Pre-Service Mathematics Teachers' Use of Web Resources

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The internet is used by teachers to help find resources to integrate technology into their classrooms in a variety of ways (Handal, Campbell, Cavanagh, Petocz, & Kelly, 2013). The purpose of this study was to investigate the websites pre-service teachers (PSTs) used during their field experiences in secondary mathematics. To address the purpose of this study, the researchers collected survey data, lesson plans, and PST's work. The Technological, Pedagogical, Content Knowledge (TPACK) Framework and the Substitution, Augmentation, Modification, and Redefinition (SAMR) model both served important roles within a pre-service methods course. Implications of this study suggest PSTs may benefit from learning how to assess the quality of resources, learn proper implementation of website resources, and address the variety of ways resources can be used to integrate technology into their mathematics curriculum.

1 INTRODUCTION

A recent article cited in the Associated Press in the USA, "Million Dollar Teachers: Selling Lessons Online," claims that teachers have spent more than 100 million dollars on resources for their classrooms averaging $4-10 per lesson (Frederick, 2017). One particular teacher who has earned one million dollars through this source believes: "You can't go into it thinking that you are making a million dollars. If you are already creating materials and if you have something that works really well in your classroom, then why not?" (Frederick, 2017).

Teachers Pay Teachers (www.teacherspayteachers.com) is a website that has been public since 2006 and has more than 4 million active users with more than 2.8 million resources and 1 billion downloads. This site offers a variety of teacher resources published by fellow educators ranging in price from $0.99 to $40 (Walthausen, 2016). According to a national survey by the Education Week Research Center, 87 percent of teachers polled said they trusted other teachers' claims about whether curriculum materials were aligned with the Common Core, while slightly less than two-thirds said they trusted an independent panels of experts (Cummings, 2015). Only 38 percent stated that they trusted curriculum providers and publishers for resources to use in their classrooms.

Many educators decry the fact that so many teachers are profiting from their created materials instead of sharing websites for free, especially since the use of open educational resources (OERs) has significantly grown in recent years (Endsley, 2017). OERs include learning materials, data, and educational opportunities which are available without restrictions of copyright and proprietary licensing models. In this model, teachers are promoting collaboration by sharing their knowledge, insights, and ideas with one another. The United States Department of Education identified that "all OERs must be digitized, free, and editable" (Walthausen, 2016). According to the former U.S. Secretary of Education, John King in 2016, "Openly licensed educational resources can increase equity by providing all students, regardless of zip code, access to high-quality learning materials that have the most up-to-date and relevant content" (U.S. Department of Education, 2016). Chief among these sites for mathematics and science education is the National Science Foundation's' National Science Digital Library (https://nsdl.oercommons.org/). This source provides online educational resources for teaching and learning with a focus on Science, Technology, Engineering, and Mathematics (STEM) and adheres to the OER principals.

Whether freely available or for a price, teachers search for lesson plans and activities online for many different reasons and their choices are important. As Glenda Lappan and Diane Briars state (1995):

> *There is no decision that teachers make that has a greater impact on students' opportunities to learn and on their perceptions about what mathematics is than the selection or creation of the tasks with which the teacher engages students in studying mathematics (p. 139).*

Given the importance of teacher decisions on the selection of mathematical tasks, teacher preparation programs need to not only present the criteria of quality websites, but also infuse the tenets of Technology, Pedagogical, and Content Knowledge (TPACK) (Koehler, 2012). In this study, TPACK forms the framework of the mathematical methods course taken by pre-service secondary teachers. The purpose of this study was to investigate the websites pre-service mathematics teachers used and why they were used during their field experiences. The objective was to not only describe which websites future teachers used as they were learning to teach mathematics, but also to explain the various influences and situations that may have enhanced or constrained their curricular decision -

making. The following research questions shaped this research:

- What websites did pre-service teachers identify as useful during their field work?
- What is the nature of these identified sites?
- How were websites used in their planning and practice?

2 RELEVANT LITERATURE

2.1 Internet Usage in Schools

Technology has taken over our daily interactions through the use of social media and the internet. As of June 30, 2017 (Figure 1) a total of 345 million people use the internet in North America alone (Internet World Stats, 2017).

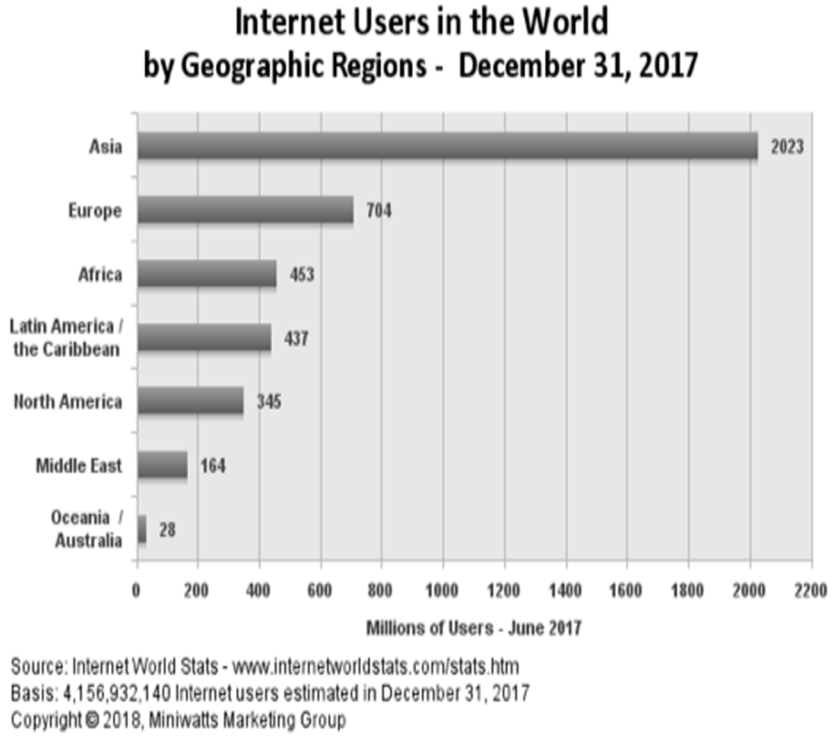

Figure 1 Millions of internet users worldwide. This figure illustrates the millions of internet users around the world in December of 2017. Permission granted by Internet World Stats.

According to an international survey by UNESCO (2003), the internet is not just for private usage, it is used within educational environments for information retrieval, individualized learning, group learning, teaching, and collaborative activities. According to the National Council of Teachers of Mathematics, "Technology has become an essential tool for doing mathematics in today's world… In this context, technology includes computers, internet, and other digital resources" (2010, p.1). With technology such as the internet influencing teaching, it is important pre-service teachers understand how to incorporate a technologically fluent culture into their classrooms.

2.2 Knowledge of Technology

The internet can help teachers find resources for lesson planning to integrate technology into their classroom in a variety of ways, from student use to pedagogical strategies (Handal et al., 2013). Finding and using a website online to find a resource does not necessarily mean the teacher is integrating technology into the classroom for the students' use. "The Technological, Pedagogical, and Content Knowledge (TPACK) framework attempts to identify the nature of knowledge required by teachers for technology integration in their teaching, while addressing the complex, multifaceted and situated nature of teacher knowledge" (Koehler, 2012). Figure 2 represents the TPACK framework for integrating technology into educational environments with a focus on connecting content knowledge with technology and research-based pedagogical strategies.

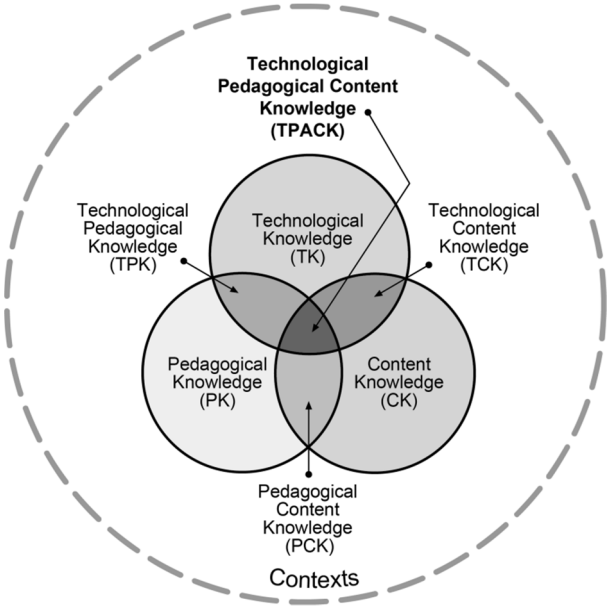

Figure 2 Illustration of the TPACK framework model. (Koehler et al, 2013; image available at: http://tpack.org). Reproduced by permission of the publisher, © 2012 by tpack.org.

The three overlapping areas in the Venn diagram (TK, CK, and PK) create the following distinct categories: technological pedagogical knowledge (TPK), technological content knowledge (TCK), pedagogical content knowledge (PCK), and technological pedagogical [and] content knowledge (TPACK). Technological knowledge (TK) includes knowledge about specific technologies and how to operate them. In this case, teachers need training on how to use the technology before incorporating it into the classroom. Technological pedagogical knowledge (TPK) addresses how to use particular technology when teaching and the strategies for incorporating it into the lesson. Understanding when a certain technology may be used and how it can be strategically planned into the lesson is essential. Technological content knowledge (TCK) refers to the change in representations (from paper to digital) along with student connections or meaning making. Teachers need to understand how student learning is affected by the use of technology. As teachers use websites and technology driven resources in their classroom, the TPACK framework is all the more necessary.

2.3 Developing and Incorporating TPACK

Pre-service teachers should be actively involved with their use of technology to solve real-world problems in their undergraduate methods courses. They should learn when and how to adequately use technology to provide their students with authentic learning experiences. To do this, Mishra & Koehler (2006) suggest asking pre-service teachers how technology will be used to support and engage student understanding, why it is appropriate, and how they will include all three elements (content, pedagogy and technology) into their lessons. "The incorporation of a new technology or new medium for teaching suddenly forces us [teachers] to confront basic educational issues because this new technology or medium reconstructs the dynamic equilibrium among all three elements" (Mishra & Koehler, 2006, p. 1030).

According to Hechter, Phyfe & Vermette (2012), teachers incorporate the TPACK framework into their classroom lessons for a variety of reasons; these include; promoting student engagement, 21st century skills, interactive and hands-on learning, student-driven learning and best teaching practices (Mishra & Koehler, 2006; Hakverdi-Can & Dana; 2012; Niess, 2006). Table 1 provides an overview of TPACK in the context of teaching mathematics (Mishra & Koehler, 2006).

TPACK Framework	Overview	Mathematics Teaching with Website Resource Examples
Technological knowledge (TK)	Knowledge about technology and how to use specific software, hardware, and websites.	Teacher knows how to use the internet and search for particular websites.
Technological pedagogical knowledge (TPK)	Knowledge about how to teach with specific technologies.	Teacher knows how to model and support students' use of a graphing calculator such as Desmos or Geogebra.
Technological content knowledge (TCK)	Knowledge about how technology aligns to various concepts.	Teacher identifies and uses websites that are aligned to the Common Core State Standards.
Technological pedagogical and content knowledge (TPACK)	Knowledge about how to use technology and instructional strategies to teach specific concepts.	Teacher knows how to model and support students' use of a graphing calculator technology such as Desmos or Geogebra.

Table 1 Overview of TPACK in the Context of Teaching Mathematics.

In this article the authors focus specifically on pre-service teachers' technological knowledge (TK) as it is developed in their undergraduate methods courses and field experiences to identify websites used and how they were utilized in their classrooms.

3 METHODS

In order to answer the research questions, the authors distributed an online survey within the U.S. to 51 secondary and middle childhood pre-service teachers enrolled in a mathematics education student teaching seminar in the Fall of 2017. Forty prospective secondary (24) and middle childhood (16) mathematics teachers volunteered to participate in this study. The analysis of these surveys focused on pre-service teacher's selection of mathematics education websites in both the course and field settings.

3.1 Description of the Teacher Education Program in Mathematics

The University that served as the site for this study requires pre-service mathematics teachers to complete a two-year advanced program across multiple semesters in addition to 40 semester hours of required mathematics content. Specifically, these classes include a three-semester calculus sequence, discrete mathematics, linear and abstract algebra, the history of mathematics, Euclidean Geometry, and probability/statistics. Two upper division electives in mathematics are also required.

Each teacher candidate is required to enroll in five mathematics education classes including: two methods, one field practicum, student teaching, and a seminar to complement student teaching. All five education courses include assessments with technology integrated throughout their teaching units. In each course, educational technology instruction includes guidelines which reflect mathematics education reforms such as the Common Core for State Standards (CCSS, 2010), the National Education Technology Standards for Teachers (ISTE, 2017), NCTM Standards (2010), mathematical proficiency strands defined by the National Research Council (2001) and are designed to support the development of Technological Pedagogical and Content Knowledge (ISTE, 2017).

In their mathematics teaching methods courses, pre-service teachers used The Educators Evaluating the Quality of Instructional Products (EQuIP, 2017) rubric for the evaluation and selection of websites ensuring meaningful and conceptually rich instructional materials when teaching mathematics. Within this rubric, instructional supports must possess the following qualities:

- Include clear and sufficient guidance to support teaching and learning of targeted standards; including, when appropriate, the use of technology and media.
- Use and encourage precise and accurate mathematics, academic language, terminology and concrete or abstract representations (e.g., pictures, symbols, expressions, equations, graphics, models) in the discipline.
- Engage students in a productive struggle through relevant, thought-provoking questions, problems and tasks that stimulate interest and elicit mathematical thinking.
- Address instructional expectations and be easy to understand and use.
- Provide appropriate level and type of scaffolding, differentiation, intervention and support for a broad range of learners. (EQuIP, 2017)

During the mathematics methods courses, technology-enhanced mathematics content and pedagogy are modeled for students by using a variety of technologies (e.g. interactives, websites, calculators, and software). Participants of this study were students in one of the author's classes, which was designed to introduce PSTs to teaching experiences and activities by utilizing mathematical reasoning and problem-solving skills. Researchers have found that teacher resources such as websites, TI-Nspire calculators, virtual manipulatives, and dynamic geometry software (DGS) open up new possibilities for teachers to promote connections among representations, explore dynamic mathematics environments, develop students' skills of inquiry, and support students' construction of knowledge (Özgün-Koca, Meagher, & Edwards, 2010). Based on these results, the instructor placed considerable emphasis on the use of such technologies in the teaching and learning of mathematics, with particularly extensive use of websites which integrated the strands of mathematical proficiency (National Research Council, 2001). The decision to use the National Research Council's (NRC) Strands for Mathematical Proficiency was based upon the university's conceptual framework in this study. The NRC's Strands for Mathematical Proficiency (2001) include:

1. *Adaptive reasoning*: the capacity for logical thought, reflection, explanation, and justification.

2. *Conceptual understanding*: the "integrated and functional grasp of mathematical ideas", which "enables them [students] to learn new ideas by connecting those ideas to what they already know." A few of the benefits of building conceptual understanding are that it supports retention and prevents common errors.

3. *Procedural fluency*: the skill in carrying out procedures flexibly, accurately, efficiently, and appropriately.

4. *Productive disposition*: the inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy.

5. *Strategic competence*: the ability to formulate, represent, and solve mathematical problems (NRC, 2001, p. 5).

Activities in the course focused primarily on pedagogical tasks (e.g. constructing lesson plans, creating rubrics, developing technology-oriented math tasks) and content-related activities (e.g. solving mathematics problems, analyzing mathematical accuracy of student work). For example, participants completed problem sets designed to give them the opportunity to explore (and extend) content and pedagogical knowledge of secondary school mathematics. As part of their field experience, participants completed two units in which they researched, developed, and implemented mathematics lessons. In addition, they submitted five secondary level mathematics activities that were constructed and/or modified for use with technology such as websites, GeoGebra, Desmos, and TI-Nspire. They were encouraged to use these materials in their student teaching placements whenever possible.

3.2 Participants and Settings

Of these 40 teachers enrolled in a year-long methods, student teaching, and seminar at a Midwestern university, 17 were male and 23 were female. This particular state-funded University's enrollment totals more than 38,000 students. The pre-service teachers all had varying backgrounds and reasons for wanting to student teach in their particular school of choice. Student teaching placements occurred in school districts within a 50 mile radius of the University with 40% of the students placed in urban districts, 30% in suburban, and 30% in rural schools.

3.3 Data Sources

Data sources included a brief survey of website use (Appendix A), a website evaluation assignment (Appendix B), and lesson plans within a teaching unit. The survey asked students which websites they used during their student teaching, why particular websites were chosen, and the types of classroom resources gained from using these websites. The website assignment required students to critique particular websites chosen and identify how they would implement the resources in their classroom. Lastly, lesson plans from pre-service student teachers were analyzed as to how pre-service teachers incorporated website usage into their classrooms.

3.4 Description of Websites Identified

The websites pre-service teachers used during their field experience assignments are identified within Table 2. This table lists the website identified, the link to each particular source, a description of the site based on the web site designers and also lists the number of PSTs who expressed using each source. As expected, all but one PST chose more than one site to implement during their field experience. This particular PST did not use any of the websites identified.

Websites	Link to resource	Description of Site	Number of Teachers Using Website
The Common Core Standards	http://www.corestandards.org/Math/	This site provides parents, educators, policymakers, journalists, and others easy access to the actual standards, as well as supporting information and resources.	48
Khan Academy	https://www.khanacademy.org/	Khan Academy offers practice exercises, instructional videos, and a personalized learning dashboard that empowers learners to study at their own pace in and outside of the classroom. They tackle math, science, computer programming, history, art history, economics, and more. Their math missions guide learners from kindergarten to calculus using state-of-the-art, adaptive technology that identifies strengths and learning gaps. The designers also partnered with institutions such as NASA, The Museum of Modern Art, The California Academy of Sciences, and MIT to offer specialized content.	44
The Ohio Department of Education	http://education.ohio.gov/Topics/Learning-in-Ohio/Mathematics	This site offers mathematics information supporting each part of Ohio's educational system: Ohio's Learning Standards, the model curriculum, assessments and additional resources to help teachers in the classroom.	41
Purplemath	http://www.purplemath.com/	Purplemath's algebra lessons are informal in their tone and are written with the struggling student in mind. According to their website, they advise: "Don't worry about overly-professorial or confusing language! These math lessons emphasize the practicalities rather than the technicalities, demonstrating dependably helpful techniques, warning of likely "trick" test questions and pointing out common student mistakes."	33
GeoGebra or Desmos	https://www.geogebra.org/	GeoGebra is dynamic mathematics software for all levels of education that brings together geometry, algebra, spreadsheets, graphing, statistics and calculus in one easy-to-use package. GeoGebra has become the leading provider of dynamic mathematics software, supporting science, technology, engineering and mathematics (STEM) education and innovations in teaching and learning worldwide.	33
Illustrative Mathematics	https://www.illustrativemathematics.org	Illustrative Mathematics is composed of a community of educators that collaborate to share their understanding of mathematics and skills in using it by providing expert guidance to states, districts, curriculum writers, and assessment writers working to improve mathematics education.	32
Pinterest	https://www.pinterest.com	This site is described as "the world's catalog of ideas." Teachers can use this site to find resources such as decorating their classroom, classroom management, activities, lesson plans, and more.	30
NCTM Illuminations	https://illuminations.nctm.org	Illuminations is a project designed by the National Council of Teachers of Mathematics (NCTM). Illuminations allows teachers to access quality standards-based resources for teaching and learning mathematics, including interactive tools for students and instructional supports.	21
Mathematics Assessment Project (MARS)	http://map.mathshell.org/index.php	The aim of MARS is to bring the CCSSM to life through summative tests or tasks, classroom challenges (lessons that support formative assessment) and professional development modules to help teachers improve their program.	19

Yummy Math	https://www.yummymath.com/	Yummy Math provides teachers with a resource that brings real-life into their math classrooms. It is the author's' belief that when math is explored in contexts that are familiar and of interest to students, students will be more engaged to do math, reason, think critically, question and communicate. The activities are written to correspond with the NCTM Process Standards and the CCSS Standards for Mathematical Practice.	12
Math Snacks	http://mathsnacks.com/teaching-with.html	*Math Snacks* is a series of activities teachers can use with any curriculum in grades 4-8. Materials address critical content including number sense, ratio, proportion, measurement, scale factor, and pre-algebra. Some address more than one content area and can be used in a variety of lessons at different grade levels. Don't think of the animations and games as "free time activities." All *Math Snacks* products are aligned with the Common Core State Standards for Mathematics (CCSSM) and address the CCSSM Mathematical Practices when used as recommended.	12
National Library of Virtual Manipulatives	http://nlvm.usu.edu/en/nav/vlibrary.html	The NLVM is a resource from which teachers may freely draw to enrich their mathematics classrooms. The materials are also of importance for the mathematical training of both in-service and pre-service teachers. The library is actively being extended and refined through projects including the eNLVM, a project to develop interactive online learning units for mathematics.	9
IXL	https://www.ixl.com	IXL is an immersive K-12 learning experience that provides comprehensive, standards-aligned content for math, language arts, science, and social studies.	8
Inside Mathematics	http://insidemathematics.org	Inside Mathematics provides a resource for educators around the world who struggle to provide the best mathematics instruction they can for their students. Too often, teachers who excel at reaching students have few ways of sharing these strong practices with others.	6
Mathalicious	http://www.mathalicious.com/	This site is one of the few sites that is not entirely free. It does provide some lessons that are available at no cost. The authors create lessons that explore the math behind real-world topics, from sports to shopping, to the odds of finding life on other planets. These lessons put teachers and students in a position to have interesting conversations that foster a classroom culture of curiosity and rigorous mathematical thinking.	5
Kahoot	https://create.kahoot.it/login	Kahoot! is a free game-based learning platform that makes it fun to learn – any subject, in any language, on any device, for all ages! Teachers can use this for formative assessments, quizzes, discussions, surveys, etc.	5
Mathbits--Regents Prep	https://mathbitsnotebook.com/	This website originally was dedicated to the preparation of students for mathematics testing in NY. Currently, the mathematics notebook consists of three subjects: Algebra I, Geometry, and Algebra II. Within each notebook are notes, practice, and review for teachers to use.	2
PBS Annenberg	http://www.learner.org/about/	Annenberg Learner uses media and telecommunications to advance excellent teaching in American schools. These multimedia resources help teachers increase their expertise in their fields and assist them in improving their teaching methods. Many programs are also intended for students in the classroom and viewers at home to exemplify excellent teaching.	2

Table 2 Websites Used by Pre-Service Teachers.

3.5 Data analysis

Survey data (Appendix A) were collated and analyzed based on the websites pre-service teachers identified as useful, the purpose of their use, the cost of resources, and frequency of usage during their student teaching experiences. Survey data, the website evaluation assignment, and student lesson plans were triangulated to compare student use of websites with the NRC strands of proficiency and the TPACK framework. The responses were summarized with descriptive statistics. Qualitative data from all three sources were analyzed using open coding procedures from grounded theory to identify themes (Corbin & Strauss, 1990). Data analysis began with reading through the data multiple times and identifying initial themes. By breaking the data down into discrete parts, the authors compared similarities and differences to help identify themes (Corbin & Strauss, 1990). The second step in the coding process was to use axial coding reassembling the data to develop categories across the three data sources. This process supports research triangulation of data, a method of increasing trustworthiness (Lincoln & Guba, 1984).

4 FINDINGS

4.1 Findings from Survey

Table 3 illustrates the websites PSTs used during their field experiences. Data is displayed in counts (n=40).

Use of Website	NCTM Illuminations	Mathematics Assessment Project (MARS)	The Common Core Standards Website	The Ohio Department of Education Website	Yummy Math	Math Snacks	Mathbits--Regents Prep	Pinterest	National Library of Virtual Manipulatives	PurpleMath	Khan Academy	IXL	Illustrative Mathematics	Inside Mathematics	PBS Annenberg	GeoGebra or Desmos	Other
1-5 times	4	11	7	6	4	3	2	4	2	9	6	1	5	1	0	2	1
6-10 times	2	2	0	1	0	0	0	1	1	3	3	0	3	0	0	2	0
More than 10 times	1	1	7	5	0	0	0	3	0	0	2	1	1	0	0	5	0
Total	7	14	14	12	4	3	2	8	3	12	11	2	9	1	0	9	1

Table 3 Websites used by pre-service mathematics teachers.

The top websites identified by pre-service mathematics teachers included: The Common Core Standards (14), MARS (14), The Ohio Department of Education (12), Purple Math (12) and Kahn Academy (11). Fewer than 10 out of the 40 students identified using all other websites within the survey.

Teachers chose websites to use during their field experience for the following reasons: finding lesson plans (86.49%), hands-on activities (83.78%), formative assessments (40.54%), supplemental class work to align with textbook (18.92%), classroom management ideas (18.92%), and re-teaching lessons (5.41%). All but one student selected multiple reasons as to why websites were used in their lessons. Students did not relate their usage directly to any of the particular sites identified in Table 3. The pre-service teachers stated the websites they chose within Table 3 enhanced mathematical learning through activities (92.11%), challenged students thinking (84.21%), and provided multi-step problems to promote critical thinking (55.26%) in various ways. To gain access to the resources in Pinterest, 40% of students admitted to paying $16.00 or more for their materials to use while 20% paid between $1-$5. This is an interesting finding as there are many open education resources online that are free. Also, many of these OERs have been proven to be reliable and valid resources to use in the classroom while those on Pinterest may not undergo a peer-review process.

4.2 Findings from Website Evaluation Assignment

The website assignment used in this study required PSTs to summarize websites that they used during their field experiences, identify the strengths and weaknesses of each website, and describe how they would use them in their future classrooms. The data analysis employed within this assignment used a qualitative framework which allowed the

researchers to build patterns of meaning from the data provided by students (McMillan and Schumacher 2001). Four phases, as described by McMillan and Schumacher, were employed for the analysis of the assignment: (1) recurring discovery throughout the research in order to tentatively identify patterns; (2) categorizing and ordering data; (3) refining patterns by determining the trustworthiness of the data; and (4) synthesizing themes. The researchers then assigned numerical frequencies found from individual respondents to these categories, resulting in the following list.

Common Strengths of Websites:

- Allows one to view Practice and Content Standards (35)
- Engages students in real-world problems- relevant (34)
- Provides support for students who may struggle (28)
- Supports easy navigation tools (25)
- Offers a wide variety of resources (24)
- Includes cognitive high demand tasks (18)
- Access to free, current materials (17)
- Provides a platform for collaboration and sharing by other teachers (11)
- Represents all grade levels (10)
- Differentiates learning (6)
- Motivates students through fun and enjoyable activities/games (4)

Common Weaknesses Found in Websites:

- Lacks one-to-one correspondence with standards. For example, some sites do not provide resources for each standard (35)
- Navigation is difficult among sites (29)
- Does not identify to the Common Core Standards (27)
- Links found on the website are often incomplete or not found (17)
- Too difficult problems (18)
- Not appealing, boring (7)
- Membership fee for solutions and accounts (6)
- Not enough information (4)
- Not motivating (4)
- Some posts are of one teacher and only his or her opinion (2)

Three overall themes were revealed by these lists: (1) usefulness, (2) accessibility to navigation, and (3) variety in resources. First, PSTs judged the value of websites based upon its usefulness to their needs. They wanted the website to include information and tools for not only themselves as pre-service teachers, but for parents and students to use as well. PSTs wanted the resources to include their specific grade level, connections to real-world issues, and be motivating and relevant to their students. Although many PSTs expressed a need for high demanding tasks, many also expressed that some of these websites included math problems that were too challenging and wanted the site to include more practice-based activities.

Second, the results of the survey revealed that at times, PSTs valued accessibility, not necessarily the quality of the tasks within the website. PST's judged sites negatively if they were under construction, had missing links, appeared boring, were hard to navigate, or required membership fees. These apparent contradictions could be explained through PSTs inexperience with the websites or their inability to know what they needed. Although membership fees were perceived negatively, 60% of PSTs stated that they paid for teaching resources. Therefore, PSTs may be willing to pay for other ideas, but not be content with or willing to pay a monthly fee. Also, not all pre-service teachers found the same websites difficult to navigate; views varied among sources.

Third, PSTs expressed negativity toward a site if it did not include lesson plans with all supplementary materials. Thus, if a website only offered standards and commentary (which many state standards do), PSTs considered this a weakness. They appeared to want activities and lessons which linked directly to particular standards. PSTs wanted the website to include a variety of resources pertaining to multi-age groups with specific content standards and mathematical practices. They also wanted lessons to be differentiated by ability level. Overall, they wanted to find resources that would be easy to implement in their classroom without having to make any changes.

4.3 Findings from Lesson Plans

The same pre-service teachers were required to write lessons plans with the use of additional resources. Findings from the PSTs 40 unit plans and approximately 5-10 lesson plans within each unit were summarized using the Substitution Augmentation Modification Redefinition (SAMR) Model (Puentedura, 2014). While TPACK offers a framework for the integration of technology throughout the curriculum, the SAMR model offers a lens into how the websites PSTs chose might impact teaching and learning. It also creates a progression that adopters of educational technology often follow as they progress through teaching and learning with technology. Table 4 provides a definition of each element of the SAMR model with examples using Desmos (an online graphic/scientific calculator).

	SAMR Model	Description of SAMR Components	Pre-service Teachers' Use of Websites (Example with Desmos)	Number of PSTs at various levels.
Enhancement	**S**ubstitution	Website is used to perform the same task as was done before the use of computers.	Instead of using a hand-held calculator, PSTs used Desmos.	8
	Augmentation	Website offers an effective tool to perform common tasks.	PSTs import images to examine how functions are used in real life or are able to examine transformations with the graphic calculator.	24
Transformation	**M**odifications	Websites allows for significant task redesign.	PSTs utilize activities created by Desmos to develop conceptually rich mathematics content that enable students to communicate with each other.	16
	Redefinitions	Website allows for the creation of new tasks; previously inconceivable.	PSTs created their own activity in the activity builder option of Desmos.	3

Table 4 SAMR model developed by Puentedura (2014).

Eight PST's used websites as a substitute for textbooks. They downloaded an activity or task and used the resource with very few deviations from the websites' instructions. As they taught a lesson, PSTs simply gave instructions that were on the page. In their unit reflections, PSTs remarked that they "wanted to try something a little different." Five of the eight students wanted to make the classroom either "fun" or to "change the pace." The website, YummyMath (http://www.yummymath.com), was cited as a source of "real life" mathematics, where students used the pdf format without any modification.

Twenty-four PSTs used features of the website that would encourage more meaningful mathematics. As one PST suggested in her reflection on her unit, "I used this website in the lesson to make it more conceptual in nature for her my students." Although these students substituted websites for their textbooks, they used the website features to enhance the topic. For example, in teaching function transformations, students imported images of objects in GeoGebra (http://www.geogebra.org) and found that they could create a function by locating points along the image. In this manner, the students were relating the graphs to real world objects. The use of NCTM's Illuminations (https://illuminations.nctm.org/) interactives was a source that many PSTs used to help students develop concepts through games. PSTs' attempts to enhance textbook lessons through modifications were based on their desire to make math less abstract and more meaningful for their students. They often used activities from *Illuminations* or *Illustrative Mathematics* (http://www.illustrativemathematics.org) for sources of tasks but changed them to meet the needs of students. For example, one PST described her use of the Illustrative Mathematics website, "I like the website for its demanding tasks, but I have to differentiate. So, I use the website for problems but then I have to 'translate' the problem for some students."

PSTs (n=14) often used features of websites for inspiration to modify lesson activities, since their high school placements did not have textbooks or used texts that were highly procedural in nature. Many of these PSTs used websites to "make the class more interesting." The conceptual understanding of how students perceived the relevance of a website, was secondary for these PSTs. Students within this category often examined the topic they were teaching and the materials available to them from their cooperating teacher. They then sought websites that would take the lesson in different directions. For example, three PSTs used the teachingchannel.org site to find ideas on teaching linear equations. Once they found a video that explained the topic in an engaging way, they adapted the ideas to their own circumstance. One PST had students creating a coordinate

plane in their room with students representing individual points on the plane while others used large posters to graph points in groups. Their modifications not only made the class more enjoyable, but they also found that these websites gave them opportunities to informally assess student understanding in ways that their textbook could not. For example, when students physically became points on a line (an idea from http://www.teachingchannel.org), one of the PSTs noticed which parts of the linear equation students attended to first.

Only a few students (n=3) used websites to generate learning that was conceptually rich while using website tools such as Desmos (http://www.desmos.com) or GeoGebra. At this level, common classroom tasks and websites existed not as ends but as supports for student-centered learning. For example, one PST shared a Desmos demonstration of how pi evolved as described by Archimedes. According to the three PSTs who created classroom materials using interactive websites, questions and discussion were increasingly student generated.

5 CONCLUSION AND IMPLICATIONS

It is important for pre-service teachers to understand the relationships among technology, pedagogy, and mathematics in order to use technology to enhance their teaching and learning (Hechter, Phyfe & Vermette, 2012). Unfortunately, many pre-service teachers may not feel comfortable using technology in their practice (Chien, Chang, Yeh, & Chang, 2012; Niess, 2006). This may be due to multiple reasons; for example, teachers may not have learned the content in this way, they may be new to the technology, or may understand how to use it but not how to apply its use to specific teaching methods.

Pre-service teachers must be "challenged to reconsider their subject matter content and the impact of technology on the development of that subject itself" (Niess, 2006, p. 511). During their undergraduate courses, pre-service teachers may see what is learned in class as separate and may need assistance in making connections to future application. For example, students may learn how to navigate and use tools for a website but may not see how they can integrate this into their lesson planning without specifically being told or given explicit examples.

Therefore, it is important to prepare pre-service teachers how to use websites by providing guidance in the implementation of materials addressed in class and not simply share websites as resources. Demonstrating technology integration (i.e. TPACK) can help pre-service teachers focus on how to incorporate other resources they may find into their planning.

This study complements prior K-12 website research on teaching and learning by focusing on pre-service teachers and their use of websites in secondary and middle school level classrooms. While most of the websites pre-service teachers used in this study may not be for their own education as mathematics teachers, by examining data in light of two models (TPACK and SAMR), findings suggest that websites can assist pre-service teachers in many ways, e.g. evaluation tools for the quality web resources, analytic tools to review how technology is used in the classroom. Although prospective teachers have yet to develop the kind of experience needed to create lessons which meet their individual and students' needs, the teacher education program can promote pre-service teacher recognition of potential websites and provide alternatives to their textbooks for teaching and learning mathematics. Teachers need to think about the content, pedagogy, and technology at the same time to influence the design of their curriculum. When teachers integrate technology at the modification or re-definition level of the SAMR model, they are implementing TPACK in a transformative way.

The analysis and adaptations of lessons from websites provides opportunities to help pre-service teachers consider the strengths and weaknesses of particular materials from mathematical, curricular, and pedagogical perspectives. Assignments asking students to critique the strengths and weakness of particular websites may provide opportunities for teacher educators to gain an understanding of what pre-service teachers find important and how to engage students mathematically through their selection of tasks (Crespo, 2003; Nicol, 1999).

This study may also provide insight into considering pre-service teachers needs when it comes to curriculum materials. Using websites as reference materials to learn mathematical concepts and standards may be problematic as websites often do not provide conceptual understandings that underlie many of the mathematical principles pre-service teachers are expected to teach. Learning to teach from websites, although they may provide some significant mathematical principles, can also perpetuate reliance on worksheets and procedural style of teaching. PSTs need to be encouraged to examine the validity of the websites they chose to use. This background information may provide support for beginning mathematics teachers' investigations by providing discussion of the important conceptual ideas that are embedded in tasks or activities. The use of websites can offer opportunities for pre-service learning, but PSTs may need support to foster learning that will carry them through their practicum and into their beginning practice.

REFERENCES

Chien, Y. T., Chang, C. Y., Yeh, T. K., & Chang, K. E. (2012) Engaging pre-service science teachers to act as active designers of technology integration: A MAGDAIRE framework, *Teaching & Teacher Education,* **28**, 578–588.

Common Core State Standards Initiative (CCSS) (2010) About the standards. Retrieved from http://www.corestandards.org/about-the-standards.

Corbin, J., & Strauss, A. (1990) Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology,* **13**(1), 3-21.

Crespo, S. (2003) Learning to pose mathematical problems: Exploring changes in preservice teachers' practice, *Educational Studies in Mathematics,* **52**, 243–270.

Cummings, M. (2015) Why is this marketplace for teachers to sell their lesson plans thriving? *Slate.* Retrieved from http://www.slate.com/blogs/schooled/2015/06/03/teachers_pay_teachers_why_the_site_for_teachers_to_sell_their_lesson_plans.html.

Endsley, R. (2017) What is open education?: Open source resources. Retrieved from https://opensource.com/resources/what-open-education.

EQuIP (2017) EQuIP rubric for lessons and units: Mathematics. Retrieved from https://www.achieve.org/our-initiatives/equip/rubrics-and-feedback-forms.

Frederick, J. (2017) Million dollar teachers: Selling lessons online, *The Associated Press.* Retrieved from https://www.youtube.com/watch?v=aXSVEVy-ZEs.

Hakvedi-Can, M., & Dana, T. M. (2012) Exemplary science teachers' use of technology, *The Turkish Online Journal of Educational Technology,* **11**(1), 94-112.

Handal, B., Campbell, C., Cavanagh, M., Petocz, P., & Kelly, N. (2013) Technological pedagogical content knowledge of secondary mathematics teachers. Retrieved from http://www.citejournal.org/volume-13/issue-1-13/mathematics/technological-pedagogical-content-knowledge-of-secondary-mathematics-teachers

Hechter, R. P., Phyfe, D. L., Vermette, L. A. (2012) Integrating technology in education: Moving the TPCK framework towards practical applications, *Education Research and Perspectives: An International Journal,* **39**, 136-152. Retrieved from http://erpjournal.net/wp-content/uploads/2012/10/ERP-Submission-Sept-26.pdf

Internet World Stats (2017). Retrieved from http://www.internetworldstats.com/stats.htm

International Society for Technology in Education (ISTE) (2017) ISTE standard for educators. Retrieved December 22, 2017, from https://www.iste.org/standards/for-educators

Koehler, M. J (2012) TPCK Explained. Retrieved from http://tpack.org

Lappan, G., & Briars, D. (1995) How should mathematics be taught? In I. Carl (Ed.), *Prospects for school mathematics*, Reston, VA: National Council of Teachers of Mathematics.

Lincoln, Y.S., & Guba, E. G. (1984) *Naturalist Inquiry.* Beverly Hills: SAGE Publications.

McMillan, J. H., & Schumacher, S. (2001) *Research in education: A conceptual introduction* (5th Ed.), New York: Longman.

Mishra, P., & Koehler, M. J. (2006) Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record,* **108**(6), 1017-1054.

National Research Council (NRC). (2001) *Adding it up: Helping children learn mathematics,* J Kilpatrick, J. Swafford, and B. Findell (Eds.), Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

National Council of Teachers of Mathematics (NCTM) (2010) *Principles and standards for school mathematics*, Reston, VA: Author. Niess, M. L. (2006), Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education,* ***21***, 509-523.

Nicol, C. (1999) Learning to teach mathematics: Questioning, listening, and responding. *Educational Studies in Mathematics, 37*, 45–66.

Özgün-Koca, S., Meagher, M., & Edwards, M. (2010) Preservice Teachers' Emerging TPACK in a Technology-Rich Methods Class, *The Mathematics Educator,* **19**(2).

Puentedura, R. R. (2014), SAMR and TPCK: A Hands-On Approach to Classroom Practice, Presentation slides presented at the 1C Learning Conference, Hong Kong. Retrieved from http://www.hippasus.com/rrpweblog/archives/2014/12/11/SAMRandTPCK_HandsOnApproachClassroomPractice.pdf

UNESCO (2003) Internet in educational materials: Support materials for educators, UNESCO institute for information technologies in education. Retrieved from http://iite.unesco.org/pics/publications/en/files/3214612.pdf.

U.S. Department of Education (2016) U.S. department of education recognizes 14 states and 40 districts committing to #goopen with educational resources, Retrieved from https://www.ed.gov/news/press-releases/us-department-education-recognizes-13-states-and-40-districts-committing-goopen-educational-resources.

Walthausen, A. (2016) How the internet is complicating the art of teaching, *The Atlantic Monthly Group.* Retrieved from https://www.theatlantic.com/education/archive/2016/10/how-the-internet-is-complicating-the-art-of-teaching/505370/

BIOGRAPHIPCAL NOTES

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APPENDIX A

Default Report

Websites Preservice Math Teachers Use

May 22nd 2018, 7:49 pm EDT

Survey - The Websites Math Teachers Choose to Use

This study involves an online survey designed to understand what websites you used while in your student teaching and/or in your current teaching position. No deception is involved, and the study involves no more than minimal risk to participants (i.e., the level of risk encountered in daily life). Participation in the study typically takes 10-15 minutes and is strictly anonymous. Participants begin by answering a series of questions and provide reasons for their choices. All responses are treated as confidential, and in no case will responses from individual participants be identified. Rather, all data will be pooled and published in aggregate form only. The purpose of this study is to not only better prepare future teachers by providing web resources that are helpful to beginning teachers, but also to understand reasons for your selection. Participation is voluntary, refusal to take part in the study involves no penalty or loss of benefits to which participants are otherwise entitled, and participants may withdraw from the study at any time without penalty or loss of benefits to which they are otherwise entitled. If you consent to participate in the study, click on the "I Agree" button to begin the survey.

#	Answer	%	Count
1	I agree	100.00%	51
2	I do not agree	0.00%	0
	Total	100%	51

Q1#1 Given the opportunity, what websites did you use during your student teaching or current teaching experience? & Select all that apply & Please add any more that you may have used. - Did you use this website?

#	Question	Yes		No		Total
1	NCTM Illuminations	45.45%	15	54.55%	18	33
2	Mathematics Assessment Project (MARS)	40.00%	14	60.00%	21	35
3	The Common Core Standards Website	97.37%	37	2.63%	1	38
4	The Ohio Department of Education Website	84.62%	33	15.38%	6	39
5	Yummy Math	23.53%	8	76.47%	26	34
6	Math Snacks	23.53%	8	76.47%	26	34
7	Mathbits--Regents Prep	6.06%	2	93.94%	31	33
9	Pinterest	60.00%	21	40.00%	14	35
10	National Library of Virtual Manipulatives	18.18%	6	81.82%	27	33
11	PurpleMath	68.57%	24	31.43%	11	35
12	Khan Academy	89.19%	33	10.81%	4	37

13	IXL	15.63%	5	84.38%	27	32
14	Illustrative Mathematics	65.71%	23	34.29%	12	35
15	Inside Mathematics	11.76%	4	88.24%	30	34
16	PBS Annenberg	3.03%	1	96.97%	32	33
17	GeoGebra or Desmos	68.57%	24	31.43%	11	35
8	Other (type resource here): Matholicious, Kahoot	11.11%	1	88.89%	8	9

Q1#2 Given the opportunity, what websites did you use during your student teaching or current teaching experience? Select all that apply. Please add any more that you may have used. - If yes, how often?

#	Question	1-5 times		6-10 times		More than 10 times		Total
1	NCTM Illuminations	80.00%	12	13.33%	2	6.67%	1	15
2	Mathematics Assessment Project (MARS)	78.57%	11	14.29%	2	7.14%	1	14
3	The Common Core Standards Website	36.11%	13	16.67%	6	47.22%	17	36
4	The Ohio Department of Education Website	37.50%	12	21.88%	7	40.63%	13	32
5	Yummy Math	66.67%	6	0.00%	0	33.33%	3	9
6	Math Snacks	75.00%	6	12.50%	1	12.50%	1	8
7	Mathbits--Regents Prep	100.00%	2	0.00%	0	0.00%	0	2
9	Pinterest	40.00%	8	10.00%	2	50.00%	10	20
10	National Library of Virtual Manipulatives	66.67%	4	16.67%	1	16.67%	1	6
11	PurpleMath	66.67%	16	20.83%	5	12.50%	3	24
12	Khan Academy	41.94%	13	29.03%	9	29.03%	9	31
13	IXL	40.00%	2	0.00%	0	60.00%	3	5
14	Illustrative Mathematics	38.10%	8	42.86%	9	19.05%	4	21
15	Inside Mathematics	100.00%	3	0.00%	0	0.00%	0	3
16	PBS Annenberg	100.00%	1	0.00%	0	0.00%	0	1
17	Geogebra or Desmos	26.09%	6	30.43%	7	43.48%	10	23
8	Other (type resource here): Matholicious, Kahoot	33.33%	1	33.33%	1	33.33%	1	3

Q2#1 Websites that require payment - Response

#	Answer	%	Count
1	Yes	15.38%	6
2	No	84.62%	33
	Total	100%	39

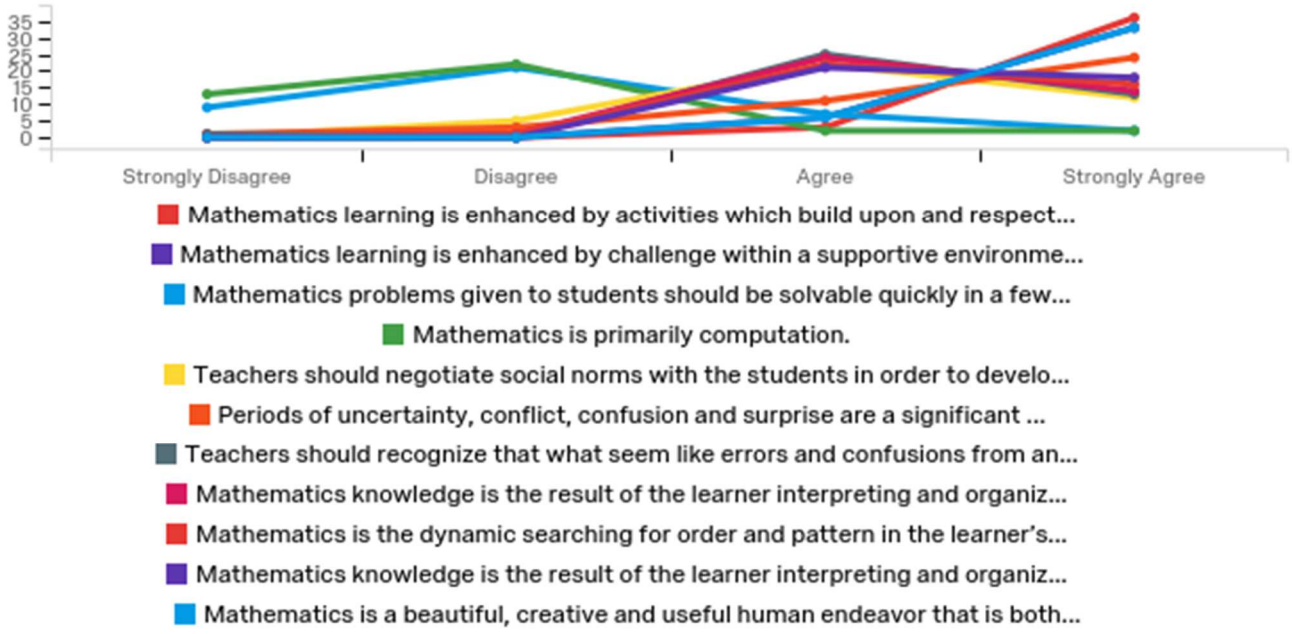
Q2#2 Websites that require payment - Approximately how much did you spend on these resources in total?

#	Answer	%	Count
1	$0	40.00%	4
2	$1-$5	20.00%	2
3	$6-$10	0.00%	0
4	$11-$15	0.00%	0
5	$16 or more	40.00%	4
	Total	100%	10

Q3 Why did you use websites during your student teaching or teaching? Select all that apply.

#	Answer	%	Count
1	For lesson plans (outside resources only)	34.02%	33
2	For use with the textbook	8.25%	8
3	For assessment (Kahoot)	15.46%	15
4	For use with classroom management such as attendance and/or grades	7.22%	7
6	For activities	32.99%	32
5	Other Uses: help with remembering/ explaining, for classwork	2.06%	2
	Total	100%	97

Q4: Beliefs of Mathematics Teaching and Learning: Please Indicate your belief on the following items: (Strongly Disagree to Strongly Agree)



APPENDIX B
Website Evaluation Assignment:

For each of the following websites please summarize the website, identify its strengths, weaknesses, and how you will use the website. Strengths and Weaknesses are based on Mathematics Proficiency strands.

- National Council of Teachers of Mathematics http://illuminations.nctm.org/
- Ohio's Learning Standards in Mathematics http://education.ohio.gov/Topics/Ohios-Learning-Standards/Mathematics
- Mathematics Assessment Project http://map.mathshell.org
- Common Core Math Standards http://www.corestandards.org/Math/
- Math Snacks http://mathsnacks.com/
- Yummy Math www.yummymath.com
- Pinterest https://www.pinterest.com
- National Library of Virtual Manipulatives http://nlvm.usu.edu/en/nav/vlibrary.html
- Purple Math http://www.purplemath.com
- Kahn Academy https://www.khanacademy.org
- IXL https://www.ixl.com
- Illustrative Mathematics https://www.illustrativemathematics.org
- Inside Mathematics https://www.insidemathematics.org
- PBS Annenberg https://www.learner.org
- Geogebra https://www.geogebra.org