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# Investigating Flipped Learning: Student Self-Regulated Learning, Perceptions, and Achievement in an Introductory Biology Course

**Sarah Rae Sletten**[1]

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**Abstract** In flipped classrooms, lectures, which are normally delivered in-class, are assigned as homework in the form of videos, and assignments that were traditionally assigned as homework, are done as learning activities in class. It was hypothesized that the effectiveness of the flipped model hinges on a student's desire and ability to adopt a self-directed learning style. The purpose of this study was twofold; it aimed at examining the relationship between two variables—students' perceptions of the flipped model and their self-regulated learning (SRL) behaviors—and the impact that these variables have on achievement in a flipped class. For the study, 76 participants from a flipped introductory biology course were asked about their SRL strategy use and perceptions of the flipped model. SRL strategy use was measured using a modified version of the Motivated Strategies for Learning Questionnaire (MSLQ; Wolters et al. 2005), while the flipped perceptions survey was newly derived. Student letter grades were collected as a measure of achievement. Through regression analysis, it was found that students' perceptions of the flipped model positively predict students' use of several types of SRL strategies. However, the data did not indicate a relationship between student perceptions and achievement, neither directly nor indirectly, through SRL strategy use. Results suggest that flipped classrooms demonstrate their successes in the active learning sessions through constructivist teaching methods. Video lectures hold an important role in flipped classes, however, students may need to practice SRL skills to become more self-directed and effectively learn from them.

**Keywords** Flipped learning · Flipped classroom · Self-regulated learning · Active learning · Self-directed learning

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✉ Sarah Rae Sletten
sarah.sletten@mayvillestate.edu

[1] Mayville State University, 330 3rd St. NE, Mayville, ND 58257, USA

The *flipped classroom* is a current instructional model in education that is gaining popularity at the post-secondary level in science as well as other fields (Raths 2014). In a flipped classroom, content (i.e., lectures), which is normally delivered in-class, is assigned as homework in the form of video lectures, and assignments that were traditionally assigned as homework are done as learning activities in class (See Fig. 1; Bergmann and Sams 2012). By moving the content delivery portion of a class out of the classroom, instructors have more time to devote to student-centered, active learning strategies in which learners can integrate and apply their knowledge (Hamdan et al. 2013).

The Flipped Learning Network, a group of educators dedicated to advancing the flipped learning model, has developed the following *four pillars of flipped learning* (Hamdan et al. 2013):

1. Flipped learning creates flexible learning environments, allowing students to learn where they want to learn and when they want to learn.
2. Flipped learning creates "student-centered" classrooms in which students are actively involved in knowledge construction.
3. Flipped learning requires instructors to evaluate what material should be directly taught in video lectures outside of class in order to maximize in-class active learning time.

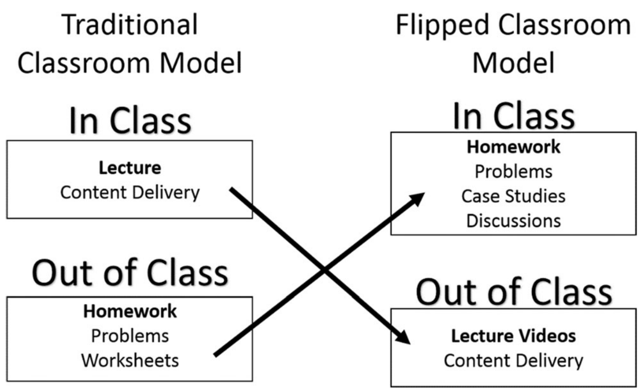


**Fig. 1** In flipped classrooms, the content delivery is moved out of class in the form of video lectures, while the homework is completed in class as collaborative activities

4. Flipped learning requires instructors to facilitate students in active learning environments, providing feedback and guidance as students construct knowledge.

In science, it is easy to understand the appeal of a learning environment in which students are self-driven to fully prepare for class by watching and taking notes from video lectures, as well as actively participate in the in-class activities. It is also apparent how the flipped model may fall short of an instructor's expectations; students may not adequately prepare for class on their own, or may fail to fully engage in learning activities while in class. The effectiveness of the flipped model appears, therefore, to hinge on a student's desire and ability to adopt the self-motivating behaviors a flipped class necessitates. The current study examined the relationship between two variables—students' perceptions of the flipped model and their self-regulatory study behaviors—and the impact of these variables on achievement in a flipped introductory biology class.

## Background

The flipped model has been identified by the New Media Consortium and EDUCAUSE as being a key emerging technology strategy in higher education (Johnson et al. 2014). Much evidence exists to support this decrease of lectures and increase in active learning in science classes (Auerback and Schussler 2016; Wood 2013). In response to the research, science instructors on college campuses across the United States are shifting lectures out of large group settings into students' personal environments through the utilization of a plethora of available technologies (Hamdan et al. 2013). If the flipped model is to be most effective at the post-secondary level, students may have to take on a more self-directed role in their learning than they would in a traditionally taught lecture-based class, such as introductory biology. There is also evidence that suggests student perceptions play a role in the instructional model's effectiveness (Enfield 2013)

In a flipped science course, students are required to view lectures on their own time, and therefore may need to be aware of their interaction level with video lectures and regulate their motivation to learn in order to be successfully prepared for activities during class time. Self-regulated learning (SRL), as described by Zimmerman and Kitsantas (2007), involves student's use of a variety of strategies to aid in optimal learning. SRL strategies can be divided into regulation of three academic dimensions—cognition, motivation, and behavior (Wolters et al. 2005). Self-regulating students exhibit the use of any combination of strategies that work best for them in order to prepare for their classes. Therefore, understanding the role of SRL and promotion of its use in flipped science classes may lead to higher student success in such classes.

Science students state that flipped classes are less boring and provide for a more engaging environment because of the interactive nature of the in-class sessions (Smith 2013). McLaughlin et al. (2013) found students believed the flipped model greatly enhanced their learning of course material. They further identified classes based on the flipped model as engaging and efficient, which fostered development of critical thinking and problem solving skills. This suggests that learning activities in flipped science classes at the college level may motivate students to participate in class, leading to a more effective course.

Despite the increased presence of the flipped model in science courses on college campuses, educational researchers point out that there is very little empirical data that supports this model of instruction, and that any peer review research that has been done to this point is mainly anecdotal in nature (Herreid and Schiller 2013; Milman 2012). Strayer and Hanson (2014) highlight the gap in knowledge between the available "practice-based" support and the lack of "research-based" support in their work with flipped classes. In this light, it seems as if educators are moving to the flipped model based on its popularity alone (Straumsheim 2013). Instructors are not the only ones who are encouraging the move to flipped instruction; approval of the new model among student populations has also been documented (Pierce and Fox 2012; Roach 2014), yet little to no research exists to gain insight into how students' academic cognition, motivation, and behaviors are regulated in a flipped class. Some data exists on student perceptions of flipped classes, but no study to date looks at how those perceptions predict students' use of SRL strategies for class preparation and in-class participation, even though both may ultimately play a role in achievement.

## Theoretical Framework

The flipped model of instruction can be thought of as a two-armed process, centered on self-directed learning (SDL) theory. In a flipped class, SDL lays the foundation for knowledge construction through out-of-class preparation and in-class learning activities (see Fig. 2). The out-of-class preparation—the first

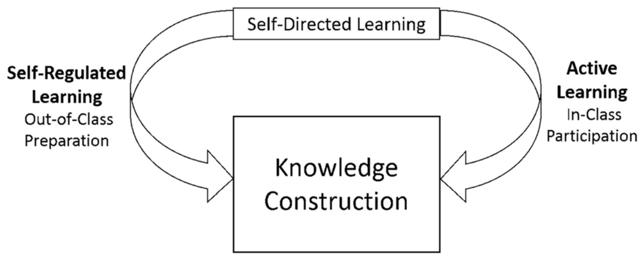


**Fig. 2** The study's theoretical learning model for the self-directed learner in a flipped classroom has two components that lead to knowledge construction; the out-of-class preparation utilizes self-regulated learning skills and the in-class participation facilitated through active learning

*arm* of the flipped model— requires students to identify and utilize strategies that aid in content acquisition and understanding (i.e., SRL). In-class active learning exercises—the second *arm*—are the learning activities in which students participate to engage with and gain a deeper understanding of the content.

## Literature Review

### Self-Directed Learning

SDL was described by Knowles in 1975 as a process initiated by a learner, with or without guidance from others, in which learning needs and goals are self-defined as are the resources, strategies, and assessment methods utilized in meeting those goals (Boyer et al. 2014), and was founded on the premise that learners are capable of effectively controlling and monitoring what they learn and how they learn. Simply stated, SDL occurs when learners take responsibility of their own education (Kaufman 2003).

In SDL, the teacher's role shifts from that of an instructor to more of a facilitator of learning (Borich 2014; Brookfield 1986; Merriam et al. 2007). A learner can be driven by an instructor to become more self-directed when class materials and activities are designed to foster independent construction of understanding (Borich 2014). Lectures, assignments, activities, and assessments for flipped science classes can all be created using SDL models. For example, lectures are moved out of the classroom, requiring students to self-direct their content knowledge acquisition. Note-taking must be done independently, with limited outside motivation for accountability. In class, students are expected to locate and utilize resources for a variety of learning activities, which are facilitated but not dictated by the instructor. These activities are aimed at engaging students in their own learning through collaborative exercises and multiple points of view (Meyer 2014).

### Self-Regulated Learning

The SRL model assumes that students are able to monitor and regulate the various aspects of their cognition, behavior, and study environments, and can effectively assess whether or not their learning process is working for them, or if changes need to be made (Pintrich 2004). Winne (1995) describes how self-regulated learners approach a learning task:

> When they begin to study, self-regulated leaners set goals for extending knowledge and sustaining motivation. They are aware of what they know, what they believe, and what the differences between these kinds of information imply for approaching tasks. They have a grasp of their motivation, are aware of their affect, and plan how to manage the interplay between these as they engage with a task. (p. 173)

Wolters (2003) states that these learners make use of a large number of strategies to assist them in their academic pursuits and in managing the learning process. Wolters et al. (2005) organize a variety of self-regulatory strategies into *cognitive*, *motivational*, and *behavioral* dimensions. Cognitive regulation can occur through (a) rehearsal strategies—repeating things over and over again until committed to memory; (b) organizational strategies—organizing information into diagrams, concept maps, etc.; (c) elaboration strategies—summarizing material in one's own words; and (d) monitoring of metacognition—assessing comprehension and progress towards goals. Four sets of strategies are classified as regulators of motivation in their schema: (a) self-consequating—extrinsic consequences for goal achievement or failure; (b) environmental structuring—arranging surroundings so academic work can be completed with few distractions; (c) self-talk—either intrinsic thoughts or extrinsic vocalization to convince the learner to continue with the task; and (d) interest enhancement—increasing intrinsic motivation by identifying personal value of a task. Last, they identify management of effort, study time regulation, and help-seeking as regulation of behavior strategies.

Since success in a flipped class requires students to prepare for class by performing a task (e.g., watching a lecture) that is traditionally considered a passive event, students may need to be aware of their interaction level with the task and regulate their motivation in order to be successfully prepared for class. Wolters et al. (2005) capture the potential relationship between SRL and the flipped model:

> The challenge to complete academic work at home without the structure of social pressures to continue working that are present in the classroom can be even more difficult. In light of these obstacles, students' ability to actively influence their own motivation is viewed as an important aspect of their self-regulated learning. (p. 254)

In a flipped science class, students are responsible for watching pre-recorded lectures in prepartion for in-class activities; optimal preparation for a may occur through the utilization of SRL strategies.

The role of student perceptions is another important consideration. Lee and Tsai (2011) compared student perceptions of SRL in online and traditional learning environments and found that students were more interested in utilizing SRL strategies in online learning contexts than traditional learning contexts. This finding is supported by Liaw et al.'s (2008) investigation of learners' attitudes towards online learning. They found that learners' attitudes can directly influence cognition, which in turn has a direct effect on behaviors. In a follow-up study, Liaw and Huang (2013) looked specifically at how student perceived satisfaction of online learning environments (i.e., acceptance of system and degree of comfort using system) affected SRL. Their findings indicated that SRL in online environments was predicted by perceived satisfaction; explicitly, student attitudes about online environments affected learning behaviors.

## Active Learning

Active learning is not an individual, concrete theory that can be attributed to a particular educational theorist, but rather an instructional approach that is firmly grounded in constructivism (Meyer 2014). The work of renowned constructivists John Dewey, Lev Vygotsky, and Jean Piaget have greatly influenced current efforts to increase active learning in the classroom (Kolb 1984; Zuckerman 2003; Karpov 2003; Bonwell and Eison 1991). Brooks and Brooks (1993) state that the constructivist' framework calls for teachers to design a learning environment where student autonomy is encouraged. Under this framework, learning tasks are designed around the use of data and primary resources, which require students to think critically, and open dialog is promoted among students and with the instructor. Vygotsky was a strong proponent of the idea that knowledge is constructed both through individual processes and in social contexts (Kozulin 2003; Zuckerman 2003). Support for the use of social construction, in the form of cooperative learning or team-based learning where individuals actively engage with each other to address real-world problems, has been shown to substantially increase achievement and benefit learners (Hrynchak and Batty 2012; Stockdale and Williams 2004). The flipped model relies heavily on learners constructing their understanding of content while engaged in learning activities. Meyer (2014) explains that learners who are actively engaged in a content-related task are able to construct knowledge through the interaction, and that learning is an active, rather than passive process.

The major argument behind the use of the flipped model is to increase the time students have to actively engage in collaborative activities and decrease the time students passively listen to a didactic instructor. Moving out of the Industrial Age and into the Information Age has placed a different demand on education (Watson and Reigeluth 2008); technology has made the learning task of memorizing facts nearly obsolete (Park and Choi 2014). In their review of the literature on active learning, Bell and Kozlowski (2008) found that compared to passive learning methods, active methods give learners more control over their learning and foster the "inductive" learning process of knowledge construction. Learners in a classroom that supports active learning are involved in higher-order thinking skills, such as analysis, synthesis, and evaluation, and are thinking about what they are doing while they are doing things (Bonwell and Eison 1991). Specific to science courses, Slater et al. (2006) state that collaborative learning groups are the most successful strategy an instructor can utilize. Institutions are also interested in increasing the collaborative learning occurring among their students. The National Survey of Student Engagement (NSSE), a very large and well-known collegiate satisfaction survey, is built on five benchmarks. Notably, active and collaborative learning is one of them (Meyer 2014). Specially designed active learning classrooms (ALC) are being developed on college campuses and utilized by science faculty to facilitate new instructional methods where learners can better interact and communicate about course content. Large granting agencies, like the National Science Foundation (NSF), are supporting ALC with funds provided to institutions to decrease the amount of lectures and increase active learning in introductory science courses (Mervis 2009). Many groups have shown that the investment in increasing active learning is paying off, with significant growth of academic performance being observed in courses where passive teaching methods have been replaced with more active methods (Freeman et al. 2007; Mervis 2010; Lord 1997). Results have been particularly encouraging among disadvantaged students (Haak et al. 2011; Carini et al. 2006).

## Flipped Model of Instruction

The primary driving force behind the increased presence of flipped classrooms on college campuses is the instructors' desire to provide their students with better learrning opportunities (Sonic Foundry 2013). Students in a flipped science course watch pre-recorded videos containing lectures on the course concepts prior to coming to class, and then participate in learning activities during class time. The learning activities help integrate the content in the video lectures with authentic problems and issues, aligning the flipped model with constructivist approaches (Ray and Powell 2014).

Anecdotal evidence across disciplines identifies several justifications for the move to the flipped model of instruction, including (a) an increase in student engagement, (b) stronger collaboration skills, (c) differentiated instruction, (d) deeper discussion of content, and (e) creative freedom for faculty

(Millard 2012). Empirical research comparing different aspects of the flipped model to traditional methods of instruction is showing up more often in the literature. Hussey et al. (2014) found that the flipped model in a psychology stats course increased the number of learning opportunities over the traditional model and led to significantly improved learning. In an upper-division engineering course, Mason et al. (2013) also found improved learning where students in a flipped course out-performed students in a traditional course on problem sets. In a study on learners' autonomy in a flipped statistics course, Marchionda et al. (2014) learned that flipped courses contribute to the development of autonomy of learners, but this independence did not result in higher course grades.

Studies focused on comparing student achievement in flipped and traditional courses have produced mixed results. Wilson (2013) examined course grades in a statistics course both before and after the flipped model was implemented and found that grades increased after the instructor flipped the course. Pierce and Fox (2012) also showed that the flipped model positively impacted student performance in a pharmacy course, citing the increase of active learning strategies as the major reason. In their study, McLaughlin et al. (2013) found no difference in students' academic performance between the flipped and traditional models, but did find significant increases in student engagement and autonomy. No studies reviewed were found to show that the flipped model resulted in a decrease in student academic achievement.

Roach (2014) explains that to best understand how the flipped model works in practice, it is important to consider student attitudes about flipped learning alongside of the model's efficacy. Holbrook and Dupont (2011) found that students in both introductory and advanced courses indicated the online lectures to be helpful for learning the course content. Enfield's (2013) study showed that students valued the ability to view lectures at their own pace. Francis (2014) found that higher-achieving students had higher viewing frequencies than lower-achieving students; those getting A letter grades spent more time watching lectures than those getting D or F letter grades. Smith's (2013) study provides support to these findings. When he asked students about their attitudes towards the flipped model, he uncovered that students generally perceive lectures outside of class as an added burden, but students recognize their usefulness in learning course content. His participants also indicated that they preferred lectures that were short and engaging, and provided an easy to locate specific content. Many studies on student perceptions of the flipped model indicate that students have positive attitudes towards the in-class learning activities (McLaughlin et al. 2013; Wilson 2013; Smith 2013; Pierce and Fox 2012). Students value the student-centered classroom atmosphere and increased collaboration realized in a flipped classroom (Newman et al. 2014). Wilson (2013) suggests that students' individual personalities might predict how students perceive a flipped class.

## Purpose of the Study

The purpose of the current study was to test the relationship between undergraduate students' perceptions of the flipped model, use of SRL strategies, and course achievement in an introductory biology course where the instructor utilized the flipped model for instruction. Two research questions guided the study; are students' perceptions of a flipped class predictive of their SRL strategy use? and does the use of SRL strategies in a flipped class predict student achievement? Based on the research questions and available literature, two hypotheses were formed:

> *Hypothesis 1*: perceptions of the flipped model predict SRL strategy use.
> *Hypothesis 2:* SRL strategy use in a flipped environment predicts achievement.

Together, these hypotheses suggest that perceptions affect SRL strategy use, and the use of SRL strategies affect achievement.

## Method

### Participants and Procedures

Participants were 76 undergraduate students recruited from Biology (BIOL) 111 at a large, mid-western public research institution. BIOL 111 is an introductory, non-majors biology course in which the instructor had been teaching using the flipped model for several semesters. A majority of participants (82.9%) indicated that this was their first flipped course while 17.1% indicated that they had taken at least one flipped course at some point in the past. Table 1 displays all demographic information collected on participants.

The study utilized a cross-sectional survey design and was approved by the Institutional Review Board (IRB) of the university with which the author is affiliated. Data was collected at a single time-point during the 13th week of a 16-week semester via a paper survey.

### Measures

**SRL Strategies** A modified version of the Motivated Strategies for Learning Questionnaire (MSLQ; Wolters et al. 2005) was used to measure SRL behaviors in students. Modifications included the removal of a few complete scales not central to the study, along with some individual items displaying redundancy. A few of the items were also re-worded so that they better aligned with the flipped model. The modified MSLQ contained 52 items that assessed three dimensions of SRL— academic cognition, academic motivation, and academic behavior. Items

**Table 1** Demographic characteristics

| Variable | Subcategory | BIOL 111 $N = 76$ | |
|---|---|---|---|
| | | *n* | % |
| Gender | Female | 52 | 68.4 |
| | Male | 24 | 31.6 |
| Age in years[a] | 18 | 14 | 18.4 |
| | 19 | 29 | 38.2 |
| | 20 | 20 | 26.3 |
| | 21 or older | 13 | 17.1 |
| Ethnicity | White | 72 | 94.7 |
| | Black | 1 | 1.3 |
| | Amerindian | 1 | 1.3 |
| | Asian | 1 | 1.3 |
| | Other | 1 | 1.3 |
| Year in College | Freshman | 33 | 43.4 |
| | Sophomore | 32 | 42.1 |
| | Junior | 6 | 7.9 |
| | Senior | 5 | 6.6 |

Totals of percentages are not 100% for every characteristic because of rounding off

[a] 1 = 18, 2 = 19, 3 = 20, 4 = 21 or older ($M = 2.42$, $SD = .98$)

were grouped on a theoretical basis to create subscales within each dimension and tested by the calculation of Cronbach's alpha as a measure of internal consistency among the items. Academic cognition included two subscales, *study strategies* (10 items; $\alpha = .78$) and *regulation of metacognition* (5 items; $\alpha = .82$) One item was removed from the regulation of metacognition subscale to improve the reliability coefficient. Academic motivation was comprised of four subscales: (a) *self-talk* (8 items; $\alpha = .84$), (b) *interest enhancement* (8 items; $\alpha = .92$), (c) *environmental structuring* (3 items; $\alpha = .84$), and (d) *self-consequating* (3 items; $\alpha = .93$). The environmental structuring and self-consequating subscales each had one item removed to improve their reliability coefficients. Academic behavior was measured using two subscales, *effort* (6 items; $\alpha = .64$) and *help-seeking* (3 items; $\alpha = .93$). One item was removed from the effort regulation sub-scale to improve reliability of the coefficient. All items were assessed on a 7-point scale (1 = *not at all true of me*, 7 = *very true of me*). Scores on negatively worded items were reversed, and items in respective sub-scales were averaged before any analyses were conducted. The descriptive statistics demonstrate normal distributions of each sub-scale for individual sub-scales and are provided in Table 2.

**Perceptions of the Flipped Model** Items aimed at measuring student perceptions of the flipped model were identified in previously published surveys (Newman et al. 2014; McLaughlin et al. 2013; Smith 2013; Roach 2014; Pierce and Fox 2012), modified, and compiled into a 32-item survey. This collection of items aimed to assess the two dimensions of the flipped model—the online video lectures and in-class active learning. Since the items were not part of a validated scale, exploratory factor analysis was conducted to assess the validity of any sub-constructs within the two dimensions.

Initial exploratory factor analysis called for the extraction of four factors from the video lectures dimension. However, upon review of the content of each item, it was decided to remove items not central to the research questions of the study (technical aspects of accessing videos and asking question). Exploratory factor analysis was again conducted, this time leading to the extraction of three sub-scales. Reliability analysis was conducted on the items within each sub-scale and results indicated strong internal consistencies: (a) *preference of video* (3 items; $\alpha = .79$), (b) *value of video* (7 items; $\alpha = .92$), and (c) *viewing frequency* (3 items; $\alpha = .84$)

The preference of video and viewing frequency sub-scales each had one item removed to improve their reliability coefficients. The viewing frequency items addressed specific lecture viewing behaviors rather than attitudes, yet was included

**Table 2** Study 1: self-regulated learning measure items and averaged descriptive statistics

| Dimension | Subscale | # of items | Descriptive statistics | | | |
|---|---|---|---|---|---|---|
| | | | *M* | *SD* | Skewness | Kurtosis |
| Academic cognition | Study strategies | 10 | 4.27 | .93 | .20 | −.24 |
| | Metacognition | 5 | 4.41 | 1.25 | −.37 | −.47 |
| Academic motivation | Self-talk | 8 | 5.12 | .97 | −.20 | −.90 |
| | Interest enhancement | 8 | 3.34 | 1.34 | −.11 | −.92 |
| | Environmental structuring | 3 | 4.86 | 1.41 | −.43 | −.36 |
| | Self-consequating | 3 | 4.31 | 1.84 | −.32 | −1.17 |
| Academic behavior | Effort regulation | 6 | 5.05 | .94 | −.33 | −.05 |
| | Help-seeking | 3 | 5.33 | 1.46 | −.93 | .80 |

Descriptive statistics were calculated using the averaged vales of each individual scale

Range for all subscales was 1 (not at all true of me) to 7 (very true of me) in this construct because of thier relationship to video lectures, which have been shown to positively influence achievement (Francis 2014). Exploratory factor analysis of the second set of items concerned with in-class active learning proposed that two factors be extracted from the video lectures dimension. Reliability analysis was conducted on the items within each subscale and results indicated strong internal consistencies: *learning enhancement* (4 items; α = .93) and *value of active learning* (7 items; α = .87). The value of active learning subscale had one item removed to improve the reliability coefficients.

All flipped model perception items were assessed on a 7-point scale (1 = not at all true of me*,* 7 = *v*ery true of me). Scores on negatively worded items were reversed, and items in respective subscales were averaged before any analyses were conducted. The descriptive statistics for each subscale are provided in Table 3. All subscales demonstrated normal tendencies except for *learning enhancement*, which shows a peaked distribution around the high levels of agreement.

**Course Grades** Course grades were collected at the same time that the survey was completed. Grades obtained from the instructor reflected the students' achievement in the course at that point in the semester (1 = *F*, 2 = *D*, 3 = *C*, 4 = *B*, 5 = *A*; *M* = 3.82, *SD* = 1.029).Descriptive statistics were calculated using the averaged vales of each individual scale

Range for all subscales was 1 (not at all true of me) to 7 (very true of me)

### Data Analysis

Data analysis (using computer software SPSS 23) aimed at addressing the two research questions was completed using the subscale averages. Correlational analyses were used to identify relationships between SRL, flipped perceptions and achievement variables. Because of previously published models describing direct effects of perceptions on SRL behaviors in online environments (Liaw and Huang 2013; Liaw et al. 2008) and direct effects of perceptions on SRL and then SRL on achievement (Mega et al. 2014), multiple regression was carried out to determine if SRL and flipped perceptions predict student achievement and also if flipped perceptions predict SRL. In the first set of regressions, all of the SRL strategies and flipped perceptions subscales collectively served as the predictor variables, while course grades was the criterion variable. In the second set of regressions, the SRL strategies and flipped perceptions subscales were individually tested as predictors of the dependent variable of course grades. A hierarchical regression was also completed with flipped perceptions subscales as the first-level predictor and SRL strategies as the second-level predictor of course grades.

## Results

### Correlations

Analysis began with a Pearson correlational analysis to identify the magnitude and direction of relationships among the study variables. SRL and flipped perceptions averaged subscales, along with course grade and previous experience with the flipped model were all included in the analysis. Table 4 presents several significant, positive intercorrelations of subscales within the SRL construct. Notably, study strategies had strong bivariate relationships with metacognition, self-talk, and effort. Also, self-talk was strongly correlated with metacognition and effort. Many significant, positive intercorrelations were also realized among the flipped perception construct subscales. Strong bivariate relationships were found to exist between value of video and viewing frequency, as well as between active value and learning enhancement.

Table 4 also shows that several significant, positive relationships existed between the SRL flipped perception subscales. However, video preference was the only flipped perception subscale to not significantly correlate with any of the SRL subscales. Students' previous experience with the flipped model also showed no significant correlation with any of the subscales from either construct. Students' course grade only weakly correlated at a level of significance with effort within the academic behavior dimension of SRL, and did not correlate with any of the flipped perception subscales.

Overall, the correlational analysis identified that positive relationships not only existed among subscales within each individual construct, which was anticipated, but also between

**Table 3** Study 1: flipped perception measure items and averaged descriptive statistics

| Dimension | Subscale | # of items | Descriptive statistics | | | |
|---|---|---|---|---|---|---|
| | | | *M* | *SD* | Skewness | Kurtosis |
| Flipped video perceptions | Preference of Video | 3 | 2.57 | 1.37 | .74 | −.15 |
| | Value of Video | 7 | 3.96 | 1.50 | −.35 | −.54 |
| | Viewing Frequency | 3 | 3.17 | 1.66 | .29 | −.85 |
| Active learning perceptions | Learning Enhancement | 4 | 5.76 | 1.36 | −1.59 | −2.26 |
| | Value of Active Learning | 7 | 5.19 | 1.32 | −.86 | −.10 |

**Table 4** Correlations among SRL, flipped perceptions, grades, and flipped experience

| Scales | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Study strat | – | | | | | | | | | | | | | | |
| 2. Metacognition | .62** | – | | | | | | | | | | | | | |
| 3. Self-talk | .63** | .68** | – | | | | | | | | | | | | |
| 4. Interest enhance | .29* | .35** | .40** | – | | | | | | | | | | | |
| 5. Environ struct | .28* | .37** | .48** | .45** | – | | | | | | | | | | |
| 6. Self-conseq | .22 | .42** | .31** | .37** | .45** | – | | | | | | | | | |
| 7. Effort | .53** | .46** | .61** | .33** | .43** | .13 | – | | | | | | | | |
| 8. Help-seeking | .20 | .34** | .22 | −.05 | .13 | .07 | .18 | – | | | | | | | |
| 9. Pref of video | .18 | .11 | −.07 | .16 | .10 | .12 | .03 | .16 | – | | | | | | |
| 10. Value of video | .37** | .39** | .34** | .33** | .30** | .29* | .44** | .12 | .30** | – | | | | | |
| 11. Viewing freq | .41** | .38** | .29* | .29* | .29* | .27* | .39** | .07 | .36** | .68** | – | | | | |
| 12. Learn enhance | .26* | .34** | .35** | .34** | .14 | .15 | .18 | .37** | .25* | .46** | .16 | – | | | |
| 13. Value of active | .34** | .40** | .25* | .37** | .13 | .16 | .27* | .49** | .44** | .54** | .38** | .74** | – | | |
| 14. Grade | .12 | −.00 | .17 | −.20 | .12 | −.04 | .23* | .07 | .02 | −.01 | −.03 | −.08 | −.06 | – | |
| 15. Prev flip exp | −.09 | .07 | −.04 | −.12 | −.08 | .12 | −.01 | −.14 | −.12 | .00 | .07 | −.06 | −.18 | .11 | – |

* $p < .05$ (two-tailed), ** $p < .01$ (two-tailed)

constructs, which suggests that students' perceptions about the flipped model may be related to their SRL strategy use. This idea was further examined through regression analysis, specifically aimed at addressing the research questions.

## Multiple Regression

**Question 1** The first research question asked if students' perceptions of a flipped class were predictive of their SRL strategy use. To address this question, a set of simultaneous multiple regressions were conducted with the subscales of flipped perceptions serving as the predictor variables of the individual SRL strategy subscales. The results of these regressions are displayed in Table 5. The overall flipped perceptions model significantly predicted six of the eight SRL strategy subscales, including study strategies, metacognition, self-talk, interest enhancement, effort, and help-seeking. Only environmental structuring and self-consequating, both part of the academic motivation dimension of SRL were not predicted by the overall flipped perceptions model. When looking at specific perceptions of the flipped model, only a few significant predictors were realized. Study strategies were predicted by viewing frequency, self-talk strategies were predicted by learning enhancement, and help-seeking strategies were predicted by value of active learning.

**Question 2** The second question asked if the use of SRL strategies in a flipped class predicts student achievement. To address this question, a simultaneous multiple regression analysis was conducted with the subscales of SRL strategies predicting student grades. Results of the regression analysis did not indicate that the overall SRL model significantly predicted grades ($R^2 = .19$, $p > .05$).

Hierarchical multiple regression analysis was also conducted in an effort to uncover any predictive relationships that might exist between SRL and flipped perceptions on student grades. Aligning with the two research questions, flipped perceptions were selected for the first level of predictors while SRL was selected as the second level. No significant results were generated from this analysis.

## Discussion

The purpose of this study was to examine the relationship between two variables—students' perceptions of the flipped model and their SRL behaviors—and the impact that these variables have on achievement in a flipped introductory biology class. Several significant positive intercorrelations were found among the SRL subscales. Study strategies, a subscale of the academic cognition dimension of SRL had strong positive bivariate correlations with subscales in the other two dimensions of academic motivation and behavior. This suggests that SRL strategies, regardless of which dimension they fall into, are all interrelated and demonstrate students' ability to be mindful of how they best learn. One assumption of SRL as a whole is that learners are able to regulate aspects of cognition, motivation, and behavior (Pintrich 2004), and so it is logical that intercorrelations among SRL variables exist.

Likewise, many flipped perception variables positively correlated with each other. Strong positive relationships between students' perceived value of the video and how often they watched the videos before coming to class were found.

**Table 5** Flipped perceptions as predictors of SRL strategy use

| SRL subscale | Flipped perceptions | Overall model $R^2$ | Individual β | *p* |
|---|---|---|---|---|
| Study strategies | Overall | .22** | | .00 |
| | Preference of video | | −.02 | .87 |
| | Value of video | | .05 | .77 |
| | Viewing frequency | | .33* | .04 |
| | Learn enhancement | | .11 | .51 |
| | Value of active | | .11 | .53 |
| Metacognition | Overall | .25** | | .00 |
| | Preference of video | | −.13 | .28 |
| | Value of video | | .03 | .88 |
| | Viewing frequency | | .30[†] | .06 |
| | Learn enhancement | | .14 | .41 |
| | Value of Active | | .23 | .20 |
| Self-talk | Overall | .24** | | .00 |
| | Preference of video | | −.24[†] | .05 |
| | Value of video | | .09 | .60 |
| | Viewing frequency | | .29[†] | .07 |
| | Learn enhancement | | .39* | .02 |
| Interest enhance | Overall | .18* | | .02 |
| | Preference of video | | −.02 | .86 |
| | Value of video | | .06 | .72 |
| | Viewing frequency | | .17 | .31 |
| | Learn enhancement | | .18 | .31 |
| | Value of active | | .15 | .42 |
| Environ struct | Overall[a] | .10 | | .18 |
| Self-consequating | Overall[a] | .09 | | .27 |
| Effort | Overall | .24** | | .00 |
| | Preference of video | | −.17 | .17 |
| | Value of video | | .31[†] | .07 |
| | Viewing frequency | | .20 | .21 |
| | Learn enhancement | | −.04 | .79 |
| | Value of active | | .13 | .46 |
| Help-seeking | Overall | .28** | | .00 |
| | Preference of video | | −.05 | .69 |
| | Value of video | | −.22 | .20 |
| | Viewing frequency | | .01 | .96 |
| | Learn enhancement | | .04 | .80 |
| | Value of active | | .59** | .00 |

[a] Individual subscale results were not provided due to lack of statistical significance of overall model

*$p < .05$, **$p < .01$

[†] Results may be statistically significant with a larger sample size

Although other studies show student positive attitudes towards video lectures (Newman et al. 2014; Holbrook and Dupont 2011; Smith 2013; Enfield 2013; Pierce and Fox 2012; Roach 2014), this direct linkage between value and viewing frequency was not found in the literature. An additional strong relationship was also found to exist between the value placed on active learning and learning enhancement; students who value active learning strategies indicate that in-class activities enhance their learning. In regards to learning enhancement, Svinicki (2004) states that "during the learning of content, learners are picking out key features that define the concepts and making connections between that new information and their existing world views" (p. 14). This aligns with active learning and constructivist teaching where there is a stronger emphasis on understanding concepts than on memorizing facts (Lord 1997).

Correlational analysis also pointed out positive relationships between many of the SRL and flipped perception subscales. Study strategies had a moderately strong relationship to viewing frequency. This may mean that students who are able to regulate their study behaviors are more likely to view the assigned lectures. Lecture value and viewing frequency were also shown to correlate with effort; those students who put forth greater effort in the course will prepare by watching the videos and understand what value comes from doing so. Additionally, metacognition regulation correlated with value of active learning, indicating that students who perceive the in-class activities as valuable to learning the content, utilize metacognitive strategies.

Overall, several positive relationships were found among SRL and flipped perception variables suggesting that students' perceptions of the flipped model may influence their SRL strategy use. The two research questions yielded two separate hypotheses about predictive relationships that may exist between student perceptions and SRL, and between SRL and student achievement. These hypotheses were tested through simultaneous multiple regression analysis.

**Hypothesis 1: Perceptions of the Flipped Model Predict SRL Strategy Use** Based on Liaw and Huang's (2013) work that demonstrated SRL in online environments was predicted by student perceptions of usefulness and satisfaction, it was anticipated for the current study that students who have positive perceptions of the flipped model would utilize SRL strategies in a flipped course. A set of simultaneous multiple regressions showed that the overall flipped perceptions model significantly predicted study strategies, metacognition, self-talk, interest enhancement, effort, and help-seeking. Only two subscales within the academic motivation dimension—environmental structuring and self-consequating—were not predicted by flipped perceptions. Although subscale means cannot be used to rationalize correlation results, it is of note that students indicated low agreement with preference of video ($M = 2.57$) and viewing frequency ($M = 3.17$) items. Out-of-class videos could be involved with structuring a study environment and motivating one's self to watch the videos before class, possibly by setting consequences.

Of the remaining six subscales, only three significant predictors of SRL were found when specific perceptions of the flipped model were examined. First, study strategies were significantly predicted by viewing frequency. It is logical to think that students who take the time to view the lectures are likely to regulate their study time. The use of study strategies in flipped classes is highlighted by Talbert (2016) when he posits that students must utilize SRL strategies, especially for video lectures because of the "emphasis on individual responsibility for learning basic material prior to class" (p. 31). Pigg and Morison (2016) add that "the ability to make appropriate choices about when and under what conditions to view the content" (p. 141) is important in retaining information from video lectures. Second, self-talk strategies were predicted by students' perception of enhanced learning. This relationship can be restated to say that students who feel their learning of course content is enhanced through in-class activities are more likely to speak words of encouragement to themselves as they study, whether it be via internal thoughts or actual vocalization. Finally, help-seeking behaviors were predicted by student perceptions regarding the value of active learning. Interestingly, in active learning situations, students are typically constructing knowledge in small groups through some sort of inquiry-based activity. However, it has been found that in large college class settings, students are more likely to seek help from teachers rather than other students (Karabenick 2003). This practice may change over time as the role of the instructor more clearly shifts to a facilitator of learning with the increased prominence of active learning classrooms on college campuses.

**Hypothesis 2: SRL Strategy Use in a Flipped Environment Predicts Achievement** Zimmerman (2008) states SRL is a proactive process and Bergmann and Sams (2012) posit the flipped model requires students to take an active role in learning, so for the current study it was anticipated that students who utilized SRL strategies in the flipped classroom would have higher course grades than those students who do not utilize SRL strategies, and specific SRL strategies that had the most influence on success in the flipped model would be exposed. Simultaneous multiple regression failed to indicate any impact of the overall SRL model on course grades. Course letter grades were the dependent variable, and only consisted of five different possible options—A, B, C, D, and F—leaving little room for variability among the participants. Even though the grade data for the current study was normally distributed according to skewness and kurtosis values, the sample size may not have been large enough for statistical analyses to have enough power to detect significance (Warner 2013). Additionally, bias in grading may come into play in flipped classrooms, resulting in grades that are not truly reflective of the students' actual understanding of the content. Malouff (2008) identifies a variety of types of bias that are possible in grading, many of which may come about in a flipped classroom because of the increased student-teacher exchanges.

## Implications for Flipped Science Courses

Student perceptions identified in this study displayed a large acceptance and preference of active learning practices, but a low perception of the utility of video lectures. The findings suggest students desire the in-class activities, but not the out-of-class preparation for them. This may be a result of not knowing how to effectively interact with a video lecture. Herreid and Schiller (2013) propose that perceptions may change as familiarity with the flipped model increases. Newman et al. (2014) support this idea. Their study found that students were more comfortable and appreciative of working collaboratively with others if they had prior experience with the flipped model. They suggest that when students are initially exposed to the flipped model, they are not prepared to learn independently (via videos) and constructively during class; it is only with practice that most students can realize the benefits of a flipped class.

SRL strategies can be a vital aspect of learning in a flipped science course. Winne (1995) claims that SRL is inherent in learners; in academically poor students it might be less complex, yet strategy use can be fostered by environmental influences. Instructors of flipped courses may have to spend time with students at the start of a flipped course, showing them ways to develop their SRL skills. Students may perceive the out-of-class lecturers in flipped courses as non-effective and consequently they may do little to regulate their cognition, motivation, and behaviors when first exposed to the new teaching style. When students enter their first flipped course, the instructor may need to take time to model SRL strategies when interacting with lecturers; the first few lectures could be viewed together in class with the instructor guiding students in SRL techniques.

Education in the twenty-first century is changing to better prepare students for the work they are going to encounter upon graduation. Manual routine work is being replaced by technological advances, and jobs that require collaborative problem solving and applied complex skills are rapidly increasing (Trilling and Fadel 2009). The active learning that occurs in the flipped classroom allows for the perfect environment for students to build twenty-first century 4C skills (i.e., collaboration, communication, creativity, and critical thinking; Newman et al. 2014). Employers are not interested in a student's ability to passively listen to information: they demand a workforce that can demonstrate the 4Cs along with social competence.

This study found that biology students prefer the active learning aspect of the flipped model, but have less positive perceptions about the online lecture component. Data analysis found that these perceptions do have some impact on SRL strategy use, although limited. Taken together and incorporating the available literature, these results suggest that flipped classrooms have their successes in the active learning sessions. Video lectures hold an important role for those self-directed learners who are able to self-regulate their academic cognition, motivation, and behaviors, giving them the ability to watch and re-watch if they wish. However, the active learning exercises engage a larger range of students, not only getting them to interact with the content, but also fostering twenty-first century skills through constructivist teaching methods.

## Limitations

The findings of this set of studies need to be interpreted in light of the limitations. This study makes the assumption that students are accurately reporting their SRL behaviors and flipped model perceptions on a survey. There is also the assumption that the students' course grades are an accurate reflection of their understanding of the content of the course materials. There were also limitations realized in the study design. The sample size was small; a larger sample size would have given more power to the statistical analyses that were conducted. The use of course letter grades as a measure of achievement may not have been the most reliable and precise method of measurement. Many instructors provide students a variety of ways to earn a course grade, including things such as participation and behavior-based points, neither of which accurately reflect understanding of content. The cross-sectional survey design also limits the findings due to its single time-point data collection. A longitudinal design, utilizing two or three surveys throughout a course would provide for a more reliable data set, even showing changes in SRL over the course.

## Future Research

The findings of this study add to the growing body of empirical research on the flipped model of teaching. Student perceptions have been a common theme across many studies, but the investigation of what role SRL plays has not. Future studies should further investigate how important SRL skills are for students to adequately prepare for active learning during the in-class sessions. A mixed-method study offers an approach at gaining a better understanding of how, and if, students are actually interacting with video lectures. A study with this focus may help assess whether or not the videos are worth the time and technological resources that must be invested in their creation. A study designed to better detect effects of mediation would be a great follow-up to the current study. The model that perceptions of a course can impact achievement, mediated through SRL strategy use, could be tested for significance through structural equation modeling and lead to a better understanding of SRL in flipped science courses.

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