Utilizing Video Resources in Undergraduate Mathematics Classes: A Systematic Review Research Synthesis

Catherine Dennis
University of New Hampshire

The increased use of educational technology has raised questions about technology equity in mathematics education research and pedagogy. This paper provides a subset of findings from a larger systematic review, which aims to investigate literature on equity and personal device use in undergraduate mathematics courses from 2009-2023. For the systematic review, literature was searched and screened for information on personal device access, utilization, and outcomes. This paper reports on the subset of findings specific to the utilization of video resources in mathematics classes. Through the synthesis process variable information regarding student outcomes and student perceptions of use was pulled from 82 studies. Findings suggest that the use of video resources correlates to either higher academic outcomes or no difference in academic outcomes. Additionally, student perceptions suggest that video resources can afford an equitable educational experience in a variety of ways, but elements of distraction and communication can serve as limitations.

Keywords: research synthesis, personal devices, video resources, technology

Technology use in the teaching and learning experience has become more ubiquitous since the turn of the century (Meehan & Halmun, 2016), especially in the form of utilizing personal devices, such as laptops, tablets, or smartphones (Galanek et al., 2018). Mathematics education scholars have raised questions about the implications of personal device use in terms of equitable education. To investigate the research on equity and technology in the literature Hennesey & Dunham (2008) published a research synthesis, *Equity and use of Educational Technology in Mathematics.* The results suggested individual students' access to technological devices varied by household and utilization proficiencies differed by identity traits, such as gender. Hennessy and Dunham concluded that a variety of factors are intertwined into answering questions involving equity and device use, including levels of access and how the technology is being integrated into the mathematics curriculum.

Since the publication of Hennessy and Dunham's 2008 research synthesis technology use in the classroom has undoubtably changed over time. For example, during the early 2000s home and school technology access was limited (Swain & Pearson, 2002). However, personal devices have become more commonplace in society at large over the last two decades. A new population of students, known as *digital natives*, are now navigating higher education with a variety of life experiences involving technology (Filippi & Agarwal, 2017; Galanek et al., 2018). This shift in the undergraduate population, as well as the gap in time since the last research synthesis, motivated a large systematic review project analyzing more recent literature on personal device access, utilization, and outcomes for undergraduate mathematics students. The results for this paper focus on a subset of the systematic review results, utilization of mathematics video resources on personal devices. Utilization is synthesized in terms of both student perceptions of the video resources and the relationship to student outcomes.

Framework

Fennema's (1990) equity framework, accommodated by Hennessy & Dunham (2008) for technology-specific research, was used in this review. This framework navigates literature on equity and technology in mathematics with three lenses: access, utilization, and outcomes. The access component explores mathematics students' access to personal devices and the affordances and barrier that may exist around device access. Personal device utilization encompasses the differing uses of personal devices and their affordances and limitations in mathematics. The multitude of resources available through personal devices have the potential to accommodate a variety of students' learning needs, which is necessary for equitable education (Tan et al., 2019). Student outcomes can also be used as measurable data for statistical analyses in research. This review addressed outcomes in terms of improved learning outcomes and retention rates, both of which are important for investigating equity in education. This paper reports findings using the utilization and outcome portions of the framework.

Research Question

1) In the literature since 2009, what are the results surrounding undergraduate mathematics students' video resource utilization in terms of student perceptions and outcomes?

Methodology

There are four steps in the systematic review methodology: searching, screening, extracting the data, and synthesis & analysis. In order to search and screen the literature inclusion and exclusion criteria must first be created.

Inclusion/Exclusion Criteria

Literature inclusion and exclusion criteria were established through the SPIDER framework (Cooke et al., 2012), which comprises the following elements.

Sample. The sample of interest within the literature is undergraduate students using personal devices in mathematics courses.

Phenomenon of interest. The phenomenon of interest is student access and utilization of personal devices in undergraduate mathematics courses. Personal devices in this review include tablets, computers, and smartphones. Research on calculators is beyond the scope of this review.

Design. This review incorporates qualitative, quantitative, and mixed methods studies through content analysis and Miles & Hubermann's (1994) synthesis methodologies.

Evaluation. Studies were first reviewed to establish the variables for evaluation within access, utilization, and assessment. For the systematic review the access variable was used to evaluate levels of access and barriers to access. Utilization was evaluated in terms of the type of personal device utilization, student perceptions on the device utilization, and the relationship to student outcomes in undergraduate mathematics courses. Outcomes involved both student learning outcomes and retention rates.

Research type. This review included empirical research with quantitative, qualitative, or mixed methods methodologies. Peer reviewed literature and grey literature (dissertations, conference proceedings, etc.) were included and found through the search and snowballing process.

Searching

The goal of the searching process was to find literature involving undergraduate mathematics students' personal device access, utilization, and outcomes. Literature published between 2009-

2023 was searched, to prepare an updated synthesis since Hennessy & Dunham's 2008 publication. ERIC (EBSCO Host), Education Source (EBSCO Host), and The International Journal of STEM Education and PRIMUS, through the University of New Hampshire PRIMO system, were searched to find the 27 foundational studies before snowballing, otherwise known as the start set. The searching methods included Boolean operators with synonyms found either on the ERIC thesaurus or through discussions with colleagues. The search string included four sections, (personal devices) AND (mathematics education) AND (equity) AND (undergraduate students). Each section included a list of synonyms for search terms, separated by OR to find a greater variety of literature.

Screening

Two types of screening were completed for this systematic review: title/abstract screening and full text screening. Studies found through the search terms and systems previously mentioned were screened using the SPIDER framework's inclusion/exclusion criteria. Three rounds of snowballing (forward and backwards) were completed on the 27 foundational studies to find additional literature for inclusion in the systematic review. Through the screening of 17,196 studies, a total of 357 were found to meet all inclusion criteria and were synthesized in the systematic review. The 27 foundational studies in the start set were then reviewed to establish how the literature discusses access, utilization, and outcomes to establish synthesis variables for extraction. For example, studies discussed resources utilization in terms of who assigned or chose the utilization (teacher vs. student choice) and student perceptions of the utilization. Therefore, utilization variables included sub-variables for data extraction of "assigned vs. choice" and a "student perception".

Data Extraction

After establishing the variables of interest within access, utilization, and outcomes, data was extracted from each study using data extraction forms (Briner & Denyer, 2012). Variable data and general literature data, such as country and methodology of research, were extracted to supply some background information on the included studies.

Data Synthesis and Analysis

Synthesizing literature is a process of aggregating the results of multiple studies to establish new knowledge about a phenomenon of interest in the field (Campbell et al., 2003; Denyer & Tranfield, 2009). Literature was first synthesized in this review by looking for common themes or results amongst the data extraction forms. It was then analyzed through cross case data analysis methods and content analysis.

The Miles and Huberman methods involve coding results and establish themes amongst those codes (Dixon-Woods et al., 2004; Miles & Huberman, 1994). This process was used when aggregating and synthesizing results surrounding student perceptions of video utilization. For example, some student perception codes included "Flexibility, mobility, can learn anywhere, helpful for pacing learning, can pause videos, can rewind videos, and can split into smaller learning chunks". Codes were grouped together into the theme "Flexibility and Pacing for Learning". Content analyses were also conducted to count frequences of variable information occurrences amongst the results of each study (White & Marsh, 2006).

Results

Of the 357 studies synthesized for the systematic review project 86 use qualitative methods, 144 used quantitative methods, and 127 used mixed methods. Additionally, studies were conducted in 52 different countries. Through synthesizing and analyzing the studies for this review, six major categories of utilization were found amongst the literature: online learning modality, the flipped classroom, video resources, online homework/practice problems, communication, and additional tool interventions. Please note the results reported in this paper are a subset of the larger results and focus only on the utilization of video resources.

Utilization Perceptions & Outcomes of Video Resources

This section reports results surrounding video resources, from 82 studies, in terms of both student perceptions and student outcomes. Video resources include videos made by the instructor, class recordings, and supplemental videos, such as YouTube or Kahn Academy.

Student perceptions. Student perceptions on the utilization of video resources with personal devices were investigated in 75 studies. Table 1 outlines the different student perceptions and the larger themes that they fit into (underlined). Frequency counts through a content analysis were taken in order to display how many studies reported a given perception, affordance, or limitation. While some studies reported a general liking or positive perception for video resources, counted in the positive perception frequency count, others went further detail about the elements of video resources that students found useful or limiting. A perception, affordance, or limitation was included in the table if it appeared in at least two studies.

Table 1. Student Perceptions of Video Resources

Theme Subcategory/Perception	Study Frequency
Affordances or Positive Perceptions	75
Flexibility and Pacing for Learning	25
Flexibility or Mobility	10
Helpful for Pacing Learning	10
Pausing & Rewinding Features Useful	11
Can Split into Smaller Learning Chunks	3
Modes of Representation and Engagement	8
Visual Aids in Videos	7
Multiple Modes of Representation & Engagement	3
Supplemental Learning	16
Improved Confidence on Prerequisite Knowledge/Closed Learning Gaps	6
Students Found Supplemental Videos Useful	9
Makes Math More Enjoyable	3
Limitations or Negative Perceptions	7
Need for More Communication with Instructor or Other Students	5
Distraction or Lack of Motivation Using Technology	2

Throughout the literature undergraduate students reported both positive and negative perceptions for using video resources for learning mathematics. Positive perceptions include themes of self-pacing and learning flexibility, videos providing multiple forms of representation and engagement for learning, videos affording additional supplements for learning, and videos making mathematics more enjoyable. Negative perceptions included students wanting more direct communication with peers and instructors for collaborative learning and a general lack of motivation or distraction using personal devices to watch mathematics videos.

Student learning outcomes and retention. Student learning outcomes for the systematic review were assessed in one of three ways: better outcomes with device use, no difference in outcomes, or better outcomes with control group (no device use or less frequent device use). Also note that the assessment to measure learning outcomes varied by study. For instance, some used exam scores, while others used final grades. In the review 22 studies investigated video resources and learning outcomes. Some compared video resource use to no resource use, while others looked at frequency of use. Figure 1 shows the frequency of study results in terms of the three possible outcomes.

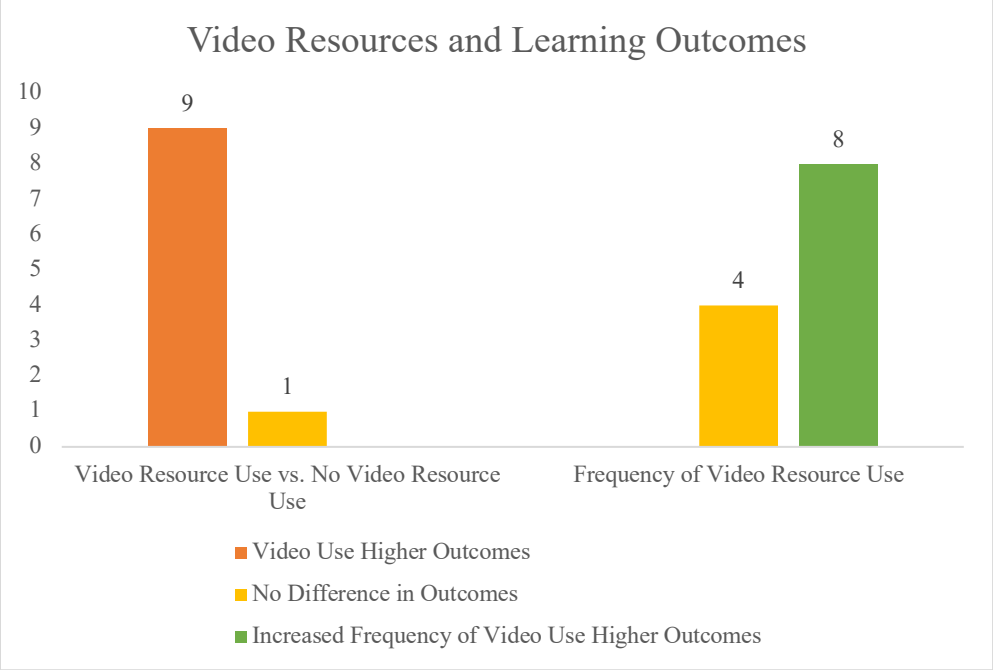

Figure 1. Video Resources and Learning Outcomes Results Amongst Studies

In the studies examined, the results suggested that groups who utilized video resources either had higher academic outcomes or no difference in academic outcomes compared to the control groups. The same was true when comparing the higher frequency use group to the lower frequency use group. Only one study reported on retention rates in relationship to video resource use and suggested that video resource use was related to higher retention rates than the control group, implying that students were more likely to drop out of the course if there were no video resources available for learning in the course.

Discussion

Systematic reviews can afford both scholars and educators a better idea of the existing knowledge within the field and assist with future research and pedagogical choices (Briner & Denyer, 2012). This section will provide an overview of the findings from this part of the larger systematic review, how they may impact the field of mathematics education, and the limitations to the study.

The literature in the systematic review was from 52 countries around the world, suggesting it is an area of interest for scholars at a global level. Additionally, all three empirical methodologies were used amongst the literature: qualitative, quantitative, and mixed methods. These multiple methodologies afforded a variety of data types for synthesis and analysis and suggest there is no one way to investigate personal device use in undergraduate mathematics courses.

Video Resource Utilization

While six categories of utilization were established in the systematic review project, this paper only focused on personal device utilization for video resources. In terms of student perceptions there were more papers reporting positive perceptions or affordances than negative perceptions or limitations. According to the literature, students found video resources useful for flexible, paced learning practices, multiple modes of representation and engagement, such as visual aids, and closing learning gaps. In turn, student participants in the literature reported feeling easily distracted while using personal devices and wished for more live communication with others while learning, which the videos could not provide. Learning outcomes were either higher with video resource interventions or there was no significant difference. These findings are significant for educators when deciding what resources to provide or encourage students to utilize in mathematics learning. Students may be more likely to utilize video resources than others because of the positive perceptions and ability to pace for student agency over learning. The research suggests video resources do not hinder learning outcomes and may even improve them. Additionally, student participants reported many video resource affordances that align with equitable educational practices. The affordance of multiple modes of representation and engagement is beneficial for diverse learning needs, which supports equitable learning practices (Tan et al., 2019). The process of closing learning gaps, reported by students in multiple studies, is equitable because it provides the ability for students to achieve a similar starting line. Students found videos to be beneficial for self-pacing and splitting into smaller learning chunks as well. These student-made learning decisions can promote learner autonomy, a skill known to be necessary for undergraduate learning and career development (Caprara et al., 2008; Zimmerman, 2008).

Given these findings amongst studies, educators may want to include video resources for their mathematics students. By providing supplemental resources that students generally enjoy utilizing, and find useful for learning, pacing, and multiple modes of representation, students may be able to learn mathematics in a more equitable, inclusive way. Furthermore, the review found either no change or improves academic outcomes with video resource use, suggesting that video utilization has the potential to improve mathematical learning. However, the synthesized findings indicate some cautionary measures should be taken, such as still maintaining educator-student communication and being aware of the potential for distraction while on a personal device. Educators may be able to accommodate students' communication needs by opening new avenues for inquiry, such as a discussion board, to assist with questions or concerns that may

arise while watching videos. Additional research can be done to further investigate how to address elements of distraction and focus with personal device use as well.

Limitations

Synthesizing data from studies with multiple methodologies can be difficult in a systematic review (Mays et al., 2001). While the techniques for data synthesis and analysis in this study afforded the ability to aggregate qualitative, quantitative, and mixed methods data, the analysis is not as robust as more rigorous statistical methods, such as meta-analysis. Hence, assumptions made from the findings should be made with caution. The methodology for searching in a systematic review is used to find the most literature possible on a given topic or phenomenon. The process of snowballing was used to find a large variety of research findings and grey literature, but note it is not possible to complete a fully exhaustive search, so other studies on this topic may still exist outside of this review.

Conclusion

This paper includes a subset of findings from a larger systematic review project on personal device use in undergraduate mathematics classes. Literature was searched and screened for evidence of findings involving the three elements of Fennema's (1990) equity framework: access, utilization, and outcomes. Through review synthesis and analysis, results regarding personal device video resource utilization student perceptions and video resource outcomes were discussed. Video resources were utilized in 82 studies, with results regarding both student perceptions and student outcomes. Students reported affordances involving equitable benefits, such as multiple modes of representation, self-pacing, and closed learning gaps. However, students also reported negative perceptions involving elements of distraction and lack of communication. Student learning outcomes were either improved with video resources or no difference was found.

This review is beneficial for both research and pedagogy. Scholars can use the information to further investigate ways to improve upon the limitations reported and find elements of video use that are most beneficial to learning. Educators can use this review to inform decisions around personal device access and utilization within the classroom. The findings suggest a general student liking and perception of usefulness, as well as unchanging or improved academic outcomes. Therefore, providing video resources for student use may be beneficial to both student enjoyment of mathematics courses, as well as mathematical understanding. However, educators should take caution with providing meaningful communication outside of video use, and the potential for distraction.

Acknowledgments

Thank you to Dr. Sheree Sharpe and Dr. Karen Graham for your continued support and assistance with this research project.

References

Briner, R., & Denyer, D. (2012). Systematic Review and Evidence Synthesis as a Practice and Scholarship Tool. In *Handbook of evidence-based management: Companies, classrooms and research* (pp. 112–129). https://doi.org/10.1093/oxfordhb/9780199763986.013.0007

Campbell, R., Pound, P., Pope, C., Britten, N., Pill, R., Morgan, M. and Donovan, J. (2003) Evaluating meta-ethnography: a synthesis of qualitative research on lay experiences of diabetes and diabetes care. Social Science and Medicine 56: 671-84.

Caprara, G. V., Fida, R., Vecchione, M., Del Bove, G., Vecchio, G. M., Barbaranelli, C., & Bandura, A. (2008). Longitudinal analysis of the role of perceived self-efficacy for self-regulated learning in academic continuance and achievement. *Journal of educational psychology*, *100*(3), 525.

Cooke, A., Smith, D., & Booth, A. (2012). Beyond PICO: the SPIDER tool for qualitative evidence synthesis. *Qualitative health research*, *22*(10), 1435-1443.

Denyer, D., & Tranfield, D. (2009). Producing a systematic review. In *The Sage handbook of organizational research methods* (pp. 671–689). Sage Publications Ltd.

Dixon-Woods, M., Agarwal, S., Young, B., Jones, D., & Sutton, A. (2004). *Integrative Approaches to Qualitative and Quantitative Evidence*.

Fennema, E. (1990). Justice, equity, and mathematics education. *Mathematics and gender*, 1-9.

Galanek, J. D., Gierdowski, D. C., & Brooks, D. C. (2018). *ECAR study of undergraduate students and information technology* (Vol. 12). 2018.

Hennessy, S. & Dunham, P. (2008). Equity and use of educational technology in mathematics. *Research on Technology and the Teaching and Learning of Mathematics: Cases and perspectives, 1,* 345-418.

Mays, N., Roberts, E. and Popay, J. (2001) Synthesising research evidence. In: Fulop, N., Allen, P., Clarke, A. and Black, N. (eds). Studying the organization and delivery of health services. London: Routledge.

Meehan, K. C., & Salmun, H. (2016). Integrating technology in today's undergraduate classrooms: A look at students' perspectives. *Journal of College Science Teaching*, *46*(1), 39–47. http://www.jstor.org/stable/24892411

Miles, M.B. and Huberman, M. (1994) Qualitative data analysis: an expanded sourcebook. London: Sage.

Swain, C., & Pearson, T. (2002). Educators and technology standards: Influencing the digital divide. *Journal of Research on Technology in education*, *34*(3), 326-335.

Tan, P., Padilla, A., Mason, E. N., & Sheldon, J. (2019). *Humanizing Disability in Mathematics Education: Forging New Paths*. Reston VA, USA: The National Council of Teachers of Mathematics, Inc.. Retrieved May 5, 2023, from https://pubs.nctm.org/view/book/9781680540253/9781680540253.xml

White, M. D., & Marsh, E. E. (2006). Content Analysis: A Flexible Methodology. *Library Trends*, *55*(1), 22–45. https://doi.org/10.1353/lib.2006.0053

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American educational research journal*, *45*(1), 166-183.