REVIEWING THE LITERATURE ON FLIPPED MATHEMATICS INSTRUCTION: A QUALITATIVE META-ANALYSIS

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Flipped instruction is often viewed in relation to what is done outside of class (e.g., watching instructional videos) but it is also important to attend to what happens in class. Flipped instruction also has similarities to inverted or blended learning, but "flipping" terminology has garnered enough traction in practice and research as a contemporary phenomenon that it is worthwhile examining it on its own terms. In this research brief, we presented an overview of some initial findings from an ongoing meta-analysis of literature on flipped mathematics instruction. Understanding the research methods previously used to study flipped instruction and the contexts in which those methods were used, will provide future researchers and practitioners with a greater understanding of the impact of flipped instruction on the teaching and learning of mathematics at all levels.

Keywords: Technology; Instructional Activities and Practices; Curriculum Enactment; Research Methods.

Introduction

With the rise of YouTube and other video platforms, flipped instruction—also called "flipped learning" or "flipped classrooms," defined by videos or other multimedia assigned as homework rather than skill practice or problem set homework—has become more prevalent over the past decade (Smith, 2014; Talbert,2018). It has been implemented most often in mathematics and science, especially at the post-secondary levels (Uzunboylu & Karagozlu, 2015). But even in K12 schools, more than 10% of teachers report flipping mathematics lessons at least once a week (Banilower et al., 2018).

As an innovation, flipped mathematics instruction has been predominantly teacher driven, with individual teachers deciding to try it as a way to, for example, accommodate students who miss class or have difficulty following a live lecture and to free up more time in class for active student work (de Araujo, Otten, & Birichi, 2017). Practical implementations, therefore, were outpacing research until recently when a surge of empirical studies on flipped instruction began (Talbert, 2018). The emerging literature, however, encompasses studies with different foci in terms of the outcomes of interest, from student attendance (Asarta & Schmidt, 2015) to their attitude and engagement (Clark, 2015) to measures of content learning (Ichinose & Clinkenbeard, 2017). Even studies that focus on similar outcomes have produced potentially conflicting results. For example, Clark (2015) had positive findings in favor of flipped mathematics instruction but De Santis and colleagues (2015) had neutral-to-negative findings.

Because of the wide range of contexts and foci for research on flipped instruction, and because of the contradictions in preliminary findings, it is important to systematically review the literature. The specific question guiding this review was, In what ways and to what extent has prior research examined flipped mathematics instruction? This literature review study complements existing reviews such as that of DeLozier and Rhodes (2017) that examined instructional activities that are

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included in studies of flipped instruction and Zainuddin and colleagues (2019) who, like us, examined methodological approaches and overarching results but which looked across multiple subject areas over a short period of time (2017-2018). Our study will focus on flipped mathematics instruction, specifically, and will include a broader timespan.

Framing Flipped Instruction

Flipped instruction is often viewed in relation to what is done outside of class (e.g., watching instructional videos) but it is also important to attend to what happens in class. Bergman and Sams (2012), for example, wrote about flipped instruction but focused largely on ways of using newly-available in-class time. de Araujo et al., (2017) have also pointed out the importance of planning for in-class activities, which is what separates flipped instruction from fully-online instruction. Flipped instruction, because of the possibility of content delivery occurring at home, also has similarities to inverted (e.g., Strayer, 2012) or blended (e.g., Graham, Woodfield, & Harrison, 2013) learning, but "flipping" terminology has garnered enough traction in practice and research as a contemporary phenomenon that it is worthwhile examining it on its own terms.

Method

For this qualitative meta-analysis of the literature on flipped instruction in mathematics classroom, the authors identified the publications through searches on multiple databases and individual journals, excluded the relevant publications using criteria (e.g., empirical, mathematics focused), and screened and recorded each article's details (e.g., definition of flipped instruction, methodology, findings). The details of each phase will be unpacked in the following sections.

Article Identification

To identify the publications relevant to this qualitative meta-analysis, we conducted our initial search in the ERIC database. Using the search terms "flip*" and "flipp*," our search focused on titles, abstracts, and keywords. Our search was restricted to peer-reviewed empirical articles (means have some forms of research questions, methods, and findings in them) published and available as of August 2018. During our initial search, we realized that some scholarly journals in mathematics education (e.g., ESM, SSM) or computer journals (e.g., EJMSTE) were not listed in the index on the ERIC database, we expanded our searches to the individual journals listed in top 7 mathematics education journals, as defined by William and Leatham (2017), or appeared within top 10 mathematics education either Scopus or Google Scholar Metrics. We did the same to the computer journals ranked within top 10 on either Google Scholar Metrics, Scopus, or Web of Science. For these individual journals, we searched peer-reviewed empirical articles using the search terms focusing on titles, abstracts, and keywords on their website or through ProQuest. If the individual journals did not allow us to search using either of titles, abstracts, and keywords, then we expanded our searches to full text if the option was available. If the individual journals did not have a searchable engine on their website, then we used Google Scholar and searched the full text using the same search terms.

Article Inclusion and Exclusion

Overall, as of August 2018, after further removing duplicates, we retrieved 1148 entries (822 from the ERIC database and 326 from the individual journals). For the 1148 publications, we read through their abstracts to check whether each article focuses on flipped instruction for teaching and learning mathematics (e.g., geometry, college algebra, statistics). Thus, we used the following criteria of inclusion: peer-reviewed empirical article, flipped instruction, and content area. Two raters individually read through the abstract and individually examined each criterion as "Yes," "Maybe," or "No." If the examination of each article was not matched, the raters discussed until they agreed with one or another. Also, if the abstract is not available, the raters skimmed through the full article and examined the criteria. After the first round of coding, there were 105 Yes's, 851 No's, and 192 Maybe's. For the Maybe's, both raters skimmed through the full article and examined the criteria, and it turned out that there were 12 Yes's and 180 No's. Consequently, we identified 117 Yes's and 1031 No's after the initial round of coding.

Coding the Literature

Both the screening and coding of the studies were conducted by the authors. To ensure the quality of these as key steps in our qualitative meta-analysis, we utilized a spreadsheet to organize and record the details of each study. The authors developed an initial coding scheme and recorded each article's definition of flipped instruction, research questions, overall methodology, details of methodology and data sources, participant information, mathematics content of focus, measured outcomes, and findings. Using the initial coding scheme, the authors coded two articles together in order to get familiar with the coding scheme and to test how the coding scheme works. Then, the research team deviated the articles and coded independently, and then met to discuss any issues or concerns that emerged while coding the articles. After discussing the issues that arose during the coding process, the team decided to add two more dimensions—length of study and details of the flipped classroom and comparison classroom (if applicable)—to the coding scheme.

Findings

We conducted a synthesis of literature within each category using an inductive and iterative process. As of February 2020, 97 of the 117 articles selected for inclusion in this qualitative meta-analysis were coded. The findings presented in this paper represent a brief overview of the methodology, geographic location, mathematics course, participant grade band, and findings in favor, against, or mixed of flipped instruction from the 97 coded articles. Coding of remaining articles is ongoing. Findings resulting from ongoing synthesis of literature involving the theoretical frameworks and definitions of flipped instruction guiding each study, instruments and measures, specific mathematics content, and activities used within each study, if provided, will be presented in future manuscripts.

Methodology and Context of Included Studies

The methodology used by the researchers and contexts of the included studies provided a picture of how and where flipped instruction was being studied. Of the 97 coded articles, we found that nearly 49% of the studies used quantitative research methods, 12% used qualitative research methods, and 39% used both qualitative and quantitative methods. Study participants included elementary, secondary, and post-secondary students in the United States, Canada, Europe, Asia, Africa, and Australia. Our synthesis of the literature revealed that an overwhelming majority of the studies were conducted within post-secondary institutions in the United States (n = 71); and very few studies were conducted in elementary classrooms (n = 3) (see Table 1).

Table 1: Geographic Location and Grade Band of Participants

Grade Band	Total	*Geographic Location				
		United States	Canada	Europe	Asia	Australia
Elementary K - 5	3	3	0	0	0	0
Secondary 6 - 12	22	15	1	1	2	0
Post Secondary	71	52	2	2	3	2
TOTAL	97	70	4	3	5	2

*if specified

The mathematics content studied ranged from fourth-grade mathematics content through graduate level mathematics courses. Post-secondary mathematics course content represented nearly 70% of mathematics content in classrooms using flipped instruction, with statistics (21.5%) and calculus (15.2%) courses being the majority (see Figure 1). Few studies included elementary mathematics content. Of the 7 studies that included elementary mathematics content, participants in 4 of those studies were undergraduate students majoring in elementary education.

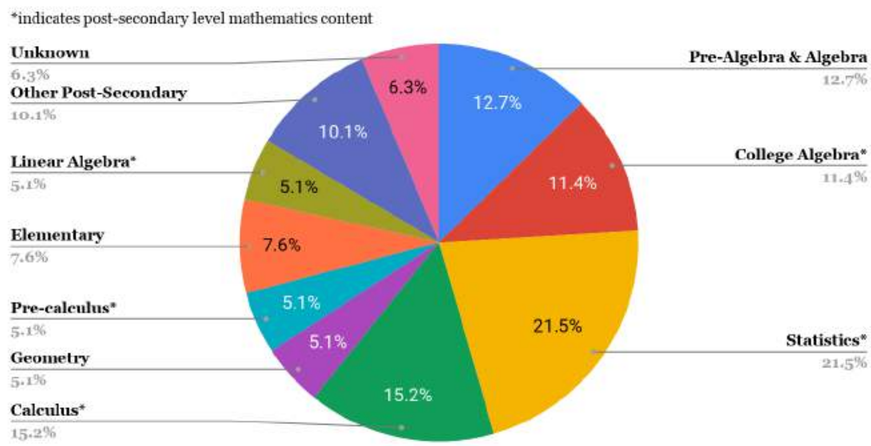

Figure 1: Mathematics Content

Findings in Favor, Against, or Neutral of Flipped Instruction

Findings from included studies revealed numerous positive findings in favor of flipped instruction in mathematics classrooms. Of the 57 included studies (from the 97 coded studies) that measured mathematics achievement of students in classrooms with flipped and non-flipped instruction, 53 of those studies reported at least one statistically significant result in favor of flipped instruction. Fifteen studies reported at least one result that did not show a statistically significant difference in student achievement; and, 3 studies reported at least one statistically significant result in favor of non-flipped instruction. Additional reported findings included both positive and negative reports of participants' perceived impact of flipped instruction on mathematics achievement, level of anxiety, class attendance, motivation, and study habits.

Conclusion

In this research brief, we presented an overview of some initial findings from an ongoing meta-analysis of literature on flipped mathematics instruction. Understanding the research methods previously used to study flipped instruction and the contexts in which those methods were used, will provide future researchers and practitioners with a greater understanding of the impact of flipped instruction on the teaching and learning of mathematics at all levels. As coding and synthesis of the studies included in our meta-analysis continues, the findings presented in this research brief are expected to change.

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