WHAT FACTORS CONTRIBUTE TO STUDENT SUCCESS IN PRECALCULUS FLIPPED CLASSROOMS

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Flipped instruction has been flaunted as a pedagogical strategy that supports improved learning and retentive abilities of students. Nevertheless, one of the twin challenges reported in the literature, students' failing to complete preparatory work, impedes the efficacy of the model. Thus, learners' motivation and attitude to work are essential for the successful implementation of the constructivist learning-centric approach. Yet very few studies have examined the connections between students' motivation and achievement goals in flipped instruction. To address the current gap, this study investigated the relationship between students' motivation beliefs, flipped method, and achievement in precalculus using pre- and post-course surveys collected from 32 undergraduates. Both motivation beliefs and flipped instruction influenced academic achievement positively in the course and were moderated by students' efforts.

Keywords: Flipped instruction, precalculus, motivation beliefs,

The literature on undergraduate education in science, technology, engineering, and mathematics (STEM) indicated that mathematics, especially, calculus prevents many students from pursuing a career in STEM (Almeida, Queiruga-Dios, & Cáceres, 2021; Bressoud, 2015; Rasmussen et al., 2019; Sande & Reiser, 2018). Prior research faulted inadequate preparation at high school (Bressoud, Camp, & Teague, 2017; Sadler & Sonnert, 2016) and subpar teaching methods (Gilboy, Heinerichs, & Pazzaglia, 2015; Rasmussen et al., 2019). Thus, educators continue to explore active learner-centered strategies to provide individualized instructions for each student (Blumberg, 2008; Weimer, 2012). The flipped instruction method embodies this description.

The current study investigated the contributions of the flipped strategy on students' perceived motivation to learn precalculus, an extensive and rather demanding course with a high failure rate but required for success in calculus (Bressoud, 2021). Many of the students enrolled in the college precalculus have taken the course in high school, but often struggle to comprehend the course content and become unmotivated to pursue success (Bressoud et al., 2017; Sadler & Sonnert, 2016). Comparative studies have been conducted on the efficacy of flipped instruction in secondary and postsecondary courses by comparing students' performances in courses taught using flipped instruction with the same taught using the lecture method (Love, Hodge, Grandgenett, & Swift, 2014; Pattanaphanchai, 2019). However, research on the flipped strategy remained underexplored; particularly, the role of motivation on achievement goals in a flipped instruction setting. We aimed to contribute to the literature by examining the relationship between the components of motivation beliefs. We also examined how preference for flipped instruction affected students' cognitive processes and learning achievement in the course. The following research questions are used in this study:

1. What are the relationships between the components of students' motivation beliefs including expectancy beliefs, perceived value, the cost of and preference for learning precalculus in a flipped instruction?
2. To what extent do effort, motivation beliefs and preference for the flipped instructional method contribute to students' overall academic success in a flipped college precalculus course?

Research on Flipped Instruction

Flipped instruction is a constructivist learning-centric approach (Araujo, Otten, & Birisci, 2017; Gilboy et al., 2015) that provides learners the opportunities to construct knowledge of content independently and through collaborative efforts for effective learning, increased engagement, improved academic performance, and better retention (Araujo et al., 2017; Clark, 2015; Graziano & Hall, 2017; Love et al., 2014). The model involves moving all or part of content delivery outside of the classroom by having students watch video lectures and/or read assigned texts at home, while class time is used for discussions and problem-solving to promote conceptual understanding (Nielsen, Bean, & Larsen, 2018). The didactic approach promotes effective learning through the construction and reconstruction of content knowledge (Gilboy et al., 2015; Love et al., 2015). This is to say students have two attempts at learning concepts: first, independently before class, and again during class under the tutelage of the teachers and through collaborative learning with peers. However, motivation is crucial for academic success in a flipped instruction setting (Huang & Hong, 2016; Zainuddin, 2018), where the onus of learning is more student-centered. Yet, limited studies explored the direct connection between students' motivation (Zainuddin, 2018), including their ability beliefs, expectancy for success, interest and perceived value of learning, and the effort needed to succeed (Barron & Hulleman, 2015) in a flipped instruction.

Despite the enumerated benefits, a commonly reported limitation in the literature is inadequate pre-class preparations, especially failing to watch lecture videos (Araujo et al., 2017). Others are resistance to change due to increased student and teacher workload, time constraint (Araujo et al., 2017), difficulty of learning tasks (Clark, 2015; Graziano & Hall, 2017), and inability for students to receive immediate feedback during out-of-class activities (Chen, Wang, Kinhuk, & Chen, 2014). Empirical data revealed that curriculum, task difficulty, and test anxiety, correlate with students' effort and perceived beliefs of their ability to successfully complete a task (Almeida et al., 2021; Barron & Hulleman, 2015; Wigfield, 1994). Although the flipped instruction method is supportive of multiple higher-order-thinking learning strategies (Akçayır & Akçayır, 2018), the same could lead to an increased psychological state of the student and impede their academic success rather than improve it (Barron & Hulleman, 2015; Flake, Barron, Hulleman, McCoach, & Welsh, 2015). Consequently, learning achievement is dependent on the extent to which students can relate novel situations to prior learning (Dawson, Meadows, & Haffie, 2010), motivation, and the effort committed to learning content.

Several studies revealed that students have positive attitudes toward the flipped instruction approach (Clark, 2015; Graziano & Hall, 2017; Pattanaphanchai, 2019). Nonetheless, their positive perceptions about the model did not necessarily translate into learning gains. This is an indication that other factors may be influencing the achievement of desired outcomes. Thus, this study examined the role of student's motivation beliefs and commitment to learning achievement regardless of challenges experienced. While several studies have used qualitative research approaches to explore the efficacy of flipped instruction, the current study utilized

quantitative method to investigate the relationship between components of undergraduates' motivation beliefs and efforts to learn content in a flipped college precalculus course.

Theoretical Framework: Expectancy-Value-Cost Theory

Achievement theorists postulated that individual's actions and inactions, including their decisions and determinations to succeed, are driven by subjective beliefs about their abilities, expectancies for success, interest, and perceived value of the desired outcome, and preferences (Wigfield & Eccles, 2000). The Expectancy-Value-Cost (EVC) theory of motivation (Barron & Hulleman, 2015) is an extension of the Expectancy-Value (EV) theory, which has been reviewed extensively by theorists in the achievement traditions (Barron & Hulleman, 2015; Getty et al., 2017). However, the cost component of the EVC model is a relatively novel field of study (Barron & Hulleman, 2015; Getty et al., 2017). The component exists because of the limitation of the EV theory at explaining why an individual with excellent expectancy and a strong perception of the utility of certain tasks, would fall short of achievement. It was inferred that other factors like the difficulty of the task, discouragement, embarrassment, related and unrelated efforts required for success were not accounted for by the EV theory (Barron & Hulleman, 2015; Flake, Barron, Hulleman, McCoach, & Welsh, 2015).

Cost, deemed as the forgotten component of the EV theory (Flake et al., 2015), was originally introduced as a subcomponent of the value component (Wigfield, 1994; Wigfield & Eccles, 2000) and was hypothesized to moderate the effect of the value component on an individual's motivation beliefs and achievement goals (Barron &Hulleman, 2015; Flake et al., 2015; Wigfield & Eccles, 2000). Cost, a barrier-related construct, is multi-dimensional and focuses on what an individual must sacrifice to achieve success (Wigfield, 1994). The construct elucidates negative appraisal of time and effort related to the task, outside of task effort, loss of valued alternatives, and emotional cost of success (Flake et al., 2015). Thus, the cost component is a negative predictor of success and mitigates the effect of both expectancy and value.

Eccles and colleagues (1983) (cited in Wigfield & Eccles, 2000) postulate the expectancy component as a two-dimension construct comprised of ability beliefs and expectancies for success (Wigfield, 1994; Wigfield & Eccles, 2000). Ability beliefs pertain to what the student perceives he or she can do now, while expectancy beliefs are apropos for the future. In this study, we focus on students' perception of their present ability to succeed at learning precalculus in a flipped classroom. Because passing the course and retention in college are utmost for first-year students who already viewed the remedial course as a setback (Kane et al., 2020).

The value component focuses on students' beliefs about the importance and interest of the task and provides answers to the questions: "Do I want to do this task?" and "Why am I doing this task?" (Barron &Hulleman, 2015). The component is described as having four subcomponents including intrinsic value, (student enjoys watching lecture videos because it is fun and interesting), utility value (actively learning precalculus because it is required for desired major), attainment value (passing the course allow students to move to Calculus I and be on track for timely graduation) and cost a negative predictor of the overall value of tasks. The same has now become the third component of the EVC theory (Barron & Hulleman, 2015; Getty et al., 2017). In this study, the EVC theory as defined by Barron and Hulleman (2015) was used to explain and interpret the data collected about the effect of students' expectancies, perceived values, and cost implications, as well as preference for the flipped instructional approach on their academic success.

Methods

The current study used observational methodology to examine students' expectancy beliefs, perceived values, and the cost of learning the content in a flipped college precalculus course. The cross-sectional study utilized data from self-reported surveys.

Participants and Data Collection

Data was collected in a flipped college Precalculus course in a four-year college in the Midwestern region of the United States during the fall 2019 semester using motivation scale. Thirty-two students (7 females and 25 males) representing 71% of the students taught that semester using the flipped method participated in the study. The participants self-registered for the course, although they are unaware of the teacher's planned teaching method. Most of the participants (82%) took Precalculus in High School and 49% reported taking Calculus. All participants indicated interest in pursuing a major in STEM-related disciplines.

Research Instrument

Students responded to two online surveys (pre-course and post-course) during the first and last week of the semester, respectively. The main component of the surveys consisted of eight motivation-related items adapted from Expectancy-Value-Cost Scale (EVC-S) (Getty et al., 2017; Kosovich, Hulleman, Barron, & Getty, 2015), and four researchers-created items to measure students' perceived liking for flipped instruction. The 12 ordinal items were theorized to measure motivation beliefs and likability for the flipped instructional strategy.

EVC-S, which was developed, field-tested, and validated is novel and had reliable psychometric properties (Getty et al., 2017; Kosovich et al., 2015). For example, a rapid version of the scale consisted of three subscales with three items measuring *Expectancy* ($\alpha = \omega = 0.82$), three measuring *Value* ($\alpha = \omega = 0.84$, and four items to measure the *cost* ($\alpha = \omega = 0.83$) subscale (Getty et al., 2017). To keep our instrument short, we dropped two of the original items, one from expectancy, and reworded a statement to combine two items from the cost subscale into one while still preserving the intended meaning of both constructs. The adapted research instrument was validated to ensure its consistency with the original EVC-scale and to determine the reliability and validity of the additional items. The following constructs were addressed.

Expectancy. This subscale focused on self-confidence, that is, the importance of believing in one's ability to succeed on a task (Barron & Hulleman, 2015; Kosovich et al., 2015; Wigfield & Eccles, 2000). Expectancy included two items (*I am sure, I can learn the material for Precalculus;* and *I am confident that I can do well in Precalculus this semester*) with a reliability coefficient of $\alpha = 0.89$.

Value. The value subscale addressed the reasons why the students would want to engage in certain actions or achieve academic success. The value subscale contained three items focused on understanding students' perceptions of the importance and personal interest for learning Precalculus, (e.g., "*Precalculus is an interesting course*," "*Precalculus is useful to me*," etc.). The value subscale had a reliability of 0.77.

Cost. The cost subscale addressed "what is invested, required, or forgone engaging in a task" (Flake et al., 2017; p.235). The construct was hypothesized to influence motivation through effort and time related and unrelated to the task, the loss of valued alternative, and negative effect (Barron & Hulleman, 2015; Flake et al., 2017; Getty et al., 2017). There were three cost items including, *I have to sacrifice too many things to do well in Precalculus, etc.* with a reliability of $\alpha = 0.88$.

Preference for Flipped Method Subscale. The remaining four were researcher-created items to measure students' preference for the flipped method. This was based on a study by

Sahin, Cavlazoglu, & Zeytuncu (2015) with calculus students. The authors investigated students' views and experience in flipped courses, and the impacts on their academic achievement, when compared with non-flipped classes. Sahin and colleagues found that students preferred watching class videos to reading their textbook and preferred courses with lecture videos. On this premise, we developed the following four questions to verify the validity of their claims. Q9-*I am sure I will learn more in a flipped instruction*; Q10-*I prefer a course with video lessons to a course without video lessons*; Q11-*I like the flexibility of choosing how I learn the course content in this course*; and Q12- *the syllabus helped me understand the goals and expectations of this course*. The last question was later dropped due to low factor loading. The subscale had a reliability of 0.92.

All responses were rated on a 5-point scale where 1 = strongly agree and 5 = strongly disagree. We recoded positively worded statements. Overall, there were 57 (pre-course = 29 and post-course = 28) usable survey data from both surveys before multiple imputations.

Data Analysis

Based on the EVC theoretical perspective as well as a review of relevant studies, the study utilized structural equation modeling (SEM) (Schumacker & Lomax, 2016) to examine the relationship between components of students' motivation and to determine predictive abilities of effort, flipped instruction method, and motivation beliefs on academic success in Precalculus.

A two-steps full-SEM (Anderson & Gerbing, 1988) in Lisrel 11 software (Jöreskog & Sörbom, 2021) is used to analyze the predictive abilities of motivation beliefs and preference for flipped instruction on academic success in a college Precalculus course. The statistical technique which combines both measurement and path analyses was selected because of its ability to explain the causal relationships between and among the latent and observed variables (Schumacker & Lomax, 2016). The measurement part was used to verify the existence of the study's latent variables (*expectancy, value, cost, preference, effort, and success*) and to determine whether the latent variables can be explained by the observed variables (using responses from the self-reported questionnaires). The structural model postulates the relationships between the variables, including the strength and direction of the causal relationships as follows. *Effort* was measured by the number of time students logged in to watch lecture videos (*Watch-Video*) is theorized to explained academic success (Dweck & Yeager, 2019; Flake et al., 2017). We hypothesized that the observed variables would measure *expectancy, value, cost*, and *preference* for the flipped method. Then *expectancy, value,* and *cost* were conjectured to measure motivation beliefs (Getty et al., 2017), and preference measured the use of the flipped method (Sahin et al., 2015). Both second-order factors would then have positive effects on *academic success* (measured by *grades*) and moderated by *effort* as shown in figure 1, the hypothetical model.

Considering our sample size, we generated values in LISREL for the first order latent variables and used them in higher-order analysis, thereby reducing the number of estimated parameters.

Several fit indices were used to assess the adequacy of the proposed model based on recommendations of Schumacker and Lomax (2016). The model was evaluated using the following indices: (a) Comparative Fit Index (CFI), (b) Goodness of Fit Index (GFI), (c) Normed Fit Index (NFI), (d) the Root Mean Square of Approximation (RMSEA), and (e) Chi-square test ($\chi 2$). The recommended cut-off that indicates a good fit for CFI, GFI, and NFI is 0.90 or higher. A non-significant chi-square is desired indicating a close fit and RMSEA values less 0.08 represents a good fit (Hu & Bentler, 1999; Schumacker & Lomax, 2016).

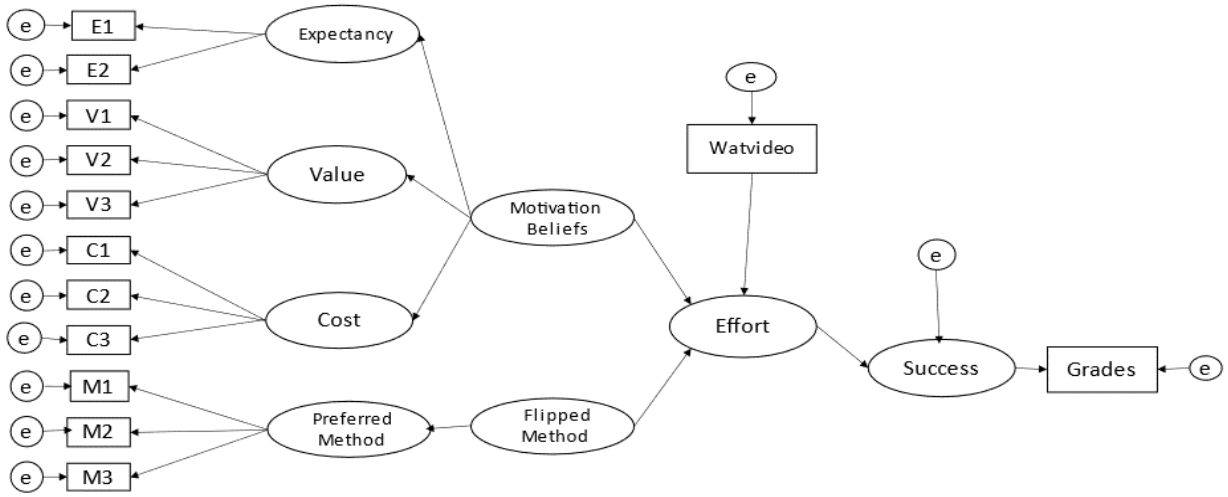

Figure 1: Research **Model**

Results

This study examined whether college students who report high expectancies and values for success would also report a higher preference for the flipped method. Using confirmatory factor analysis (CFA), we also tested whether there is a direct effect of students' motivation beliefs and flipped instruction on success moderated by students' efforts (measured by the number of logins to watch prerecorded lecture videos). Table 1 presents the direct, indirect, and total effects between motivation beliefs, preference for the flipped instructional method and students' overall academic success in a flipped college precalculus course. Figure 2 specifically shows direct effect of students' motivation beliefs (expectancy, subjective values, and cost beliefs) and flipped instruction (high preference for the method) on success (grades) moderated by students' efforts (measured by the number of logins to watch prerecorded lecture videos).

Table 1: Direct, indirect, and total effects of variables on Academic Success

Variable	Direct effect	Indirect effect	Total effect
Motivation Beliefs	0.126	-0.022	0.105
Method	**0.085**	-0.059	0.026
Effort	**-0.220**		-0.220

First, it was revealed that students who reported high *expectancy* for success also reported high *value* and are favorably disposed to learning in a flipped instruction (see Table 1). However, *effort* had a negative influence on success in the course, thereby moderating the effect of motivation and method on achievement as theorized.

Next, to determine the strengths and directions of each factor in relation to learning achievement, we further analyzed how well the hypothesized model fit our data. Figure 2 shows that the collected data supported a four-factors solution, which validates and extends the EVC theory to include preference for specific cause, in this case, flipped method.

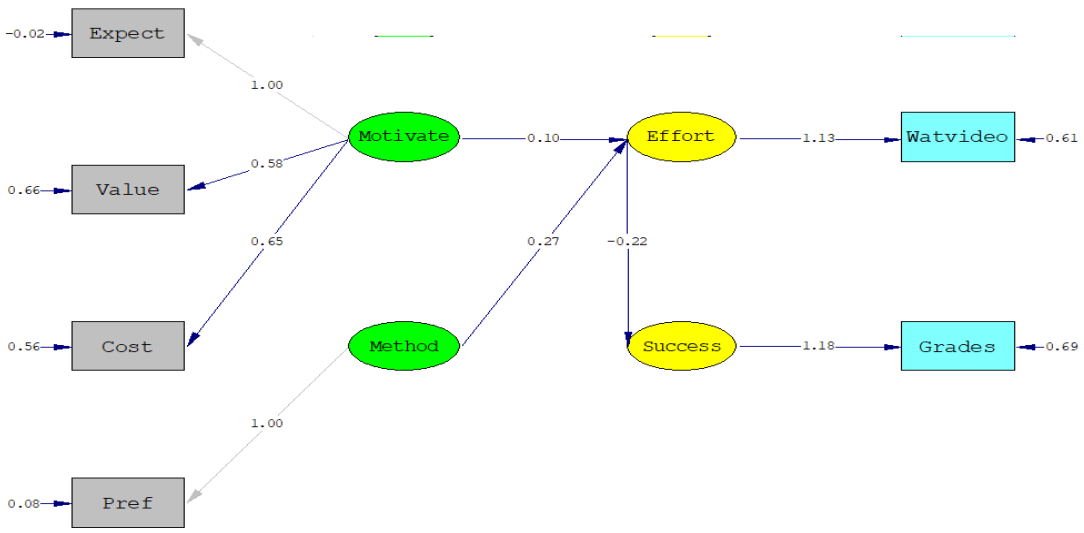

Figure 2: Analytical Model

The correlations between the factors ranges from moderate to strong positive relationship except the connection between *Grades* and *Watch-Videos* (r = -0.017, p >0.05). There is a direct effect of students' motivation beliefs (expectancy, subjective values, and cost beliefs) and flipped instruction (high preference for the method) on success (grades) moderated by students' efforts (measured by the number of logins to watch prerecorded lecture videos). As shown in Figure 2, the measurement model fits the data well showing that all indicator variables each explained only one latent variable as hypothesized. All the fit indices except RMSEA were within acceptable ranges ($\chi^2(3) = 5.29,\ p > 0.05$, RMSEA = 0.11, NFI = 0.94, and CFI =0.97, GFI = 0.97). Both motivation beliefs and flipped method contributed positively to success, although the significance of the paths could not be determined. The fit indices remained unchanged with the addition of the structural paths. The findings show that a combination of preferred method and motivation would lead to academic success by jointly explaining about 11% of the variations in success and 33% of students' effort. Conversely, students' commitment to learning (*Effort*) contributed negatively to success. Possible explanations may include poor learning retentions, or students may be watching the lecture just to check boxes and could become overconfident since the content is somewhat familiar. The significant error variances of *Watvideo* and *Grades* are indications that the latent variables were influenced by other confounding variables than the hypothesized indicators.

Discussion and Conclusion

We found that students who reported high *expectancy* for success also reported high *value* and are favorably disposed to learning in a flipped instruction. This finding can be supported by prior research studies (e.g., Kosovich et al., 2015; Getty et al., 2017). Yet, different from Barron and Hulleman (2015), we found positive, and significant relationships between cost and both expectancy and value. Furthermore, students' preference toward flipped method was an excellent indicator for the effective implementation of flipped instruction. We noted that a direct relationship existed between motivation and success and between flipped method and success. This may not be surprising, because motivation plays a significant role in human's achievement of desirable goals (Dweck & Yeager, 2019). Several studies found flipped instruction useful for promoting deep learning (Akçayır & Akçayır, 2018; Araujo et al., 2017; Graziano & Hall, 2017;

Huang & Hong, 2016; Zainuddin, 2018); but none considered the effect of personal preference for the model. This study shows that a combination of preferred method and motivation jointly explained about 11% of the variations in success and 33% of students' effort. Conversely, students' commitment to learn (*Effort*) contributed negatively to success needing further research.

Considering students' motivation and preference when selecting teaching methods could improve learning and achievement, the findings of this study provide teachers with tools to educate, inspire, and involve students in how they learn (e.g., freedom to choose based on personal preference). This study also addresses research gaps on motivation and effectiveness of flipped instruction. A few limitations should be noted, such as the small sample size, lack of diversity of instructors, subjects, and learner groups. More research and replications are needed to substantiate the study's findings.

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