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# Flipped Learning in Grade 7 and 9 Mathematics

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**Abstract**

This design-based study focused on supporting students in grade 7 and 9 math classes by implementing a flipped learning model. In this study the researchers explored the perceptions of teachers and students about the benefits and challenges of a technology-enhanced pedagogy such as flipped learning. The study was conducted from January to June 2021 with two junior high math classes in a charter school in Alberta with a specialization in English language learning, and at a time when classes were shifting between in-person and online learning frequently due to COVID-19. Through a design-based approach, teachers engaged in reflective conversations and journaling, students were surveyed about their experiences with the flipped learning approach, and data analytics were reviewed from the videos and embedded quizzes assigned as pre-learning activities. The Technological Pedagogical Content Knowledge (TPACK) framework was used to explore the relationship between technology, pedagogy, and content knowledge for designing flipped learning activities. The results from this study demonstrated the efficacy of the procedures, instruments, and value in extending the study to involve more classes and subject areas. Participants were satisfied with using the flipped learning approach for improving students' engagement, agency, and mathematical understanding. Research in flipped learning can help inform teachers and schools in any teaching scenario whether in person, when teaching online, in blended learning environments, and when employing emergency remote learning.

**Keywords**: flipped learning, mathematics, design-based, TPACK, technology-enhanced

## Introduction

Flipped learning is a pedagogical approach that integrates technology, such as instructional videos that can be personalized for individual learning spaces so there can be increased interactive learning in group learning spaces (Bredow et al., 2021; Lo & Hew, 2017). In mathematics classes, personalized learning can be accomplished by providing students with access to customizable videos aligned with the mathematics curriculum and program outcomes for viewing individually outside of class time (Lo et al., 2017). While the research is limited in flipped learning in junior high mathematics classes, flipped learning is a promising pedagogical approach that has been shown to support higher degrees of engagement, increased knowledge acquisition, and conceptual understanding (Bredow et al., 2021; Cesare et al., 2021).

During the global pandemic K-12 schools have taken up flipped learning to support emergency remote learning and to assist in mathematics learning (Cevikbas & Kaiser, 2022). In our study, flipped learning involved the use of audio-video materials for students' class preparation as pre-learning and out-of-class activities, followed by regular in-class activities that built on and extended the concepts presented in the videos. Math videos available through EdPuzzle were embedded in the Google classroom platform for student-at-home access to support student learning prior to synchronous class-based activities with their teacher and peers (Cesare et al., 2021). This study took place during the COVID-19 pandemic when classes were frequently shifting between emergency remote teaching and classroom teaching. Flipped learning provided a flexible approach that could continue to be used throughout this period. This approach was used to help support mathematical learning and to help students who required additional at-home accommodations for remote learning (Cevikbas & Kaiser, 2022). The following question guided the study: What are the perceptions of teachers and students when using a flipped approach to teaching and learning in junior high mathematics?

### Flipped Learning in Junior High Mathematics and English Language Learning Environments

Within a technology-enhanced learning environment, flipped learning is known as a pedagogical approach used to describe asynchronous video content delivery to provide students with pre-learning resources (Bredow et al., 2021; Lo & Hew, 2017). The opportunity for students to participate in pre-learning prior to class learning activities by viewing video content allows for more time during class to engage in student-centered learning activities (Grypp & Luebeck, 2015, Kirvan et al., 2015; Mazur et al., 2015). The use of videos can increase accessibility to content and students can customize the viewing experience and pause, re-watch, or adjust the viewing speed of the video (Carhill-Poza, 2019).

Specifically applied to flipped learning in mathematics, Grypp and Luebeck (2015), Eisenhut and Taylor (2015) and Kirvan et al. (2015) used video instruction as a tool for introducing new content. For example, Kirvan et al. (2015) examined the effect of whether flipping an algebra classroom can lead to improved student learning of linear equations. Two middle school algebra classes were chosen by a student teacher to engage in action research. Using one class as a control group and the experimental group receiving flipped learning, the flipped learning cohort received instruction at home through online videos (Kirvan et al., 2015). Guided note sheets were also provided to complete while watching the videos. Students were encouraged to rewind and watch the videos multiple times. A pre-assessment consisting of one to three questions was given at the beginning of class to check student learning from videos. Findings revealed while videos provided the same types of discussions as those from the control group lectures, students were more engaged in their learning rather than completing a traditional worksheet for homework (Kirvan et al., 2015). For example, videos that only show how to solve problems are less likely to build conceptual understanding as students are not thinking about meaning, ideas, and connections (Kirvan et al., 2015; Lo et al., 2017).

Flipped learning used in environments specializing in English language learning have been found to result in an increase in student engagement and expanding motivation and satisfaction in learning (Carhill-Poza, 2019; Hung, 2015). Hung (2015) reported that English language learners using flipped learning were more committed to out-of-class learning, and likely to engage in deeper learning. High levels of student satisfaction were reported with most respondents being receptive to the structure and design of the learning.

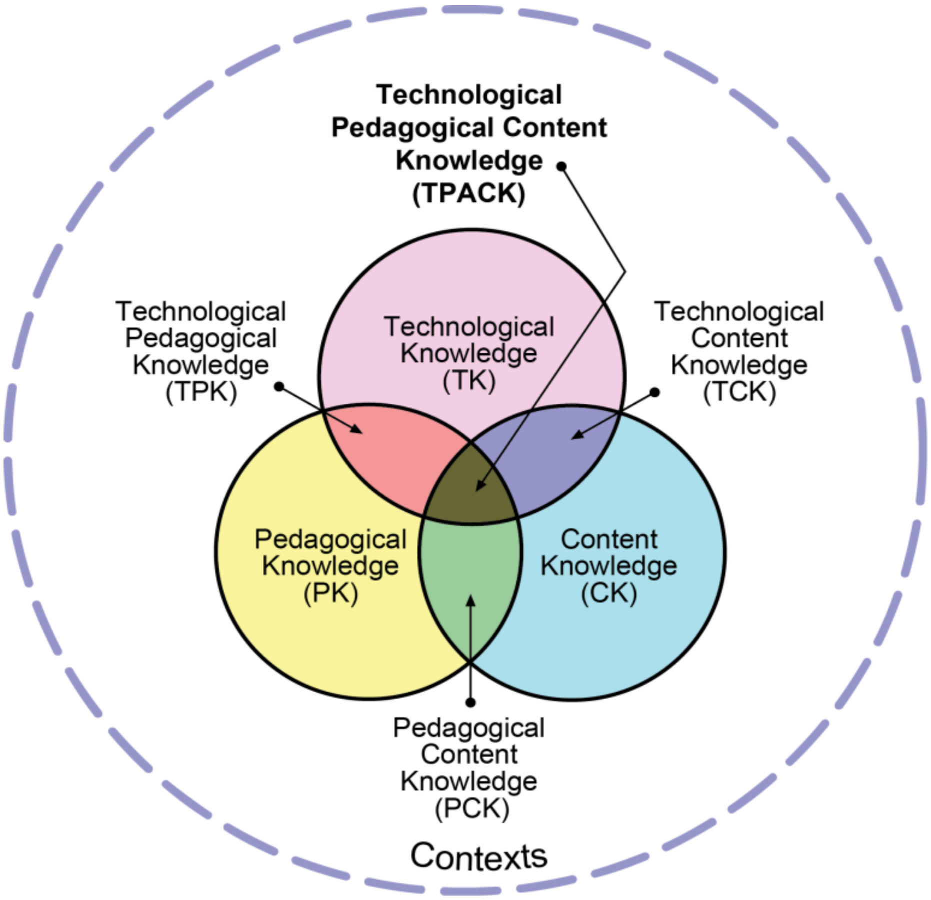
Videos increase student engagement in learning (Carhill-Poza, 2019; Hung, 2015; Kirvan et al., 2015). They also provide greater learner autonomy (Santikarn & Wichadee, 2018), most notably because students can work at their own pace and review content when desired (Grypp & Luebeck, 2015; Hung, 2015). However, video quality, specifically length, the focus on content, and ensuring content connects to classwork, is integral to success (Eisenhut & Taylor, 2015; Grypp & Luebeck, 2015; Hung, 2015; Kirvan et al., 2015). Overall, the use of video for pre-learning in flipped learning is a promising pedagogical approach.

## Methodology

In this design-based study (McKenney & Reeves, 2019), data collection methods included teacher reflections, student surveys, and video analytics. Over a period of four months teachers were using a flipped learning approach in their math classes. It is important to note that teachers were not using this approach exclusively and other approaches were also used during this timeframe. One grade 7 and one grade 9 teacher participated in the study and provided weekly reflections when using the flipped approach and met with the researchers monthly for reflective conversations. Reflective prompts were provided to the teachers to reflect on how the model was working, what were the constraints/benefits, and to share their insights about implementing a flipped learning approach. Surveys were administered to a total of 143 grade 7, and grade 9 students and student assent and parent/guardian consent were provided for eleven students. Video analytics were collected from 24 videos used by both teachers for mathematics pre-learning in their classes. Video usage was reviewed, such as sections of the video that were watched multiple times in relationship to the complexity of the concepts and assessment questions embedded in the video activity. In this paper, we report on the overall broad themes that emerged through the aggregated data and analysis and how this has informed our next steps for working with teachers designing flipped learning using the interconnected domains in the technological, pedagogical, and content knowledge (TPACK) framework as shown in Figure 1 (Mishra & Koehler, 2006; Koehler et al., 2014).

**Figure 1**

*TPACK Framework and interconnected domains*




*Note.* From "TPACK Explained," by Matthew J. Koehler, 2012. Copyright 2012 by tpack.org. Reproduced with permission.

## Results

Results indicated that (a) students in the study engaged with the flipped learning model, watched the videos, and completed the embedded quizzes that were assigned as pre-learning activities; (b) student agency was promoted and students could work at their own pace and repeatedly view all or parts of the video; and (c) viewing the pre-learning videos and completing the embedded quizzes was perceived as a support for students' learning in mathematics by the instructors and students involved in the study.

### Student Engagement with Flipped Learning

The two junior high mathematics teachers in this study discussed how they selected the asynchronous pre-learning activities (videos and embedded quizzes) and designed the subsequent synchronous learning activities for class time using elements of the interconnecting domains of technological, pedagogical, and content knowledge. Teachers perceived the flipped learning approach provided students with an opportunity to independently engage in pre-learning by viewing videos about upcoming concepts. In the surveys, students indicated they felt more comfortable interacting and communicating in smaller groups during class activities following the pre-learning activities. During the class activities that were held online during emergency remote teaching or held in the classroom when teachers and students were on-site, students reported they had more opportunities to engage and interact with peers and their instructor. Asynchronous video provided students with support outside of class time to engage with the mathematics content, develop understanding and prepare for engagement with peers and their instructor during class time.

## Student Agency

Teachers reported that as students experienced the flipped learning approach and started to see the benefits in reviewing the videos prior to class work, students demonstrated agency in their learning. Data from the video analytics showed that students made use of the built-in technology features. The video analytics demonstrated the amount of time students spent on the assigned video and showed that students rewatched the video or parts of the video prior to attempting the embedded quiz. Students viewed the videos at their own pace and reviewed the videos or parts of the videos repeatedly as needed. As mathematics concepts became more complex, the students watched and rewatched more frequently. Teachers also noted that students who were not satisfied with their quiz results would ask the teacher to “reset” their account, so they could attempt the quiz again.

## Mathematics Learning

Teachers and students indicated that using the flipped learning approach helped students become familiar with concepts prior to engaging in the class activities. Students reported that viewing the videos prior to class helped prepare for the in-class activities, such as asking questions and working in collaboration with peers or small groups. Students also preferred learning using videos that were entertaining and included elements of humour. Even though most of the videos had some elements that might be considered entertaining, teachers noted that there were occasions when students did not view the videos and did not complete the assessment questions embedded in the videos. When utilized, the videos seemed to benefit students’ learning of mathematics concepts.

The pre-learning activities also benefitted the teachers with designing their class activities. When students completed the pre-learning activities, the teachers reviewed the video analytics and embedded quiz results to develop class activities that would support understanding of complex mathematics concepts. The research team found the TPACK framework was useful in the analysis and could help with the instructional design for the next phase of the design-based study. Researchers and teachers are planning to use the TPACK framework for teacher professional learning prior to using the flipped learning approach and to design the flipped learning activities with attention to the technology, content, and pedagogical knowledge needed to support learning.

## Conclusion

In this flipped learning study and research partnership with two mathematics teachers in one school with a specialization in English language learning, a flipped learning approach was used to support students with mathematics learning. Math videos and embedded quizzes were accessed by students at-home as pre-learning activities. Based on the teacher reflections, student survey results, and video analytics, students demonstrated student agency and responsibility for viewing the pre-learning videos and completing the embedded quizzes. Students also indicated they felt more comfortable communicating in smaller groups in class once they completed the pre-learning activities. Pre-learning provided students with confidence to engage in applying knowledge during class activities with peers and to seek clarification and ask their teacher questions when needed. The video analytics can be a valuable tool for educators in gathering real-time feedback about individual student progress and to make informed adjustments when designing in-class activities. As the research continues with more teachers and students involved in the study, we plan to continue examining the benefits and challenges of flipped learning approaches and the implications for designing learning using the TPACK framework.

## Author's Contributions

Conceptualization: BB, ND, MW; Data curation: ND, MW; Formal Analysis: ND, MW; Funding acquisition: BB, ND; Investigation: BB, ND, MW; Methodology: BB, ND; Project Administration: ND; Resources: BB, ND; Software: MW; Writing draft, review, and editing: BB, ND, MW.

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## Ethics Statement

Ethics approval was obtained for this work described in this article REB20-0165.

## Conflict of Interest

The authors do not declare any conflict of interest.

## Data Availability Statement

Data is not available as per ethics agreement for this study. Authors have taken responsibility for ensuring that all steps necessary to protect the privacy of human research subjects have been taken.

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