conference in	Transcribe interviews (round 1)
	Arizona, AZ	
		NCTM Regional Conference proposal
	Conduct initial teacher interviews (virtual)	
	Write proposal for NCTM Regional	
	Conference	
	LUM 498 - Thesis Credit	
Winter 2022	TF DC Trip	Transcribe interviews (round 1)
Spring 2022	Attend the NCTM Regional Conference in	Summary report of interview data
	New Orleans, LA (depends on departure	(round 1)
	date for NZ) (present)	

		Preliminary research report
	Study Abroad New Zealand	
	In-person teacher interviews and	Present at NCTM Regional Conference
	observations at IB schools in NZ	
		Primary data from NZ IB schools
	Write proposal for NCTM Annual Research	
	Meeting	NCTM Annual Research Meeting
		proposal
	LUM 498 - Thesis Credit	
Summer 2022	In-person teacher interviews and	Primary data from Aus IB schools
	observations at IB schools in South	
	Australia	NCTM Regional Conference and SITE
		International Conference proposals
	Write proposal for NCTM Regional	
	Conference and SITE International	
	Conference	
	LUM 498 - Thesis Credit	
Fall 2022	In-person teacher interviews and	Primary data from NC IB schools
	observations at IB schools in NC	
		Summary report of interview and
	Attend the NCTM Annual Research	observation data
	Meeting in Los Angeles, CA (present)	
		Present at NCTM Annual Research
	LUM 498 - Thesis Credit	Meeting
Winter 2023	Winter Term Course at Elon (Capstone)	SURF Day proposal
	Write proposal SURF Day	Summary report of interview and
		observation data
Spring 2023	Attend the NCTM Regional Conference:	Present at NCTM Regional Conference
	Location TBD (present)	
		Present at SITE International
	Attend the Society for Information	Conterence
	Technology and Teacher Education	
	International Conference TBD (present)	Present at SURF Day

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