

# Mathematics on the Internet: Charting a Hidden Curriculum

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*I report on a pilot study for an explanatory multi-method (Creswell & Plano Clark, 2011) research project that examines how undergraduate students in mathematics courses make use of online resources in order to assist with their studies. A survey of 42 students in a diverse undergraduate institution along with 4 semi-structured follow-up interviews were used to collect preliminary data on how these undergraduates make use of the internet as well as to test the data collection protocol. Initial findings suggest that students make use of online resources (beyond those assigned by the instructor) extensively and to a greater extent than in other subject areas. I also report on which resources are being used by students and find evidence of two distinct ways in which these resources are being employed. Questions will be posed about how an expanded follow-up study can best be of service to the mathematics education research community.*

*Keywords: Information literacy, Information seeking behavior, Multi-Method*

## Introduction

Students in mathematics courses spend the bulk of their time working outside of class and much of that work takes place in an online environment. Students may post textbook questions to mathematics forums, trade advice regarding the best YouTube tutorials, make use of online graphing calculators, or even sometimes go cold turkey when they realize that they are relying on the internet too much for help. These are all anecdotes related to the author by his students and, while of limited use for making generalizations, they serve to illustrate the variety of hidden work that often occurs out of the instructor's sight. The invisible nature of this work is of particular concern when we consider those student populations (e.g., nontraditional, first generation, minoritized) for whom mathematics traditionally serves as a gatekeeper (Gainen, 1995; Atanda, 1999; Eagan & Jaeger, 2008; Martin, Gholson, & Leonard, 2010).

While there is a growing body of research devoted to undergraduate students' general online searching behavior (Rowley & Urquhart, 2007; Urquhart & Rowley, 2007; Nicholas, Huntington, Jamali, Rowlands, & Fieldhouse, 2009; Lai & Hong, 2015), there is very little work that looks at how students are employing online resources for to help themselves learn specific disciplines. Undergraduate students make use of the internet as a supplement to their learning with increasing frequency (Selwyn, 2008; Lai, Wang, & Lei, 2012). This usage cuts across all demographic groups (Selwin, 2008) including those nontraditional, first generation, and minoritized students who are already marginalized by the education system (Stone, 1998; Stein, Kaufman, Sherman, & Hillen, 2011). Unfortunately, this informal use of the internet is not reflected in teacher training or professional development. Practicing mathematics instructors' knowledge of which resources students are using and how they are using them is idiosyncratic because there exists no readily available knowledge base about such usage. Accordingly, this proposal will report on a pilot study that employs an explanatory multi-method approach (Creswell & Plano Clark, 2011) in order to a) describe the extent and type of online resources that students are using to help them study for mathematics classes and b) describe the strategies that students are employing as they make use of online resources.

## **Review of the Literature**

### **Mathematics Education and the Internet**

Much of the research on the online aspects of mathematics education explores how to teach mathematics on the internet (Timmerman, 2004; Engelbrecht & Harding, 2005; Foster, Anthony, Clements, Sarama, & Williams, 2016) or how students interact with novel web-based interventions (Rosa & Lerman, 2011; Biehler, Ben-Zvi, Bakker, & Makar, 2012). However, some researchers have looked at how students interact with online resources that are not part of assigned classroom activities. For example, Van de Sande (2011) studied 200 student interactions in a free online help forum and discovered that meaningful learning sometimes took place there. Similarly, Puustinen, Volckaert-Legrier, Coquin, and Bernicot (2009) report on a study in which they observed how 206 French middle school students sought out help with the mathematics that they were learning in school. These researchers also looked at submissions by students to a help forum. Notably, in both cases, the traces of student search activities in a particular website were examined without providing any analysis of what proportion of students relied on the website or whether the use they made of it was a typical way for students to seek out help online. For research along those lines, we must turn towards work in the information sciences.

### **Information Seeking Behavior**

If we direct our attention to studies of how students seek out information online more generally, the field is much larger. Researchers in the information sciences have been attempting to model how people seek out information for decades now (Bates, 1989). One line of inquiry explores students' pathological use of the internet (Anderson, 2001). In the course of this survey study ( $n = 1300$ ), the researcher found that mathematics majors use the internet significantly less than many other groups, particularly those in the hard sciences. While not addressing the use of the internet for academic purposes, Sin and Kim (2013) provide an example of a study that examines how a particular population of students looks for information – in their case, the everyday information seeking of international students on social networking sites. The study was conducted with surveys and found that the use of social networking sites was a positive predictor of the perceived usefulness of information for everyday life. Torre, Reiser, LePeau, Davis, and Ruder (2006) used a grounded theory approach to describe the academic information-seeking behavior of 24 first-generation Latino/a students. However, this study did not actually address questions about how these students use internet resources to help themselves academically but rather focused on how students sought out academic advising-related information, such as the requirements for different majors or possible career fields. Some research looked at differences in internet use between different demographic groups (Odell, Korgen, Schumacher, & Delucchi, 2000), but that work focused on macro-behaviors, e.g., how many online hours spent per week on games versus homework, without attempting to unpack exactly which resources students are accessing and how they are making use of them.

### **Research Questions**

Mathematics educators need a better understanding of how students are making use of the internet. Current research either focuses on specific interventions or takes a broad look at student information-seeking without providing insight into how students in mathematics classes are

making use of the internet. Thus, the goal of this pilot study is to address the following research questions:

1. Which online resources do undergraduate students in mathematics courses rely on in order to help them with their mathematics courses and to what extent do they make use of these resources?
2. How are students seeking out and interacting with these resources?

## **Method**

An explanatory mixed methods study (Creswell & Plano Clark, 2011) begins with the collection of quantitative data via surveys with follow-up interviews designed to explore the initial quantitative findings. An online survey was administered to students taking summer courses on a voluntary basis with the understanding that the students would receive a \$25 incentive if they were randomly chosen to participate in a 30-minute follow-up interview. The surveys collected basic information about the frequency with which students make use of the internet while also asking them specifically about a series of internet resources that had previously been brought up frequently in the course of informal surveys and conversations with students and colleagues. These questions had a dual purpose, they provided data on the resources that students are using and they also primed participants for the subsequent open-ended questions asking them more details about which information resources that they use and how they use them. The students were told to only refer to internet use that was not part of the curriculum provided by their instructor, thus they did not report on their use of online course management software.

The sample ( $N = 42$ ) in this pilot reflected the institution's demographics with respect to race and gender<sup>1</sup>. They were enrolled either in the Calculus sequence, Differential Equations, and/or Linear Algebra. This constrained selection of courses is a limitation of the current pilot and the subsequent larger study will draw students from mathematics courses from all different stages. Follow-up interviews were conducted with four students as part of this preliminary study. These interviews were semi-structured (Arksey & Knight, 1999) in order to build off of our findings from the initial survey. Given that our goal with these interviews is to come to a better understanding of how students seek out information, the students were asked to describe the most recent situation in which they sought out information to help with their mathematics class, to elaborate on the use of those resources that they stated that they used frequently in the survey, invited to reflect on how their use of the internet as a resource for mathematics courses had changed over the years, and to describe how they found out about the online resources they used.

## **Findings**

### **Survey Results**

The surveyed students reported using online resources, beyond those assigned by the instructor, extensively. All of the students made use of online resources at least a few times each week and almost half of them made use of those resources every day (see Table 1). Further, most of the students reported using online resources more frequently in mathematics courses than in

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<sup>1</sup> This information is available upon request, I am only leaving it out of the present proposal due to space constraints.

other subject areas with only one student reporting that they used online resources less often in their mathematics courses.

**Table 1**

*The Use of Online Resources by Students in Mathematics Courses*

How Often	Frequency	Percentages
Every Day	19	45.24%
A Few Times a Week	23	54.76%
About Once a Week	0	0%
A Few Times a Quarter	0	0%
Less Than Once a Quarter	0	0%
Compared to Other Courses		
More Often	29	69.05%
About the Same	12	28.57%
Less Often	1	2.38%

**Table 2**

*Percentage of Students Using Different Online Resources*

Online Resource	More Than Once a Week	Several Times a Quarter	Once a Quarter or Less	Do Not Recognize
Google	85.72%	14.28%	0%	0%
Youtube	66.67%	28.57%	2.38%	2.38%
Wolfram Alpha	38.09%	28.57%	16.67%	16.67%
Khan Academy	33.33%	50%	14.29%	2.38%
Desmos	21.43%	42.85%	14.29%	21.43%
Chegg	19.04%	9.52%	52.38%	19.05%
Mathematica	11.9%	14.28%	9.52 %	64.29%
Wikipedia	9.58%	26.19%	64.29%	0%
Stack Exchange	4.76%	19.05%	14.29%	61.9%

The most commonly used resources (see Table 2) were Google and Youtube, a finding that highlights the limitations of the survey format as these resources could be used in any number of ways by students. The follow-up interviews, as reported below, provided an opportunity to learn more about what students meant when they reported using those two resources. The next most commonly used resources were Wolfram Alpha and Khan Academy with around a third or more of students using these more than once a week and a strong majority of students using them several times a quarter or more. The use of these resources is consistent with two strategies for using online resources that arose in all of the interviews, namely the use of online instructional videos and the use of online calculators / answer engines. Students also had the opportunity to volunteer resources that were not mentioned by name in the survey. This elicited resources such as Symbolab, Geogebra, Mathway, Slader, IntegralCalculator and DerivativeCalculator as resources that they had used in their latest course. Symbolab, an answer engine, was brought up by over a quarter of the students who took the survey.

## **Interview Results**

There were two primary ways that these students described using online resources in their interviews: solidifying concepts by interactively viewing online lectures and making use of

online calculators and/or answer engines in order to double-check problems that were causing the students difficulty. Crucially, all four of the students were frequently (i.e., more than once per week) using the internet for both purposes. The students all elaborated on how they made use of these resources. For example, students would choose lectures based on their popularity (both in terms of the total viewers and the number of “likes” received) and scan the comments in order to determine if they should skip to particular points in the lecture or to identify whether the lecturer made any mathematical mistakes. They generally settled on specific lecturers on Youtube – these were often encountered in the course of their searching, although they sometimes had been recommended by peers or even their instructors. The students also elaborated on their use of answer engines such as Wolfram Alpha and Symbolab. They stated that they would always keep them on hand in order to check their work if it was marked wrong (in the case of online homework) or if they suspected that they had done something wrong (in the case of written homework). One of the students said that they would use these resources if they were not confident in the steps that they took to arrive at their answer, even if they had gotten the correct answer.

The student responses affirmed the importance of online resources for their studies. Indeed, beyond the fact that all four students used the internet extensively, three of the four students stated that they were uncertain whether they would have passed college-level mathematics courses without online resources. This is put in greater relief by the fact that none of these four students reported using the internet for help with mathematics when they were in high school. Two students stated that they wished that they had known about these resources when they were in high school because they may have been more successful, while another student said that it was the greater demands, particularly with respect to the amount of material being covered within an abbreviated timeframe that necessitated the use of online materials. This last student highlighted the role of answer engines as a way of checking their work, stating that they would spend much more time on their mathematics homework if they were not able to immediately confirm whether they had answered the problems correctly or not.

### **Conclusion**

This pilot study serves to demonstrate that students are making extensive use of the internet to study for their mathematics courses. In particular, the interviews suggest that these students may believe that they owe their success in mathematics courses to the judicious use of internet resources. I will be following up this work with a large-scale follow-up study. In particular, such a study will help provide a general model of students’ information seeking and information use that can help support equitable mathematics instruction by making effective strategies for the use of online resources available to all students and instructors.

### **Questions for the Audience:**

- As researchers and as educators, what would you most like to know about how your students are making use of the internet in order to aid with their studies?
- What are your experiences with your students’ use of the internet? Do you adjust your instruction in order to take their internet use into account?
- Would student diaries or screen-capture sessions be a useful supplement to the surveys and follow-up interviews?

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