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INVESTIGATING WHETHER THE FLIPPED CLASSROOM INSTRUCTIONAL APPROACH IN CONJUNCTION WITH GENDER, SATISFY STUDENTS' BASIC PSYCHOLOGICAL NEEDS AND INFLUENCE THEIR CHEMISTRY ACHIEVEMENTS IN HIGH SCHOOL

Jordan Salhoobi
Saint John's University, Jamaica New York

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Jordan Salhoobi

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Jordan Salhoobi

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Dr. Rene S. Parmar

ABSTRACT

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The current study aims to investigate whether the instructional approach (flipped or traditional) and gender (male or female) influence students' sense of autonomy, relatedness, and competence, or influence their achievements in high school chemistry. Merrill's First Principles of Instruction theory was used to design the flipped classroom (FC) implemented in this study as recommended by Lo, Lie, and Hew in 2018. The theoretical framework for the study is the Self-Determination Theory (SDT) which posits that satisfaction of individuals' psychological needs for autonomy, competence, and relatedness, enhance their intrinsic motivation and performance (Deci & Ryan, 2002). Ninety participating students who enrolled in two similar high schools located within the same school district in the Northeastern region of the United States were divided equally into flipped and traditional chemistry classrooms. Students were ethnically diverse, spoke English, and identified as either male or female. Both participating teachers (one per each group of students) were Asian-American females, certified to teach chemistry by New York state (NYS), and have at least 20 years of experience in teaching the subject. The current quasi-experimental study employed a series of four two-way ANCOVA tests to

analyze the influence of the independent variables (instructional approach and gender), on the dependent variables (academic achievement, and perceived autonomy, competence, and relatedness in chemistry classrooms). Results of the current study indicate that there were no significant differences between students' perceptions of autonomy, relatedness, or competence based upon the instructional approach or gender, however, there was a significant difference between students' academic achievement based upon the instructional approach. Students in the flipped classroom group scored significantly higher on the post-assessment than students in the traditional classroom group. The current researcher suggests that other variables may have influenced students' achievement in the flipped classroom and further research is necessary. The current researcher recommends that future researchers measure students' situational engagement and motivation in FCs using the experience sampling method and report on qualitative data to provide further insight regarding the efficacy of the FC model. The current study adds to researchers and educators' knowledge new information about the efficacy of the FC model in secondary level, hybrid chemistry classrooms during the COVID-19 global pandemic.

DEDICATION

I dedicate this project to my family, mentors, colleagues (especially Joe and Liza), friends, and students; your presence in my life has inspired me to work persistently and thrive. My dear parents, I worked in silence for several years to earn my doctorate just so I can see your smiles when I surprise you on the day of graduation; making you proud of my accomplishments has always been my top priority. This project would not have been possible without the support of my mentors, building and district level administrators, and research participants; I thank you from the bottom of my heart for your guidance, patience, and kindness.

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CHAPTER 1: INTRODUCTION

Motivation and academic achievement of U.S students in science is concerning and calls for improvement. The Programme for International Student Assessment (PISA) measured the performance of nearly 600,000 students in the year 2018; results from this test indicate that only nine percent of 15-year-old U.S students demonstrate proficiency in science, and their average score in science in 2015 did not significantly vary from their average score in science in 2018 (NCES, 2020). Additionally, according to international comparison data indicated by the 2018 PISA scores, the achievement gap between the top performing U.S students and lower performers in science is larger than the achievement gap in 50 out of the 79 participating countries. Gender differences in science achievement were noted as well. Although the 2018 PISA results showed no significant variation in the science literacy scores of U.S. students based upon gender, globally, females outperformed males in 34 out of 79 countries, while males outperformed females in only 6 countries. In a review of the 2015 PISA results, the organization for economic cooperation and development (OECD) reported that students are not generally motivated to learn science and only 10% of students aspired to pursue science related careers in the future (OECD, 2016). Data from the National Science Foundation's website (NSF, 2017) indicate that female students are more motivated to pursue undergraduate degrees in the fields of biology and agricultural science than males, however, male students display greater interest in pursuing degrees related to engineering, math, and physical sciences.

The current global COVID-19 pandemic has affected the learning of over 1.6 billion students in 200 countries; teachers worldwide were rushed into utilizing digital tools to communicate information with stakeholders and teach students remotely (UNESCO, 2020). Kuhfeld and colleagues reported that in the United States, 55 million students were out of school due to this pandemic; they projected that the lack of access to technology and support at home would further widen the students' achievement gap by fall of 2020 (Kuhfeld, Soland, Tarasawa, Johnson, Ruzek, & Liu, 2020). The variation in students' performance and interest in science over the years calls for all education professionals to implement innovative instructional strategies to motivate students and improve their achievements in science classrooms.

Researchers have concluded that the use of technology in education supports students learning of science (Webb & Cox, 2004; Kozma, 2003). Love, Hodge, Grandgenett, and Swift (2014) asserted that although lecture-based teaching remains the mainstay in most academic institutions, many think that this method of instruction is not effective; furthermore, Lord and Camacho (2007) reported that only 36% of instructors believed lecturing was effective yet 60% of them continued to use this method of instruction in their classes. Betihavas, Bridgman, Kornhaber, and Cross (2016) claim that in a traditional lecture classroom, teachers deposit information into students' brains without any regards to their learning styles or interests.

A possible alternative to the traditional classroom, is the flipped classroom model (FC), Bergmann and Sams (2014) describe the FC as simply the inverted model of the traditional classroom. Mason, Shuman, and Cook (2013) describe the FC as a form of blended learning in which students learn independently at home and at their own pace by using instructor assigned online resources; during class time, students work collaboratively to solve problems and engage in social interactions with their peers and teacher. In a FC setting, students use technology to watch instructional videos, perform simulated lab activities, and complete assignments at home. Given that a very low percentage of instructors believe that lecturing is effective and that the use of technology supports students' learning, it is important to investigate how the FC model influences students' achievements and motivation to learn.

Several researchers have posited the benefits of the FC model with school age students. Chis, Moldovan, Murphy, Pathak, and Muntean (2018) argue that the FC is a good way to introduce active learning which has greater benefits over the passive traditional learning model. Abeysekera and Dawson (2015) acknowledge that a traditional lecture approach to teaching leads to an excessive cognitive load, which is detrimental to learning, while the FC design can limit this load and enhance memory of content learned. Baker (2000) suggests that in a FC, the teacher acts as a guide on the side to mentor and coach students, and in a traditional classroom, the teacher acts as the sage on the stage to deliver information. Låg & Saele (2019) conducted a meta-analysis to investigate whether student learning and satisfaction in a FC truly differ from the learning and satisfaction of students in the traditional environment. In their meta-analysis, they found that the FC has a small positive effect on student learning especially if instructors test students' preparation at the beginning of class. On the other hand, they suggest that although the FC model was developed nearly 30 years ago, there is a significant variation in research results regarding its efficacy, and that further research is necessary to explain the variation of these results. More recently, Strelan, Osborne and Palmer (2020) conducted a similar meta-analysis and found that the FC has a medium positive effect on students' learning. On the other hand, Zainuddin and Perera (2019) found that the FC model supports university level students' psychological needs (as suggested by the Self-Determination Theory (SDT)) and supports their achievement in English classes. Despite various attempts to investigate the efficacy of the FC, there have been no studies that investigated the influence of this model on the psychological wellbeing and achievement of secondary school students in chemistry.

Purpose of the Study

The purpose of the current quasi-experimental study is to investigate whether implementing the FC instructional approach supports the academic achievement and satisfies the psychological needs of female and male students in secondary level chemistry classrooms while controlling the three covariates: prior knowledge, prior achievement, and students' self-regulation orientations. The independent variables are the instructional approach implemented by the instructor and student gender. There are two levels of the active instructional approach variable (traditional and flipped classroom) and two levels of the attribute gender variable (male and female). The first dependent variable academic achievement was measured using a 15-question multiple-choice assessment that is composed of questions derived from previous New York State (NYS) Regents exams. The second dependent variable, students' psychological wellbeing, was measured via a slightly modified version of the Basic Psychological Needs Satisfaction Survey (BPNSS) (Deci, Ryan, Gagne, Leon, Usunov, & Kornazheva, 2001) which the researcher referred to as the Academic Basic Needs Questionnaire (A-BNQ). The A-BNQ was used in the current study to measure students' perceptions of autonomy, competence, and relatedness while enrolled in flipped or traditional chemistry classrooms. The first covariate (students' prior knowledge of chemistry) was measured prior to the intervention using the same assessment that was used to measure students' achievements at the end of the intervention. This assessment was administered to control students' knowledge of concepts related to the behavior of gases prior to learning about this unit in their respective chemistry classrooms. Another 15-question multiple choice test was made using previous NYS's Regents exam chemistry questions to measure the second covariate (prior academic achievement in chemistry). This test was administered to control students' prior sense of competence based on their knowledge of topics which they learned in their chemistry classrooms during the current school year and before the study's intervention. The third covariate (students' self-regulation orientations) was measured using the academic self-regulation questionnaire (SRQ) to control students' varying levels of intrinsic motivation as indicated by their relative autonomy index scores (Ryan and Connell, 1989).

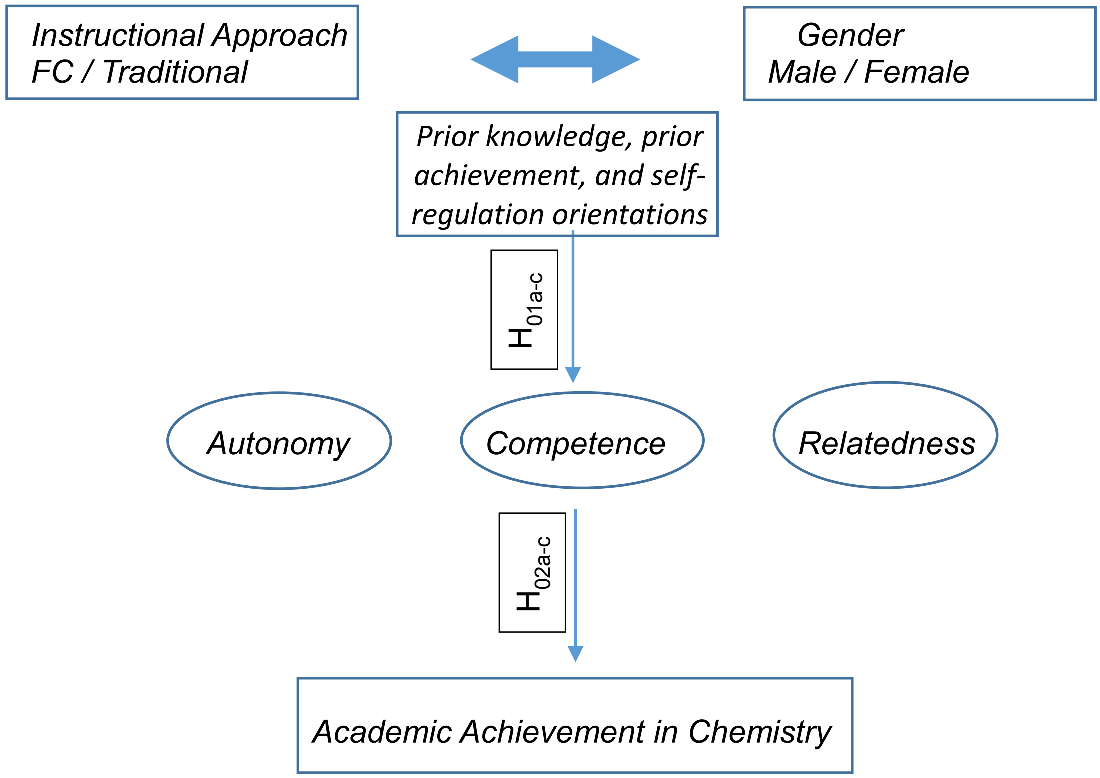
Researchers who investigated the efficacy of the FC model have emphasized that student autonomy and ability to learn independently are necessary for success within the approach. Students must be motivated to learn outside of a classroom environment and be able to monitor their own psychological states to persist to competence. The current research is framed within the principles of the Self-Determination Theory (SDT), a psychological theory that posits that individuals' motivation, personality, and emotions are influenced by the social environment of which they are a part (Deci & Ryan, 2002). Questionnaires developed by the SDT research group are used to examine student motivation and other factors that may be related to success in a FC model. The theoretical framework is further elaborated in Chapter 2.

Conceptual Framework

The conceptual framework connects the aim of the current study to the theoretical framework and provides an overview of the research. Ryan (1995) posits that the level of satisfaction of human basic psychological needs for autonomy, competence, and relatedness predict their productivity and persistence, just like satisfaction of plants' essential needs predicts their growth and productivity. Figure 1 displays the interaction effect of the current study's two independent variables- instructional approach (flipped or traditional) and student gender (male or female), as well as the effect of the covariates prior knowledge and self-regulation orientations, on students' perceptions of autonomy, competence, and relatedness, and on the students' academic achievements in chemistry. The current researcher aims to investigate whether female and male students' achievements in chemistry and perceptions of (a) autonomy, (b) competence, and (c) relatedness significantly vary when they learn in traditional or flipped high school chemistry classrooms while controlling the aforementioned covariates.

Figure 1

The Conceptual Framework for the Current Study



Theoretically, different activities often performed in a FC may satisfy students' innate psychological needs and increase students' achievements. In a FC, students transition from being passive learners to active learners who use a variety of resources to develop their skills, make connections and evaluate their understanding (Lo, Lie, & Hew, 2018). In a FC, students may learn curriculum's content autonomously outside of classroom time and in the comfort of their homes. The students choose when to learn and how much effort they invest in learning while watching online videos which they can rewind and replay to better understand concepts. Students can also measure their understanding of concepts in the comfort of their homes while practicing problems through computer programs or websites that automatically generate feedback and guide students as necessary (Lo et al., 2018). Also, in a FC, class time is often used to provide students with a greater opportunity to receive feedback and further develop their problem-solving skills while they work collaboratively with others and teach/ learn from their peers thus satisfying their need for competency (Lo et al., 2018). During class time, interaction is encouraged, teachers structure a student-centred learning environment where students work in groups to solve problems or conduct laboratory investigations thus helping students develop a greater sense of belonging and affiliation (Lo et al., 2018). When students are engaged in learning and motivated to learn, they become more likely to achieve higher grades on examinations (Wara, Aloka, & Odongo, 2018). Competency aligns with skill because when students have the skills needed for them to solve problems, the students feel more competent and confident of their abilities (Wara et al., 2018). In theory, the FC seems to be supportive of students' psychological needs, however, this claim was only supported at the university level (Zainuddin and Perera, 2019). Lord and Camacho (2007) posits that only 36% of teachers believe traditional instruction is effective, however there is no empirical evidence that suggest this method of instruction is any less supportive of students' psychological needs and achievements in secondary level, general chemistry classrooms than the flipped instructional model; therefore, the current researcher extends research in this area.

The present research also considers the possibility of gender-based variance in student responsiveness to FC and traditional classroom. Juuti, Lavonen, Uitto, Byman, and Meisalo (2010), in a study conducted in Finland, found that boys were more satisfied than girls with traditional, teacher-delivered learning activities such as lecturing, and student-centered activities that they can complete autonomously such as at-home online activities. On the other hand, Juuti et al. (2010), found that girls more than boys are engaged when they perform more activating classroom activities that facilitate interactions such as discussions and group work. Considering that the FC is designed to promote students' interactions, the current researcher investigates whether there is an interaction effect between the instructional approach and gender on students' achievement in high school chemistry.

During the current study, the researcher controlled students' self-regulation orientations, prior knowledge, and prior academic achievements in chemistry to improve the validity of the results and inform the research community about the extent of their influence on students' academic achievements and psychology. Deci and Ryan (2000) posit that differences in individuals' regulatory styles influence how individuals internalize activities. Extrinsically motivated individuals with identified self-regulation skills may experience a higher level of competence and improvement in performance because they can internalize learning and identify the purpose for engaging in activities as in line with their personal goals and self-character. On the other hand, extrinsically motivated individuals with introjected self-regulation skills often fail to find intrinsic reasons to engage in activities and solely perform tasks for extrinsic reasons such as to avoid guilt or seek validation from others. Individuals with introjected regulation skills often experience stress and pressure which negatively influence their performance on tasks. Deci and Ryan (2000) posit that social contexts which support the psychological needs for autonomy, competence, and relatedness may maintain or enhance intrinsic motivation, persistence, performance, social functioning, and facilitate internalization of extrinsically motivating tasks. The relative autonomy index (RAI) which can be calculated using the SRQ was used in the current study to control students' self-regulation orientations, the higher is an individual's RAI score, the more likely they are to internalize activities and perform them for intrinsic reasons, and the greater is their persistence and productivity. By controlling students' RAI scores, the current researcher focuses this study on the influence of the instructional approach on satisfying students' psychological needs thus improve their ability to internalize extrinsically motivating tasks.

Another factor which could influence students' achievements during the current study is students' prior knowledge and prior achievements in chemistry. Hailikari (2007) suggest that students' prior knowledge influence how students learn and essentially their academic achievements. Learning without having sufficient prior knowledge results in surface learning which is characterized by simple recall of facts without any deep understanding of concepts (Hailikari, 2007). Students with greater prior knowledge of gas behaviors (the topic taught by the participating instructors during the duration of the current study) and those who generally have high scores in chemistry may have a greater sense of competence and perform substantially better on the post-assessment than students with little or no prior knowledge of the topic and those who performed poorly on the prior achievement test. By controlling students' prior academic achievement and prior knowledge in chemistry, the current researcher eliminates the influence of students' pre-established sense of competence and prior knowledge on the variation of their post-assessment scores and competence scores during data analyses.

Significance of the Study

Designing innovative ways to motivate students to engage in science learning and promote their academic achievement is highly important today. The European Commission Horizon 2020 Work Program emphasizes that school science should better represent scientific practices and cater more effectively to the needs and interests of young people (European Union, 2016). According to the President's Council of Advisors on Science and Technology, many American students do not have the skills necessary to solve science problems and the numbers of vacant STEM related jobs in private and government industries are increasing (Olson & Riordan, 2012). Economic projections point to the need for 1 million more STEM professionals by 2022; this translates into a need to increase the number of graduates with STEM related degrees by 34% (Olson & Riordan, 2012).

Although there are several challenges associated with FC implementations, many researchers reported that such teaching approach supports students learning. However, most of these studies did not take place in secondary level chemistry classrooms (Love et al., 2014; Mason et al., 2013). Deci and Ryan (2002) posit that satisfaction of students' psychological needs for autonomy, competence, and relatedness may positively influence student achievement and motivation to learn. The current study expands on the existing literature and investigates the influence of the instructional approach in conjunction with students' gender on high school students' academic achievements, and sense of autonomy, competence, and relatedness in chemistry.

Research Questions

1- How does the instructional approach (flipped or traditional) in conjunction with student gender (male or female), influence high school students' perceptions of autonomy, competence, and relatedness in general chemistry classrooms, while controlling students' prior knowledge of chemistry, prior academic achievement in chemistry, and self-regulation orientations?

2- How does the instructional approach in conjunction with student gender influence students' academic achievement in high school Chemistry while controlling students' prior knowledge of chemistry, prior academic achievement in chemistry, and self-regulation orientations?

Hypotheses

Each of the following hypotheses was tested while controlling the covariates presented in the research questions.

H_{01a}: There will be no significant difference in students' perceptions of their (a) autonomy, (b) competence, and (c) relatedness, as measured by the A-BNQ, based upon the instructional approach (flipped or traditional classroom approach).

H_{01b}: There will be no significant difference in students' perceptions of their (a) autonomy, (b) competence, and (c) relatedness, as measured by the A-BNQ, based upon gender (male or female).

H_{01c}: There will be no interaction effect of gender and instructional approach on students' perceptions of their (a) autonomy, (b) competence, and (c) relatedness, as measured by the A-BNQ.

H_{02a}: There will be no significant difference in the mean scores of a chemistry post-assessment, as measured by a researcher-created test, based upon the instructional approach (traditional or FC).

H_{02b}: There will be no significant difference in the mean scores of a chemistry post-assessment, as measured by a researcher-created test, based upon student gender.

H_{02c}: There will be no interaction effect of gender and instructional approach on the means of students' post-assessment scores as measured by a researcher-created test.

Definition of Terms

Flipped Classroom: a classroom environment in which students learn from pre-recorded videos and assess their understanding of concepts independently outside of classroom time, then collaborate with their peers and seek guidance from their instructors to expand their knowledge of concepts and solve challenging problems during class time (Lo et al., 2018).

Relative Autonomy Index: a numerical number between -24 and +20 that represent students' self-determination or intrinsic motivation to complete tasks. The higher is the number the more likely the student will behave willfully for the sole purpose of performing a task (Ryan and Connell (1989).

Psychological needs: According to the SDT (Deci & Ryan, 2000), there are three innate psychological needs that individuals must experience to feel intrinsically motivated to perform a task and work effectively, those are:

1- Autonomy: the need to experience control of one's own behavior and feel free to complete tasks that they perceive as valuable and interesting (NASEM, 2018; Deci & Ryan, 2000).

2- Relatedness: the need to feel a sense of belonging to a group, feel cared for and care for others (Deci & Ryan, 2000).

3- Competency: the need to feel effective, successful, and accomplished when performing a task that aligns with one's current knowledge and skills (Deci & Ryan, 2000; NASEM, 2018).

Gender: Male or Female as indicated by the student.

Regents Chemistry Class: A high school classroom in which students learn chemistry according to the current NYS Regents Chemistry standards which may be accessed online through the NYS Education Department's website (NYSED.gov).

Academic achievement: the level of students' understandings of a high school chemistry topic (behavior of gases) as measured by a researcher's developed post-test.

CHAPTER 2: REVIEW OF RELATED RESEARCH

The current researcher investigates whether the instructional approach, student gender, and/or the interaction between those two variables influence the academic achievement of high school students and/or satisfy their psychological needs in chemistry. The purpose of this study was to investigate whether there is a significant variation in the means of student achievement scores as measured using a researcher developed chemistry post-assessment or a significant variation in students' perceived levels of autonomy, competence, and relatedness as measured using the A-BNQ.

The following Literature review is divided into five sections: Theoretical Framework for the Present Study, Characteristics of the FC and Recommendations for FC Design, Implications for Implementing the FC Model, Challenges Associated with Implementing the FC's Method of Instruction, and Gender Differences in Science Learning. The chapter concludes with a statement of how the present study contributes to the knowledge base on FC implementation and outcomes.

Review of the Theoretical Framework for the Present Study

The current researcher proposes that the FC supports students' psychological needs for autonomy, competence, and relatedness and supports students' academic achievement in the context of the Self-Determination Theory proposed by Deci and Ryan (2002). Lavasani, Mirhosseini, Hejazi, and Davoodi (2011) suggest that self-directed learning increases student autonomy, metacognition, performance, achievement, motivation, and appreciation for learning. In a FC setting, students may experience autonomy when learning at home and at their own pace. When at home, students have the ability to control how to learn a topic by utilizing various resources and how long to spend on an activity without feeling socially pressured to solve problems or learn concepts quickly. Students may also improve their sense of competence and relatedness by watching assigned online videos repeatedly to understand difficult concepts and be prepared to engage in meaningful classroom discussions with their peers.

According to Vansteenkiste, Niemiec, and Soenens (2010), the SDT was first developed in the 1980s and has been continuously supported by empirical evidence and improved over time. Vansteenkiste, Niemiec, and Soenens (2010) posit that five mini theories led to the development of the SDT, two of them (the cognitive evaluation theory, and the basic psychological needs theory) form the basis for the development of the basic psychological needs questionnaire used in the current study; they suggest that a social environment that satisfy individuals' needs for autonomy, competence, and relatedness positively influence their intrinsic motivation and productivity. The other three mini theories (the organismic integration theory, causality orientation theory, and goal content theory) form the basis for the development of the academic self-regulation questionnaire used in the present study; they suggest that individuals' sense of control/autonomy, level of internalization of activities, and goals justify their persistence, social interactions, and levels of psychological wellbeing.

First, the cognitive evaluation theory suggests that in general, controlling events, events that pressure people (through deadlines, evaluations, and surveillance), or events that offer rewards to attract people to behave a certain way do not support individuals' psychological wellbeing and can undermine their intrinsic motivation to perform tasks (Deci and Ryan, 2002). People who engage in activities for extrinsic reasons are more likely to disengage from these activities once the external stimuli are removed. In their meta-analysis of the effect of stimuli on intrinsic motivation, Deci, Koestner, and Ryan (1999) posit that not all rewards undermine intrinsic motivation, unexpected rewards, and performance-contingent rewards such as positive feedback, do not influence the possibility of a person to re-engage in activities.

Second, according to the basic needs theory, the ability of people to internalize situations and regulate their behaviors to engage in activities for intrinsic reasons can be improved upon satisfaction of their psychological needs for autonomy, relatedness, and competence (Deci and Ryan, 2002). Reeve, Ryan, and Deci (2004) posit that personal motives and desires to achieve goals may drive people to perform a variety of tasks however, being engaged in tasks that do not satisfy human needs may be detrimental to their psychological wellbeing. The three basic psychological needs that promote intrinsic motivation and psychological wellbeing are:

(1) Autonomy: Reeve, Ryan, and Deci (2004) claim that autonomy may be experienced when individuals feel that they are in control of their actions and are free to make choices concerning their learning or interests. In their meta-analysis, Patall, Cooper, and Robinson (2008), reported that 42 studies found that individuals' perceived levels of autonomy has a direct relationship with intrinsic motivation. Autonomy is different from independence because one can still experience autonomy while being dependent on others for suggestions and ideas (Reeve, Ryan, and Deci, 2004).

(2) Competence: In the context of SDT, competence is not defined as students' actual abilities; instead, it is defined as a feeling of being effective

while performing tasks (Reeve, Ryan, and Deci, 2004). Deci and Ryan (2002) indicate that people who perceive their abilities as low may find it difficult to engage in challenging tasks which leaves them unable to fulfil their psychological need for competence; by providing these students with constructive/positive feedback and support, and assigning tasks that align with their skills, these students may become intrinsically motivated to re-engage in activities and take on more challenging tasks in the future.

(3) Relatedness: The need for social relatedness represents individuals' needs to feel a sense of belonging to a group and a sense of affiliation (Deci & Vansteenkiste, 2004). Reeve, Ryan, and Deci (2004) claim that being part of a social setting helps people feel connected with and accepted by others; people need to be cared for and care for others to be intrinsically motivated to engage in activities.

Third, the causality orientation theory suggests that the characteristics of people and personal orientations justify their behaviors and prompt them to act in certain ways. Opposite to individuals with external locus of control, individual with internal locus of control have a higher sense of self-worth and relative autonomy; they control their behaviors to pursue goals relevant to their interests and strongly believe that their own actions can influence their destiny. When performing activities, individuals with internal locus of control work persistently, keep an open mind while interacting with others, and perform well on tasks.

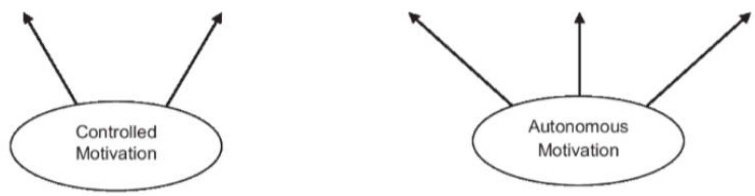
Fourth, Vansteenkiste, Niemiec, and Soenens (2010) posit that SDT is also rooted in the organismic integration theory which suggests that due to the pressures of life, adults may have less time to engage in activities they find joyful, therefore most adults regulate their behaviors and complete tasks for extrinsic reasons. Deci and Ryan (2000) suggest that the level of persistence and performance often displayed by adults vary depending on their level of internalization of a task; Figure 2 shows that people who regulate their behaviors to engage in activities for the sake of receiving rewards (external regulation) or to avoid feelings of guilt (introjected regulation) are more likely to feel heavily controlled by external and internal pressures and experience stress; removal of the possibility of earning an external reward or perhaps traveling to another country where cultural norms and expectations are different may result in immediate shift in behavior and disengagement from such activities. Other people on the other hand, may regulate their behaviors to engage in activities because they can internalize the activities and perceive them as valuable for their wellbeing (identified regulation), or reflective of their character, personal beliefs, and personal values (integrated regulation); such people are characterized as having greater psychological health, display more social interactions, and are more likely to be persistent when performing tasks (Deci & Ryan, 2000).

Fifth, Vansteenkiste, Niemiec, and Soenens (2010) indicate that goal content theory differentiates between intrinsic and extrinsic goals and is also connected to the SDT. Intrinsic goals such as those that individuals set for themselves to develop close ties with others or develop their own skills contribute to satisfaction of their psychological needs and wellbeing. Extrinsic goals that are connected with money, social validation/fame, or other external desires are often associated with poor psychological health. Vansteenkiste, Niemiec, and Soenens (2010) suggests that when human psychological needs are not satisfied, people move away from pursuing intrinsic goals to pursuing extrinsic ones in effort to satisfy their needs, however such satisfaction is often short-lived. Fostering a learning environment that promotes students to pursue intrinsic goals, promotes deeper learning, higher academic achievement, and longer engagement.

Figure 2

Types of Motivation According to the Self-Determination Theory

Type of Regulation	Amotivation	External Regulation	Introjected Regulation	Identified Regulation	Integrated Regulation	Intrinsic Regulation
Motivational intensity	Low	High	High	High	High	High
Motivational force	Discouragement and helplessness	Expectations, rewards, and punishment	Guilt, shame, and self-worth contingencies	Personal valuation and relevance	Harmonious and coherent commitment	Enjoyment, pleasure, and interest
Internalization	No	No	Partial	Almost full	Full	Not required
Underlying feelings	Futility and apathy	Stress and pressure	Stress and pressure	Volition and freedom	Volition and freedom	Volition and freedom
Locus of causality	Impersonal	External	External	Internal	Internal	Internal
Type of motivation	Amotivation	Extrinsic	Extrinsic	Extrinsic	Extrinsic	Intrinsic



Note: Information presented in Figure 2 was obtained from Vansteenkiste, Niemiec, and Soenens (2010)'s report on the Self-Determination Theory.

In an educational context, Reeve, Deci, and Ryan (2004) posit that teachers who develop a structured learning environment that supports students' autonomy, relatedness, and competency are likely to enhance students' motivation, academic performance, and psychological wellbeing. Jang, Reeve, and Deci (2010) suggest that group activities that encourage creativity and autonomy, present the learners with achievable tasks, and provide the learners with clear expectations and directions, enhance students' intrinsic motivation. Instructors may increase students' feelings of autonomy when they value their inputs, provide students with rationales for performing tasks, emphasize choice, align learning activities with students' interests and personal goals, and enhance students sense of volition by being flexible instead of pressuring and controlling. Deci and Ryan (2002) suggest that teachers may encourage students to engage in activities which they may not necessarily find enjoyable by giving them freedom to make choices and control how they learn, enhancing their perceptions of their abilities to apply the knowledge and skills that they have to solve problems effectively through positive and constructive feedback, and promoting their social interactions and sense of belonging in a caring and supportive environment.

Prior research has sought to validate the constructs of the SDT. In an article titled *Best International Practices to Foster Students Engagement*, Liem and Chong (2017) reviewed findings from several studies and suggested that teachers who encourage collaboration, use an enthusiastic and caring tone when communicating with students, and promote mastery in their classrooms are more likely to satisfy students' psychological needs for autonomy, competence, and relatedness. Also, they suggested that teachers may increase students' motivation to learn by making clear connections between the curriculum and its practical applications, providing feedback on effort not just ability, and fostering a learning environment that encourages participation and discourages social comparisons.

Sheldon and Filak (2010) manipulated satisfaction of students' needs for autonomy, competence, and relatedness in a game learning experience to determine how satisfying each of these needs predicts students' motivation and performance. Sheldon and Filak utilized a 2 (autonomy support: yes or no) x 2 (competence support: yes or no) x 2 (relatedness support: yes or no) factorial design and conducted regressions analysis to predict the outcomes. One hundred and ninety-six university level psychology students participated in this study of which 114 were women. The researcher measured students' psychological needs by using a need satisfaction scale which they developed in 2001 and validated in previous studies, utilized the interest/enjoyment scale to measure students' intrinsic motivation, and finally, used a researchers-developed pre/post-test assessment to measure students' achievements. Results from the regression analysis suggest the following: first, a learning environment that satisfies students' need for autonomy has a significant positive effect on students' intrinsic motivation ($p<.05$) but no significant effect on their achievements; second, a learning environment that satisfies students' need for competence has a significant positive effect on their intrinsic motivation and achievement; and third, a learning environment that satisfies students' need for relatedness has a significant positive effect on students' intrinsic motivation ($p<.01$) but no significant effect on their achievements. These findings are consistent with the SDT and suggest that supporting all three psychological needs contribute to improving students' intrinsic motivation and achievements.

Zainuddin and Perera (2019) conducted a 12-week mixed methods study to measure how an interactive learning environment such as the FC influence students' perceptions of their competence, autonomy, and relatedness, and influence their achievement in an English as a foreign language university level course. All 61 participating students (31 in FC and 30 in traditional class) learned from the same instructor during an hour and forty-minute class which met once per week. Students in the FC learned through instructional videos prior to coming to class; during class time they listened to the instructor for 40 minutes, engaged in a conversation with others for

45 minutes, and engaged in an interactive feedback session during the last 15 minutes. During class time, students in the traditional class watched a 15-minute video, listened to a 20-minute lecture, and engaged in a 30-minute listening activity and a 35-minute conversation. For homework, students in the traditional classroom were required to read their class handouts and answer questions. Achievement data was collected from three formative post-assessments of which one measured students use of vocabulary and writing skills, another assessed their listening and comprehension, and the last one measured their communication skills during oral presentations. Students' motivation was assessed using a 10-item questionnaire, five of those items measured students intrinsic motivation and the other five measured their extrinsic motivation. Additionally, the researchers also reported on data gathered from focus-group interviews with 10 of the FC's students. Results from independent sample t-tests suggest that students in the FC significantly outperformed students in the traditional classroom in the following areas: the second and third formative post-assessments, perceived ability to manage their own learning, perceived level of interaction with peers, motivation to watch instructional videos, and motivation to attend class. On the other hand, students in the traditional classroom were motivated to learn for extrinsic reasons such as avoid punishment or to impress others. Results from the interviews indicate that most students in the FC felt that their abilities to rewind and replay the videos helped deepen their learning and understanding of English, helped them learn more independently, and helped them manage their own learning. Additionally, students reported that their interactions with their peers increased both inside and outside the class as a result of learning under the flipped model.

Cai and Liem (2017) conducted a study to investigate the relationship between students' achievement goals, levels of anxiety and elaboration, and perceived autonomy in mathematics FCs. A total of 491 elementary level students (54% girls) participated in this study. Researchers calculated students' autonomy scores using the SRQ which was also used in the current study. Also, they measured their achievement goals via the 3x2 Achievement Goal Questionnaire, measured their anxiety and effort/persistence via the Achievement Emotion Questionnaire, and measured their levels of elaboration via the Goal Orientation and Learning Strategies Survey. Results from this study indicate that students who had a greater sense of autonomy (performed tasks because they considered them meaningful and interesting) were less likely than students with low autonomy scores to display anxiety and more likely to be persistent and elaborative while completing assignments. Also, students who scored high on the autonomy questionnaire (more intrinsically motivated) and had self-based goals (to improve their performance and avoid earning lower grades than previously earned) were more likely to preserver through challenges and achieve high grades. Lastly, Cai and Liem (2017) found that females, older students, and students from high socioeconomic status (SES) backgrounds were more likely to pursue self-based goals, however, these students displayed the least autonomy and the highest levels of anxiety.

Characteristics of the FC Model and Recommendations for FC Design

Researchers who investigated the efficacy of the FC model made several recommendations based on students' experiences, instruction design theory, and other research findings. This section contains information for education professionals who are interested in implementing a FC design that is likely to benefit students.

Bergmann and Sams (2012) indicate that in a FC setting, teachers use technology to make learning possible outside the classroom so they can free classroom time to engage students in collaborative learning activities and deep discussions to expand their learning; in a FC setting, teachers' lectures are substituted by appropriate teacher assignments which students can complete at home and at their own pace. Baker (2000) presents a framework for teachers to implement the FC successfully by simply doing the following: (a) minimize lecturing and act as mentors/coaches who encourage students' creativity and input in a social environment as opposed to act as information delivery agents; (b) put greater emphasis on critical thinking and application of the curriculum than on memorization and recall of facts; (c) provide students with more control over their learning; (d) trust students to take responsibility of their own learning; and (e) encourage students collaboration and learning from peers.

In their review of best practices and recommendations for designing the FC model, Persky and McLaughlin (2017) consider the cognitive apprenticeship theory as the root foundation of the FC's design. According to Persky and colleagues, apprenticeship takes place in a FC setting when teachers guide student learning and slowly fadeaway their support once students develop the skills required to learn independently. In a FC, teachers serve as coaches who facilitate student learning through demonstration, articulation, and modeling of important concepts and strategies. Persky and colleagues posit that students learn best when they engage in hypothesis testing, self-evaluation, and collaborative learning activities. To design a FC that promote student motivation and engagement, Persky and Mclaughlin suggest that teachers provide students with flexible deadlines to complete assignments, choice of practice activities, and additional opportunities to solve problems and receive feedback to gradually develop proficiency. Also, they suggest assigning instructional videos instead of text-readings for pre-class activities; textbooks may be written at a level that is above students' comprehension and reading abilities therefore, assigning textbook readings as pre-class activities may impose a challenge for less competent students and may lower their sense of relatedness and competence. Additionally, Persky and McLaughlin offer the following evidence-based recommendations based on their review of prior research:

1. Develop challenging and achievable SMART (specific, measurable, actionable, relevant to the real world, and timely) objectives that aim to develop students' workforce skills.
2. Design pre-class activities that motivate students to complete tasks at home and assess their learning. Such activities have meaningful objectives, clear expectations, and are easily accessible. Persky and Mclaughlin found that students learn autonomously if teachers communicate expectations, hold students accountable for learning at home, and provide students with sufficient time to complete interactive and student-friendly activities.
3. To minimize students' workload and allow them sufficient time to develop their knowledge, the time granted for students to spend on at-home activities should be double the time they spend on learning during class. When making videos, it is recommended that teachers use a slower speaking voice or give realistic reading assignments that do not take too much time to complete. Also, proper spacing of

assignments and the integration of problems of various difficulty levels are necessary to control students cognitive load and promote their engagement.

4. Design in-class activities to reinforce and extend students' knowledge, promote critical thinking, and make meaningful and practical connections,
5. Foster a learning environment that encourage collaboration and feedback, and encourage students to develop, evaluate, and correct their own ideas,
6. Design assessments that connect with course objectives, hold students accountable for pre-class learning, measure students' communication skills and contributions to group assignments, and use assessment data to drive instruction and classroom discussions.

Abeysekera and Dawson (2015) suggests that the FC model may satisfy students' psychological needs and enhance their motivation to engage in science activities if the following conditions are met: (a) students' attitudes towards themselves and others in the classroom are positive; (b) teachers guide students while they work collaboratively with their peers, and the teacher as well as the students provide others with positive and constructive feedback while learning; and (c) teachers and students have access to technological resources and tools which allow teachers to differentiate and deliver instruction remotely, and allow the students to learn independently and feel that they are in control of their learning. Abeysekera and Dawson (2015) claim that students' motivation to learn is identified as the key factor upon which everything rests in a FC, without motivation and desire to learn and/ or succeed, students can hold up in-class learning, as they are not well-prepared for it. The existence of a motivating factor is necessary for students to be more invested in the learning process, students need either a genuine interest in the material (intrinsic motivator), or plenty of feedback and support to encourage their participation in activities. In a FC, students know that they are the key to every classroom discussion, therefore, they are likely to be engaged in the learning process simply because they feel that they are an integral part of it. As a result of the FC allowing students to learn at their own pace at home and share what they have learned when they come to class, the below-average student has a chance to elevate their knowledge to a level similar to the more advanced student, making the learning process more enjoyable for all (Abeysekera & Dawson, 2015).

In their study, Lo, Lie, and Hew (2018) point out that there are very few research studies that provides empirical evidence regarding the efficacy of the FC at the secondary school level. They posit that without a firmer understanding of exactly what constitutes a FC design, the effectiveness of this teaching method cannot easily or accurately be assessed. Lo and colleagues designed a FC model that was grounded in Merrill's First Principles of Instruction design theory and tested its influence on students' achievements in math, physics, and Chinese classes. According to their FC design, at-home learning may be facilitated by structuring online videos that activate students' prior knowledge and demonstrate new information, then utilizing online resources to provide students with computerized feedback based on their abilities to solve simple problems. On the other hand, in-class learning is facilitated by activating students' knowledge of the concepts which they learned at home, demonstrating new information to advance students' learning, and giving students ample time to solve challenging problems and discuss their findings with their peers. Towards the end of the class period, teachers provide students with follow up practice problems which students can students can perform independently to further improve their skills. In their study, Lo and colleagues analyzed the influence of their FC model on the academic achievements of 382 students in grades 8 to 12. Results from this study suggest that at worst, students performed the same as those in non-flipped classrooms, however, students who were enrolled in the flipped math and physics classes scored significantly higher on assessments than their peers in traditional classrooms ($p<.05$).

Implications for Implementing the FC and Traditional Lecture Classroom Models

There are very few peer reviewed studies that were conducted to measure the implications of the FC instructional approach and none that investigated its influence on high school students' perceptions of autonomy, competence, and relatedness. Studies that reported the implications of implementing the flipped and the traditional methods of instruction are summarized in this section.

In light of the Self-Determination Theory (Deci & Ryan, 2002), educators may increase students' intrinsic motivation to learn by fostering a learning environment that encourages interactions, autonomy, and competency. Clark (2015) conducted a 7-week, mixed methods, true experimental study to measure whether there is a significant difference between flipped and traditional students' interactions, attitudes and perceptions of the instructional approach, and academic achievements. Forty-two students who were enrolled in two different secondary level Algebra classes participated in this study. The researcher administered a survey prior to and after the intervention (Student Perception of Instruction Questionnaire) to measure the changes in students' perceptions and attitudes towards the instructional approach, administered a unit test to compare students' academic achievements, and conducted student interviews. When comparing the achievements of students who enrolled in the FC to the achievements of students who enrolled in the traditional classroom, the researchers found no significant difference in students test scores. On the other hand, students in the FC showed greater improvement in their attitudes and motivation to learn (especially when learning from online videos) and experienced greater level of interactions and communication during classroom discussions. The findings of this study provide empirical evidence that high school students have positive attitudes towards the FC model and that this model supports their engagement.

Grypp and Luebeck (2015) conducted a three-week study to measure the effect of implementing the FC model in a secondary level AP calculus classroom. A total of 21 students participated in this study. According to the teacher's journal, the FC allowed them to differentiate instruction and accommodate students' different learning styles. The researcher found that classroom discussions helped students develop a deeper understanding of the material and understand its practical applications to life outside the classroom. On the other hand, the teacher reported that not all students watched the instructional videos, however, those who did, had a better understanding of the material and were more engaged during classroom discussions than those who did not.

Schultz, Duffield, Rasmussen, and Wagerman (2014), conducted a study to measure the effect of the FC model on secondary level advanced chemistry students. A total of 61 students participated in this study of which 32 were part of the traditional classroom's control group and 29 were part of the intervention FC group. Students' scores on eight-unit tests were collected over a two-year period and were analyzed via independent sample t-tests. Results from this study indicate that students who were enrolled in the FC group outperformed students in the traditional classroom group on all eight tests ($p < .01$). The researchers also reported that students in the FC group had more time to interact with each other and ask questions to further their understanding of chemistry than students in the traditional group. Schultz and colleague analyzed students' scores on the assessments based upon gender and found that male students in the FC group scored significantly higher than male students in the traditional group on all eight tests ($p < .05$); the significance value was even greater for the fifth, sixth, and seventh tests ($p < .01$). On the other hand, female students in the FC only scored significantly higher than females in the traditional classroom on three of the eight chemistry tests ($p < .05$). Furthermore, Shultz and colleagues investigated students' perceptions of the flipped model and related technological resources via a five-point Likert scale questionnaire and open-ended follow-up questions. Students answers to the questionnaires' items were analyzed using descriptive statistics while students' answers to the open-ended follow-up questions were coded by two researchers and compared to measure consistency. Analysis of students' perceptions indicate that 22 out of 29 students prefer or strongly prefer the FC model. Students reported that the FC model help them learn at their own pace via online videos which they can rewind, pause, and replay to understand difficult concepts. In the FC, students reported that there is plenty of time to interact with the teacher and peers, ask questions, and obtain a deeper understanding of the applications of the curriculum during class; also, students reported that the FC model provides them with an opportunity to learn from various online resources and avoid losing instructional time.

Only four students favored the traditional learning environment, and they were all females; these students reported that they cannot ask questions while watching online videos, described the videos as too long; and reported that they are accustomed to learning in a classroom setting thus being there helps them focus. Although this study indicates that on average, the FC model supports students' achievement in chemistry, it is important to recognize that the sample of students used in this study is comprised of high achieving students thus the results cannot be generalized to all students.

To further investigate students' achievements in the FC, Love et al., (2014) compared the effectiveness of teaching linear algebra while using a FC approach as compared with a traditional-lecture approach. The study took place in a mid-size metropolitan university and involved 55 students. The researchers of this study used a non-parametric Mann–Whitney U test to analyze students' scores on three assessments. While both groups performed similarly on the final assessment of the course, the average change in scores between the second and first assessment and between the third and first assessments were significantly higher for students who were part of the FC group ($p< 0.034$) and ($p< 0.012$) respectively; this suggests that the FC positively influences students learning. Additionally, the researchers conducted a post-course survey which contained general questions about students' experiences in the course and specific questions about students' perceptions of the instructional approach itself. The results of the survey showed that 74% of the students in the FC favored the flipped instructional approach, found the instructional videos to be very helpful ($p<.001$), felt more comfortable than traditional students to interact with their peers and solve problems during class ($p=0.003$), and perceived linear algebra to be more relevant to their careers than traditional students (*p*=.089). This study provides more empirical evidence that the FC is supportive of students learning and improvement, and also provides evidence that the FC model contributes to increasing students' interactions with each other thus support their sense of affiliation as proposed by the Self-Determination Theory (Deci & Ryan, 2002).

In science classrooms, Leo and Puzio (2016) conducted a quasi-experimental study to measure the effectiveness of the FC method in secondary level biology classes at a high school located in the Pacific northwestern region of the United States. Seventy-five students were divided into two groups and were assigned to either two flipped biology classes or two biology classes that were taught in a traditional lecture style approach. The researchers administered four assessments (pre-test, quiz 1, quiz 2, and post-test), only 69 students were present for all assessments. Students' scores on all assessments were analyzed by conducting a two-way ANOVA test using SPSS. Although students in the traditional classes performed slightly better on the pre-tests, students in the flipped classes performed somewhat better on quiz 1 (ES =+0.30, $p = 0.18$), quiz 2 (ES =+0.44, $p = 0.05$), and the post-test (ES = +0.16, $p = 0.47$). Analysis of students' comments showed that students benefited from the active learning strategies implemented in the FC and enjoyed being part of such learning environment. This study provides evidence that the FC is supportive of students learning and achievement in science classes.

Glynn (2013) conducted a mixed methods study to measure whether implementing the FC's instructional model could improve students' achievements in chemistry, free more class time to engage students in guided and independent class activities, and improve students' attitudes towards learning chemistry. Participants of the study were 46 general chemistry students (24 males and 22 females) who attended general chemistry classrooms at a suburban high school in Montana, USA. The participating instructor was the researcher himself. Results of this study were based on a nonpaired t-test analysis of the mean scores of students on two chemistry units (gases and solutions), analysis of student responses on three surveys containing a mix of multiple choice, short response, and Likert style items, and analysis of data collected during interviews with students. The results indicate that students' mean scores for each unit test did not significantly vary from each other based upon the instructional approach or gender. Results from the surveys and interviews indicate that implementing the FC model did not significantly free time for class activities. Moreover, there was a statistically significant evidence that students' positive attitudes towards learning chemistry declined during the period of the study. Approximately 60% of students thought the FC helped them learn efficiently but suggested that more time should be allocated during class to review the content of videos which were assigned for homework prior to class. Over the course of the study, it was noted that female students watched more instructional videos than males. Females reported that videos helped them learn more efficiently because they can rewind and replay concepts they do not understand. Males on the other hand reported that they "hate videos", they do not watch videos, or reported that learning from videos is pointless because they can do the same thing while sitting in class; Glynn reported that most males did not watch the videos. Although this study provides great insight about female and male students' achievements and perceptions of the FC, there could be some bias in the reporting of the results due to the investigator acting as both the researcher and the teacher and the fact that the investigator reported not being formally trained to teach chemistry.

The influence of the FC model on the achievements of at-risk youths was also investigated. Flumerfelt and Green (2013) implemented the FC model in a government class composed of 23 at-risk youths. They employed the LEAN Value Stream Mapping tool to graphically categorize what was most important in the learning process to all stakeholders, and divide classroom time effectively to meet the needs of students, teachers, parents and administrators. The Value Stream Mapping tool within the LEAN model emphasizes continual review of students' results and processes to identify where change can be made to effect continuous improvement. After thorough analysis of the effects of implementing the FC on students' achievements and behavior, Flumerfelt and Green (2013) found that the rate of homework completion by students improved to 100%, the success of students in the course increased by 11%, and no student failed the class. When the FC was subsequently implemented across all courses taken by 9th graders, Flumerfelt and Green (2013) reported that disciplinary referrals decreased by 66%, and the number of students failing math, English, science and social studies courses decreased by 31%, 33%, 22%, and 19% respectively.

McNally, Chipperfield, Dorsett, Fabro, Frommolt, Goetz, Lewohl, Molineux, Pearson, Reddan, Roiko, and Rung (2017) surveyed 563 undergraduate and post-graduate students (61% females) between the ages of 17 and 65 to investigate their perceptions of the FC model. The aim of this study was to identify whether students' attitudes towards the FC model, engagement, academic self-efficacy, and grades differed significantly if a course was flipped with an underpinning theoretical perspective, partially or entirely flipped, or had flip related assessable items. A survey containing multiple items which students rated using a five-point scale, and other items related to students' demographics and experiences during pre-class and in-class activities was administered. McNally and colleagues conducted cluster analysis of the data and analyzed students' grades using a t-test. Results from the cluster analysis indicate that flip endorsers were likely to be older students $F(3, 544) = 9.67$, $p < .001$, English language learners $t(156) = 2.17$, $p < .05$, d = .25, and females $t(535) = 2.12$, $p < .05$, $d = .18$. Additionally, students reported that they participated more actively and achieved high grades when the course was flipped with an underpinning theoretical perspective, was entirely flipped, and included a summative assessment. Results from the t-test analysis indicated that the final course grades and prior GPA of flip endorsers did not significantly differ from the final grades of flip resistors. Some limitations which may have contributed to bias in this study include the use of self-reported data in the analysis as opposed to more objective third-party data, the age gap between participants, and the teaching experience of the participating instructors. This study is important because it informs researchers and practitioners about the general characteristics of students who may benefit from the FC model, and the characteristics of a FC design which students perceive as engaging and beneficial.

The quality of traditional instruction varies; researchers cannot say with a great deal of certainty that the FC model is any less or more effective than the traditional model of instruction. Abdel Meguid and Collins (2017) analyzed students' perceptions of learning from non-interactive and interactive teacher lectures. A total of 60 students (73.33% females and 26.57% males) who were mostly between the ages of 18 and 20 participated in this study. To validate the results, the researcher repeated the intervention with 133 other participants who were in the same age group, but the majority (75.19%) were males. All participants learned in a non-interactive lecture environment for ten weeks out of twelve. During the sixth and tenth weeks, participants leaned in an interactive lecture environment that utilized the PollEverywhere website to engage students in answering questions and evaluate their understandings throughout the lectures. Students' perceptions of learning in both learning environments were measured using a modified version of a previously validated questionnaire; an overall attitude score for each student was computed. Analysis of the data indicate that from the 193 students who participated in this study, the majority (161 students) reported that answering questions during lectures through the PollEverywhere website positively influenced their motivation and engagement while learning. T-test analyses revealed no significant difference in students' attitude scores based upon students' age group, gender, or students' SES backgrounds. Additionally, results from three semi-structured focus group discussions with 24 participants indicate that students were more engaged when answering questions anonymously through the PollEverywhere website because they felt it was easy to do so (students had 25% chance of answering questions correctly), did not fear being judged or embarrassed by others, and were more motivated to participate when everyone else was engaged in the activity. Results from this study provide evidence that the traditional lecture instructional approach may support students learning and engagement if instructors embed questions into lectures and allow students to submit their answers anonymously using digital tools.

Bernard, Abram, Lou, Borokhovski, Wade, and colleagues (2004) conducted a meta-analysis to compare students' achievements, retention rates, and attitudes towards learning while enrolled in synchronous interactive online classrooms versus traditional in-person classrooms. Empirical findings from 157 research studies which were published between the years 1985 and 2004 were analyzed and included in this meta-analysis. Results from this analysis indicate that on average, there is no significant difference in students' achievements when learning through synchronous online lectures or live in-class lectures. The likelihood of students to perform well in both settings were very similar (g= +0.0551), however, the mean effect size was not a good way to compare findings because there was a large variability in the results of the studies that were included in this meta-analysis. Bernard and colleagues found that there is a direct relationship between the degree of communication and interactivity in online instruction and students' achievements; students who enrolled in online classes that encouraged two-way audio or video communication, outperformed students who learned in physical classrooms. On the other hand, retention rates were significantly lower in distance education than in traditional face-to-face settings (*ES* = - 0.2310), and students attitudes towards learning did not significantly vary based upon the instructional approach. Results from this meta-analysis suggest that students' interactions are vital to learning and that live lectures delivered online are as beneficial to students as lectures delivered face-to-face.

Teachers perceptions of students' interactions in synchronous online lecture classrooms and asynchronous online classrooms were explored in a study conducted by Murphy, Rodriguez-Manzanares, and Barbour (2011). Data from Forty-two teachers who taught a variety of online classes to high school students were collected via semi-structured phone interviews. All data were analyzed using open and axial coding methods. Findings from this study revealed that most teachers perceived asynchronous student interaction (via chat or email) to be greater than students' interactions in synchronous and live online lectures; they described teaching live online lectures to be mostly teacher-centered with little to no student interactions. Further analysis indicate that most teachers believe that student interactions is greater in asynchronous online classrooms because when students learn from online videos, they can rewind or pause lectures to learn at their own pace, therefore, they have plenty of time to process information and formulate questions. This study provides new evidence that students are less likely to ask question during live online lectures than in asynchronous online classrooms and that pre-recorded instructional videos may positively influence students' engagement.

Mayor, Lingle, and Usselman (2017) conducted a mixed methods study to explore the experiences of advanced students in a synchronous online mathematics classroom that permits two-way communication during live lectures. The study investigated whether students' grades vary when they learn from live broadcasted university lectures that support one-way teacher to student communication, versus when they learn from live online lectures that support two-way interactions between students and the instructor. A total of twenty high school students (sixteen males, four females) participated in this study. Analysis of students' final course grades revealed no significant difference in students' achievements based upon the instructional approach. On the other hand, T-test analysis of the data collected through questionnaires revealed significant improvement in students sense of relatedness over time (P <.01) and insignificant improvement in students' satisfaction and engagement. During group discussions between the researchers and the students, the students reported that being able to interact with others during class and perform group activities positively influenced their engagement, satisfaction, and sense of relatedness. There are some limitations to this study, for example: the sample size of high school students was too small and the high school students chosen to participate in the study were primarily males, and were all high achievers, thus findings from this study may not be generalized to females or low achieving students.

Challenges Associated with Implementing the FC's Method of Instruction

Lo and Hew (2017) reviewed publications from 15 different journals to investigate the implications for implementing the FC's instructional model in K-12 setting. The process of selecting relevant literature followed the Preferred Reporting of Items for Systematic Reviews and Meta-Analysis Statement (PRISMA). Lo and Hew reviewed empirical research articles that were written in English and published in peer-reviewed journals between 1994 and 2016. Analysis of all the reviewed studies suggest that on average, the FC model does enhance students' academic achievement in various classes, however, students and teachers are not always content with the FC's method of instruction and there are multiple barriers that limit its efficacy. Student-centered barriers to learning in a FC setting are difficulty adapting to the flipped method after being taught traditionally for many years, difficulty staying focused while watching long and "dry" instructional videos, finding no significant structure to in-class activities, finding pre-class workload to be too excessive and demanding, and being unable to receive immediate answers to their questions while learning from online resources at home. Teacher-centered barriers to implementing the FC model are being unfamiliar with the

FC method of instruction, having no clear guidelines to implement it effectively, and not having enough time to develop online learning materials. Lo et al., (2018) added that teachers often complain about their inability to find learning resources that would accommodate English language learners (ELL) and that teachers perceive some topics to be too complex for students to learn independently. Furthermore, Lo and Hew (2017) also identified operational challenges relevant to the FC such as lack of students access to reliable computers or internet connection at home, and technical issues with loading or uploading videos at home.

To help practitioners overcome some of the challenges associated with implementing the FC model, Lo and Hew (2017) make the following suggestions: (a) brief students about what a FC entails prior to flipping; (b) maintain a similar workload after flipping, to what was expected of students before flipping; (c) create means for students to ask questions about at-home learning before coming to class; (d) use instructional design theory to guide the development of at-home educational materials; (e) enhance teachers' understanding of the FC method; (f) provide access to institutional resources so that all students can complete assignments at home; and (g) utilize a learning management system which focuses on game-based learning.

This meta-analysis is very important because it gives educators and researchers an overview of some of the challenges that others experienced while implementing the FC, and provides various recommendations to help them overcome these challenges while implementing the flipped model in their classrooms. The current researcher followed Lo and Hew (2017)'s recommendations and met with the FC's participating teachers prior to the intervention to discuss the structure of pre-class and in-class activities. Also, the participating school district provided all students with access to computers and internet connection prior to the study and for the whole school year in effort to prepare for possible school closures due to the current COVID-19 pandemic.

A ten-week study conducted by Mason, Shuman, and Cook (2013) compared the effect of implementing the FC teaching method to the lecture-style method in a senior mechanical engineering class. There were 40 participants in this study, 20 (from which two were females) studied under the traditional instructional model, and 20 others (from which four were females) studied under the flipped model. Findings from this study indicate that students in the FC displayed equal or greater satisfaction and achieved higher grades than students enrolled in the same courses taught under the traditional method. Students with better self-regulation skills displayed higher satisfaction with the flipped instructional model by the fourth week of instruction than students in the traditional class; this implies that adjusting to this form of teaching needs time. Additionally, the FC instructor was able to cover more material during the study period than in the traditional classroom. On the other hand, Mason and colleagues reported that creating FC material requires a lot of time and effort. Not only do the students have to be motivated to do the work, but teachers must also be motivated to spend hours making instructional videos and creating practice problems. Over 100 hours are needed to create FC material the first time, however, once the material is made, the FC teacher would spend less time planning lessons than the traditional classroom teacher. To overcome the burden of spending hours in preparing material, Mason and colleagues recommends that teachers develop FC materials in stages rather than develop all at once. This study is important because it provides evidence that the FC is supportive of students learning in engineering courses and provides an estimate of the time and effort required from practitioners to develop FC material so that they can plan to manage their time accordingly.

Gender Differences in Education

The objective of the current study is not to compare gender achievements, instead, it is to investigate whether the FC instructional model supports the achievement of all students equally and support their psychological needs in high school. Halpern, Benbow, Geary, Gur, Hyde, and Gernsbacher (2007) conducted a thorough review of the literature to present valuable information regarding sex differences and suggest several practice recommendations to reduce the gender achievement gap in science. They concluded that the variation of females and males' performances in science and mathematics is due to various reasons such as biological factors (for example: females generally excel in verbal and writing activities while males excel in visuospatial activities), educational policy, childhood experiences, and culture. Moreover, after thorough review of the literature, Halpern and colleagues (2007) concluded that although females generally underestimate their knowledge and skills in science and math classes, their sense of competence and confidence may be improved if educators consider the following evidence-based practice recommendations: (a) teach all students that knowledge and skills increase over time and solidify the idea that the brain builds new connections and gets stronger with practice; (b) provide greater opportunity for students to receive positive feedback and also correct their misconceptions; (c) focus more on the process of learning rather than exam grades; (d) expose students to female and male scientists and discuss their contributions to science; (e) create a meaningful learning environment that sparks students interest in science and math and utilize technology, online resources, videos, and visual demonstrations; and (f) provide spatial skill training by encouraging girls to interact with objects and make connections as opposed to just memorize information.

Desy, Peterson, and Brockman (2011) aimed to study gender differences in science related attitudes and interests amongst school level students. Nearly 1300 middle and high school students (642 males, and 645 females) who were enrolled in science classes in six different school districts participated in this study. A 50-item Likert-style survey was developed by the researchers and was used to measure students' interests and attitudes in science classrooms. Items regarding students' attitudes in science classrooms were adapted from the Attitude Toward Science Inventory and the Attitude Towards Science in School Assessment. Pearson correlation coefficients were calculated, and multi/univariate analysis of variances were employed to analyze students' responses on the survey. Relevant findings from this study indicate that females mean score on the survey item which asked them to describe themselves as poor, fair, good, very good, or excellent students, was significantly higher than males' at the middle school level ($p<.05$) and nearly significantly higher than males at the high school level ($p=.069$). The mean self-concept in science (I believe I can learn science) score of high school females was significantly lower than the calculated mean score for high school males ($p<.01$). These findings suggest that although females perceive themselves as good students, they do not believe that they can learn science effectively. The mean scores for enjoyment while learning science, motivation to learn science, and attitudes towards science of female participants were all lower than the mean scores of males ($P>.05$). Additionally, the mean anxiety score of middle school females while learning science was significantly higher than that of middle school males (p<.05); at the high school level, the mean anxiety score of females was higher than the mean anxiety score of males but the results were not statistically significant. Lastly, analysis of students' career aspirations indicate that females mainly aspire to pursue education and health related careers while males displayed greater interest in engineering, technology, and mathematics careers. This study provides extensive information regarding gender differences in science which give more reason to implement innovative ways to increase females' motivation and reduce their anxiety in science classrooms.

Lage et al. (2000) conducted a study at the university of Miami to investigate the relationship between students' personalities and characteristics and their perceptions of the FC model. A total of 189 students (95 females and 94 males) from five microeconomics classes participated in this study. The researchers utilized the Myers-Briggs Type Indicator to determine student personality types according to their preference for connecting with others (introvert/extrovert), process information (sensing/intuitive), make decisions (feelings/thinking), and evaluate situations (judging/perceiving). Additionally, the researchers administered an end of semester Likert-style survey to assess students' perception of the FC model. T-test analysis was conducted to analyze students' mean scores on each item of the Inventory survey. Results from this study indicate that in comparison with males, females' sense of competence while learning under the FC model was significantly greater (p<.05). Also, females were more likely to enjoy working collaboratively on classroom worksheets; they reported that group interactions supported their sense of affiliation and made them more comfortable to ask questions in a noncompetitive atmosphere (p<.01). Additionally, females were more likely to find laboratory experiments to be beneficial for their learning and expressed a strong preference for experiential learning as opposed to learning from lectures (p<.01). On the other hand, teachers reported that females were more active participants in FCs than in traditional lecture classrooms. Overall, most students indicated preference or strong preference to learning under the FC model over the traditional lecture model, enjoyed working in groups, perceived their workload in the FC as equally comparable to their workload in other traditional classrooms, and reported that the FC model is beneficial for their learning. Findings from this study provide evidence that the variation of the FC activities benefit a wide population of students (especially females) regardless of their personality types while the traditional model of instruction is mainly favored by dependent or independent learners.

Reychav and McHaney (2017) investigated how secondary level female and male students perceive learning geology in a mobile learning environment (an environment where students can access information through various learning resources anytime). A total of 1131 students (589 males and 542 females) from five secondary schools participated in this study. Students were divided into two groups; students in the first group used their tablets to read and learn from texts, while students in the other group watched and learned from instructional videos. Students in both groups were allowed to work collaboratively however, in each group students were required to either answer exam questions individually or answer them with their peers. The researchers closely observed students throughout the intervention and conducted a post-intervention survey to assess students' perceived peer influence, perceived understanding, and learning satisfaction. A 2(text vs. video) x 2 (individual exam vs. group exam) ANOVA test with one-way repeated measures was used to analyze all data. Findings from this study indicate that in comparison to males, females spent significantly more time discussing video material and engaged in deeper conversations with their peers while collaborating to answer exam questions ($p<.05$). Also, females perceived their understanding of video material to be influenced by their peers significantly more than males. On the other hand, male students' satisfaction with learning from text-based material was significantly higher than females. This study provides further evidence that females favor learning in groups and from instructional videos, the two main activities that students perform in FCs.

Conclusion to Chapter 2

The most recent research literature provides some evidence regarding the efficacy of the flipped and traditional methods of instruction in secondary level science classrooms, but research in this area remains to be limited. Most researchers did not describe the instructional approach implemented in their studies; there is only one study that clearly described a theory-based FC design and measured its efficacy (Lo, Lie, & Hew, 2018). A few researchers (Abdel Meguid & Collins, 2017; Bernard et al., 2004; Murphy, Rodriguez-Manzanares, & Barbour, 2011) suggested that students' experiences in traditional lecture classrooms vary depending on the degree of students' interactions during lectures hence without a clear description of the instructional approach, one cannot determine with a great deal of certainty whether the flipped and the traditional methods of instruction vary in terms of their level of support for students' psychological needs and achievements in schools. Some researchers (Schultz et al., 2014; Love et al., 2014; Leo & Puzio, 2016; Flumerfelt & Green, 2013) have concluded that although the FC is supportive of students learning, the results are not significant enough to consider this instructional approach as primary. The only study that explored satisfaction of students' psychological needs in flipped and traditional classrooms was conducted in a university setting with university level students by Zainuddin and Perera in (2019). The present study will extend the existing literature by clearly describing the treatment plan and implementing Lo, Lie, and Hew (2018)'s theory-based FC design to measure the variation in students' perceptions of autonomy, competence, and relatedness, as well as their achievements in high school chemistry classrooms based upon the instructional approach and gender. Also, the current researcher will increase the validity of the results by controlling the covariates students' self-regulation orientations (as indicated by their relative autonomy index scores) and students' prior performance (as indicated by students' pre-assessment scores). Lastly, the current researcher will conduct classroom observations and provide teachers with feedback if necessary, to ensure that high quality instruction is provided by both participating teachers throughout the study period.

CHAPTER 3: METHODS

This Chapter will provide details on the methods to be employed to investigate the proposed hypotheses of the current study and Information on the research design, sample of participants, instruments used, and intervention.

Research Questions

1- How does the instructional approach (flipped or traditional) in conjunction with student gender, influence high school students' perceptions of autonomy, competence, and relatedness in general chemistry classrooms, while controlling students' prior knowledge of chemistry, prior academic achievement in chemistry, and self-regulation orientations?

2- How does the instructional approach (flipped or traditional) in conjunction with student gender, influence high school students' academic achievements in general chemistry classrooms while controlling students' prior knowledge of chemistry, prior academic achievement in chemistry, and self-regulation orientations?

Hypotheses

Each of the following hypotheses was tested while controlling the covariates presented in the research questions.

H_{01a}: There will be no significant difference in students' perceptions of their (a) autonomy, (b) competence, and (c) relatedness, as measured by the A-BNQ, based upon the instructional approach (flipped or traditional classroom model).

H_{01b}: There will be no significant difference in students' perceptions of their (a) autonomy, (b) competence, and (c) relatedness, as measured by the A-BNQ, based upon gender (male or female).

H_{01c}: There will be no interaction effect of gender and instructional approach on students' perceptions of their (a) autonomy, (b) competence, and (c) relatedness, as measured by the A-BNQ.

H_{02a}: There will be no significant difference in the mean scores of a chemistry post-assessment, as measured by a researcher-created test, based upon the instructional approach (traditional or flipped classroom).

H_{02b}: There will be no significant difference in the mean scores of a chemistry post-assessment, as measured by a researcher-created test, based upon student gender.

H_{02c}: There will be no interaction effect of gender and instructional approach on the means of students' post-assessment scores as measured by a researcher-created test.

Research Design and Data Analysis

The current study employs a quasi-experimental design to investigate the influence of the interaction between instructional approach and gender on high school students' achievements and psychological wellbeing. The current researcher manipulated the independent variable (instructional approach), set up a comparison group, but did not truly randomize the sample. Due to a limited sample size, a series of four two-way ANCOVA tests were employed to answer the research questions. The first three ANCOVA tests were conducted to analyze the influence of the interaction between the instructional approach and gender on students' perceptions of (a) autonomy, (b) competence, and (c) relatedness as measured using three subscales of the academic-basic needs questionnaire (A-BNQ). The fourth ANCOVA test was conducted to analyze the influence of the interaction between the instructional approach and gender on students' academic achievements in chemistry as measured using a researcher-developed Chemistry post-test which was designed to assess students' knowledge of the behavior of gases (a unit in the NYS general chemistry curriculum).

Reliability and Validity of the Research Design

Due to the inability to randomly assign students to treatment groups, there are concerns regarding the validity of the research design. However, it is noted that the *F*-statistic is relatively robust to violation of assumptions with sufficient sample size and assurance of homogeneous variance (Donaldson, 1968). In the current study, the assumption of homogeneity of variance was confirmed through critical review of histograms, QQ plots, and boxplots.

A possible threat to the current quasi-experimental study design is the possibility of non-equivalent groups related to the non-random assignment of study participants however, analysis of pre-test scores confirmed a Levene's test *P*-value that is closer to 1. Additionally, to ensure the validity of the research design, Cronbach Alpha values of all instruments used in the current study were calculated and the current researcher confirmed that they are valid and reliable.

Population and Sample

The target population for this study is 10^{th} grade students who were enrolled in Regents (general level) Chemistry classrooms. The sample chosen for this study is comprised of two teachers and 90 students who were divided equally into two groups (flipped and traditional). The two teachers were both Asian American females with over 20 years of experience in teaching chemistry. Both teachers are certified by NYS to teach chemistry and have at least a Master's degree in education. In each group of students, there were 13 males and 32 females between the ages of 15 and 17 who attended one of two suburban high schools within the same school district. Both schools are located just outside of a large metropolitan city in the north eastern region of the United States. Students who were chosen to participate in the current study were ethnically diverse and represented the population of their schools as shown in Table 1. The 90 students were purposefully sampled for comparison of two instructional approaches. Research using convenience sampling may be limited as the researcher cannot generalize their finding to the entire population (Creswell, 2015).

The sample size of 90 students met the minimum sample size required for a Two-Way ANCOVA test with a medium effect size as indicated by Cohen (1988)'s power and sampling tables set for a 95% confidence interval.

Table 1

Students' Data from Participating Schools (NYSED, 2017)

	Flipped Classroom School N (%)	Traditional Classroom School N (%)
Males	486 (40)	589 (51)
Females	730 (60)	566 (49)
African Americans	170 (14)	208 (18)
Hispanic	584 (48)	785 (68)
Asian	207 (17)	35 (3)
White	231 (19)	116 (10)
Multiracial	24 (2)	12 (1)
Economically Disadvantaged	924 (76)	1051 (91)
Students with Disabilities	97 (8)	266 (23)
English Language Learners	97 (8)	139 (12)
Total Student Population	N= 1216	N= 1155

Instruments

Chemistry Assessments

The current researcher who is a NYS certified chemistry instructor designed two different multiple-choice assessments using questions from previous NYS chemistry Regents exams. The Regents Chemistry exam is comprised of 85 questions (50 multiple choice and 35 constructed response). Students who take the regents exam are allowed 3-hours to complete it. The first assessment designed for the current study was comprised of 15 multiple choice questions which were selected to assess students' knowledge of various chemistry topics that they learned prior to the study intervention; results from this study were used to control students' prior academic achievements in chemistry. The second assessment was also comprised of 15 multiple choice questions, however, these questions were selected to assess students' knowledge of concepts related to the behavior of gases in chemistry prior to and after being taught this unit in their respective traditional or flipped classrooms; the current researcher administered this assessment to control students' prior knowledge of chemistry and to measure the influence of the study's independent variables on students' post-test scores.

The 15-item assessments used for the current study were all graded and a percentage score for each student on each test was calculated. The standardized directions that are often read prior to Regents exams were slightly modified to adjust for test length differences then read prior to all the assessments to ensure that the administration is consistent for all students. Students' scores on the two assessments that were administered prior to the intervention were used in all four of the two-way ANCOVA analyses to control for students' prior knowledge of gas behaviors in chemistry and prior academic achievement in chemistry.

The Chemistry Regents' Exam questions are considered valid and reliable as reported in the NYS Education Department's Assessment Report. Item statistics show adequate range of *p*-values with a median of .72, show local independence based on Rasch Analysis, and show appropriate fit as indicated by INFIT in the range of .7 to 1.3 with the desired mean of 1.0. The content validity was established through developing the blueprint for test items based on the NYS's Standards for Chemistry. All regents exams' items were developed by educators with appropriate teaching certifications and reviewed using criteria that included appropriateness of language and graphics, bias and sensitivity, fidelity to standards, and format (Pearson, 2017). The current researcher as well as the participating teachers are all NYS certified chemistry instructors who ensured the validity of all test items used in the current study; they reviewed each test item and ensured that it measures students' knowledge of the topics that they all agreed on prior to the study. The computed alpha values for the pre/post assessment is .721 and the computed alpha value for the prior achievement in chemistry assessment is .748. To ensure reliability of the assessments. All previously administered chemistry regents exam questions are available for public use and the researcher did not obtain a special permission to use them for this study.

Academic Self-Regulation Questionnaire (A-SRQ)

Participating teachers administered the A-SRQ (Ryan & Connell, 1989) prior to the intervention. The A-SRQ contains four main questions, each of them contains eight response statements which align with one of the following subscales (intrinsic, introjected, identified, or extrinsic). Students are expected to circle “very true,” “sort of true,” “not very true,” or “not at all true” to represent their level of agreement with each statement. According to Deci and Ryan (2000), individuals have different self-regulation orientations which determine their level of persistence and productivity. students who have high relative autonomy index (RAI) scores are classified as intrinsically motivated; they are the most persistent and productive and study for the sole purpose of learning. students who answer very true to the SRQ items that are related to introjected regulation often perform school work to avoid guilt or gain approval from others while students who answer very true to items related identified regulation engage in activities for the purpose of achieving self-valued goals such as going to college or having a good career in the future. The least persistent and productive individuals are those who perform tasks for the sole purpose of gaining external rewards such as money, fame, or grades; these individuals have the least RAI scores.

Analysis of students' responses to the SRQ questionnaire was achieved in two steps; first, the current researcher calculated the mean score of each student for each of the four subscales of the SRQ (intrinsic, introjected, identified, and extrinsic). Second, the researcher calculated the relative autonomy index (RAI) score for each student using Ryan & Connell (1989)'s formula (2 x intrinsic + identified – introjected – 2 x external). Students' RAI scores were used as covariates in the current study to control students' self-regulation orientations. The higher is the RAI score, the more intrinsically motivated a student is and the more likely they are to internalize a learning situation and perform well (Deci & Ryan, 2000). The maximum RAI score is 20 and the minimum score is -24 (Ryan & Connell, 1989).

Ryan and Connell (1989) have presented extensive validity for this scale thus the scale is considered valid and reliable. The scale's Cronbach's alpha values are as follows: .92 for Intrinsic Regulation; .87 for Identified Regulation; .78 for Introjected Regulation; and .75 for Extrinsic Regulation (Dettweiler & Ünlü, 2015). The A-SRQ is based on the Self-Determination Theory and is made available for public use.

Basic Needs Satisfaction Questionnaire

Participating teachers administered a slightly modified version of the Basic Psychological Needs Satisfaction at Work Survey (BPNSS-W) (Deci, Ryan, Gagne, Leon, Usunov, & Kornazheva, 2001) which the current researcher referred to as the academic basic needs questionnaire (A-BNQ). The BPNSS-W was originally designed for use by individuals in the workplace; for the present study, the researcher slightly modified this questionnaire to assess the extent of which students feel their psychological needs are being satisfied in their chemistry classrooms as opposed to assess how workers feel their psychological needs are satisfied at their workplace. This was accomplished by substituting the term “work” with “chemistry classroom”, and the term “workers” with the term “students”. The following is an example of how the current researcher modified a statement that is designed to measure relatedness in the BPNSS-W:

Statement: I really like the people I work with.

Modified statement: I really like the people I learn chemistry with.

The original scale as well as the modified A-BNQ are comprised of 21 statements however the A-BNQ contained two additional questions which asked students to identify themselves as male or female and provide their school ID numbers. Individuals rated how true each of the questionnaire statements was to them on a scale of one to seven, where one is not at all true, four is somewhat true, and seven is very true. The higher is the score, the greater is the amount of need satisfaction expressed by the individual. Students’ answers to statements number (3, 5, 7, 11, 14, 16, 18, 19, 20) were reverse scored before averaging item responses for each subscale (autonomy, relatedness, or competence) as they are negatively worded. There are seven statements that are designed to measure students’ perceptions of their experienced autonomy, six statements measure competence, and eight statements measure relatedness.

According to Pallant (2010) a Cronbach’s alpha value that is greater than .5 for a scale that has less than 10 items is sufficient to determine internal consistency. The BPNSS-W is available to the public for use and is considered valid and reliable. Reported measures of internal consistency and reliability has been shown to be strong with a

Cronbach's alpha coefficient for autonomy (α=.79), competence (α=.73) and relatedness (α=.84) (Deci, et. al., 2001, p.934). The computed Cronbach's alpha values for each subscale of the A-BNQ were α=.612 for autonomy (7 items), α=.625 for competence (6 items), and α=.836 for relatedness (8 items).

Data Collection

All participating students took the same assessments and completed each of them via the Castle Learning website in less than 20 minutes. The prior knowledge of chemistry assessment and the academic achievement in chemistry assessment were both administered by participating teachers before the intervention; the post-assessment was administered during the last day of the intervention. In effort to keep the identities of all research participants confidential, students were asked to use their school ID numbers to access the assessments as opposed to their names or other personal identifiers. At the end of the study, the current researcher exported the documents containing students' responses and scores from the Castle Learning website to a flash drive then secured the flash drive in a cabinet.

Prior to the intervention, students completed the A-SRQ questionnaire in approximately 25 minutes using Microsoft Forms. Similarly, they completed the A-BNQ at the end of the intervention. All students used a secured link and their ID numbers to gain access to the questionnaires. Students answers to the questionnaires were sent directly to the current researcher for analysis who then transported this data to a portable flash drive and locked it in a secured cabinet as per IRB guidelines.

Intervention

Due to COVID-19 social distancing guidelines, the participating school district employed a hybrid instructional model throughout the school year. Parents were given the option to enroll students in track, A, B, or D. Students enrolled in track A, came to school on Mondays and Tuesdays to meet with their instructors in person, and used Microsoft Teams to meet with their instructors via the internet from home for the remainder of the week. Similarly, students in track B, met with their instructors in the classroom on Thursdays and Fridays, then used Microsoft Teams to meet with the instructors via the internet from home for the remainder of the week. Students in track D met with their instructors from home Monday through Friday via Microsoft Teams. Regardless of what track students were enrolled in, teachers were expected to meet with, and teach all students five days per week. By using Microsoft Teams, teachers were able to teach at-home students and in-class students synchronously in real time. Each teacher's computer screen was mirrored for at-home students via Microsoft Teams, and viewed by students physically in their classrooms via classroom projectors simultaneously. Students at home interacted with their teachers via Microsoft Teams chat room or verbally by using the "raise hand" feature on Microsoft Teams and unmuting themselves to speak directly through their computers' microphones when then teacher called on them. Students who were physically present in the classrooms interacted with others simply by raising their hands and speaking. The teachers' computers were connected to loud classroom speakers so that students in the class can hear students at home. When a student in the classroom participates, the teachers were expected to repeat what that student said to ensure that students at home heard them. Due to social distancing regulations and health safety guidelines, students who attended school physically were not allowed to work near each other, and were required to wear masks and sit six feet apart throughout the day; teachers only monitored students from distance.

The current researcher divided the participating students equally into two groups based on the school they attended, however, did not randomize the sample. Analysis of students' prior assessment scores indicate no significant difference in students' prior knowledge of chemistry based upon the group they were assigned to (flipped or traditional). The intervention took place over a period of ten instructional days which equate to a two-week period. Each class period was approximately 45 minutes long. Students in the control group learned a Regents chemistry unit in a traditional lecture pedagogical approach; students in the treatment group learned the same chemistry unit (behavior of gases) according to Lo, Lie, and Hew (2018)'s FC design.

The current researcher conducted several informal observations and two formal observations (one of each instructor) and confirmed proper implementation of the flipped and traditional models. The FC teacher designed instructional videos that activated student's prior knowledge and demonstrated new information. Also, the FC teacher assigned students with follow-up practice problems to complete via the castle learning website to evaluate their understanding of concepts taught in the videos before class. The Castle Learning website was used because it provides students with computerized feedback and hints after they answer a multiple-choice question incorrectly the first time, and also provides them with an explanation to the correct answer if they answer the same question incorrectly twice. During class, the current researcher observed that the FC teacher began lessons with a few questions to assess students' learning of content presented on previously assigned instructional videos then expanded students' learning by presenting new information and discussing practical applications of the curriculum. During the last 30 minutes of class, all students were asked to work collaboratively to solve challenging questions that are relevant to the lesson or conduct laboratory activities related to the behavior of gases. All students conducted laboratory investigation by using PhET interactive simulations which are publicly available on the University of Colorado's website. The FC's teacher assisted at-home and in-person students during group activities by spending a few minutes with each group to facilitate discussions and provide students with positive or constructive feedback. During informal observations of students who were physically in classrooms, the current researcher noticed that most students worked individually on class assignments despite being arranged to work in groups; only two students were seen communicating with each other to solve problems. Students who attended the FC from home were divided into small groups of approximately four students per group using Microsoft Teams and were asked to work collaboratively to solve problems or conduct simulated laboratory experiments. Students at home were encouraged to communicate with each other via several class channels which the teacher created on Teams in advance. Despite teacher's attempts to encourage all students to speak to each other during group activities, only a few students appeared to be comfortable to talk with their peers via Microsoft Teams or others who were physically present in the same classrooms with them. The current study took place at the beginning of the school year and most students did not appear to be familiar with each other or comfortable with interacting with their peers; also none of the students learned in a flipped classroom prior to the beginning of the current study. When students were asked: “why don’t you ask your peers about this question?”, students often replied: “because that’s weird, I don’t know them”, “I would rather work alone”, or “I don’t like the way I sound on the computer”.

The traditional classroom teacher presented their class notes or PowerPoint slides and engaged students throughout the class period by asking them to solve problems or simply read the information presented. Each lecture began with a review of students’ homework or previous lessons, followed by a brief demonstration of new information, and ending with demonstrating solutions to practice problems. Despite several teachers attempts to facilitate classroom discussions, most students were not engaged. Neither students in class, nor students at home were inclined to ask questions during the lectures, however some students did reply when the teacher called on them but often did not provide correct answers to teacher’s questions. After every class period, students were expected to use their class notes and the information they learned during class to complete their homework assignments via the Castle Learning website independently and at home.

Reliability and Validity of the Treatment

The current researcher assured the validity of the treatment by meeting with both participating teachers prior to the study to ensure they understood their roles and the structure of the flipped and traditional classrooms. The FC teacher was already familiar with the FC approach and had used it in the past, hence they already had plenty of material prepared for students to complete virtually and only had to make minor modifications. On the other hand, the traditional classroom teacher utilized the instructional model to teach chemistry for many years prior to the study and did not have to make any modifications to their instruction or notes. The current researcher ensured that the instructional resources developed by both teachers cover the same unit topics, and confirmed that both teachers were able to use a variety of technological tools to create assignments and interact with students effectively. Evidence from observations indicate that each of the participating teachers understood their role and taught their assigned group of students according to the study plan. The current researcher could not control extraneous variables which could have influenced the results of the study for example, students in both groups could have received support from their parents, tutors, or siblings during after school hours to improve their understanding of the lessons and performance on the post-assessment. To control for this threat, both participating teachers volunteered to provide all students with additional support outside of school hours.

CHAPTER 4: RESULTS

This chapter presents the findings of the current study in two parts, the first part addresses the first research question through analysis of students' perceptions of autonomy, competence, and relatedness as measured by the A-BNQ. The second part addresses the second research question through analysis of students' post-assessment scores in chemistry. Descriptive statistics of all the instruments are provided in Table 2.

Table 2

Means and Standard Deviations for Questionnaires and Tests

	Gender of Students	Flipped Class	Traditional Class
		M (*SD*)	*M* (*SD*)
A-BNQ: Autonomy	Male	4.30 (1.065)	4.38 (0.602)
	Female	4.23 (0.705)	4.28 (0.986)
A-BNQ: Competence	Male	4.72 (0.843)	4.91 (0.843)
	Female	4.61 (0.877)	4.6 (0.996)
A-BNQ: Relatedness	Male	4.78 (0.681)	4.46 (0.929)
	Female	4.30 (1.019)	4.28 (1.115)
A-SRQ: RAI	Male	-0.64 (2.157)	-0.94 (1.299)
	Female	-1.16 (1.512)	-1.25 (1.651)
Prior Achievement in Chemistry Test	Male	74.85 (11.241)	75.38 (11.594)
	Female	72.94 (11.984)	72.03 (11.38)
Prior Knowledge Test	Male	46.15 (13.031)	44.92 (13.586)
	Female	41.91 (14.933)	47.28 (16.334)
Post-Intervention Test	Male	80.00 (16.047)	68.69 (19.610)
	Female	73.97 (15.518)	71.28 (15.590)

Part 1: Students' Perceptions of Autonomy, Competence, and Relatedness

Research Question

1- How does the instructional approach in conjunction with student gender, influence high school students' perceptions of autonomy, competence, and relatedness in general chemistry classrooms, while controlling the covariates students' prior knowledge of chemistry, prior academic achievement in chemistry, and self-regulation orientations?

Hypotheses

Each of the following hypotheses was tested while controlling the covariates presented in the research question.

H_{01a}: There will be no significant difference in students' perceptions of their (a) autonomy, (b) competence, and (c) relatedness, as measured by the A-BNQ, based upon the instructional approach (flipped or traditional classroom model).

H_{01b}: There will be no significant difference in students' perceptions of their (a) autonomy, (b) competence, and (c) relatedness, as measured by the A-BNQ, based upon gender (male or female).

H_{01c}: There will be no interaction effect of the instructional approach and gender on students' perceptions of (a) autonomy, (b) competence, and (c) relatedness, as measured by the A-BNQ.

To test the above hypotheses, the current researcher conducted three separate two-way ANCOVA tests in SPSS to investigate the first research question's hypotheses. Results of these analyses suggest that there were no significant differences between students reported feelings of autonomy, competence, or relatedness based upon the instructional approach or gender. The current researcher accepts all the hypotheses relevant to the first research question. Details regarding the analysis of each ANCOVA test are presented next.

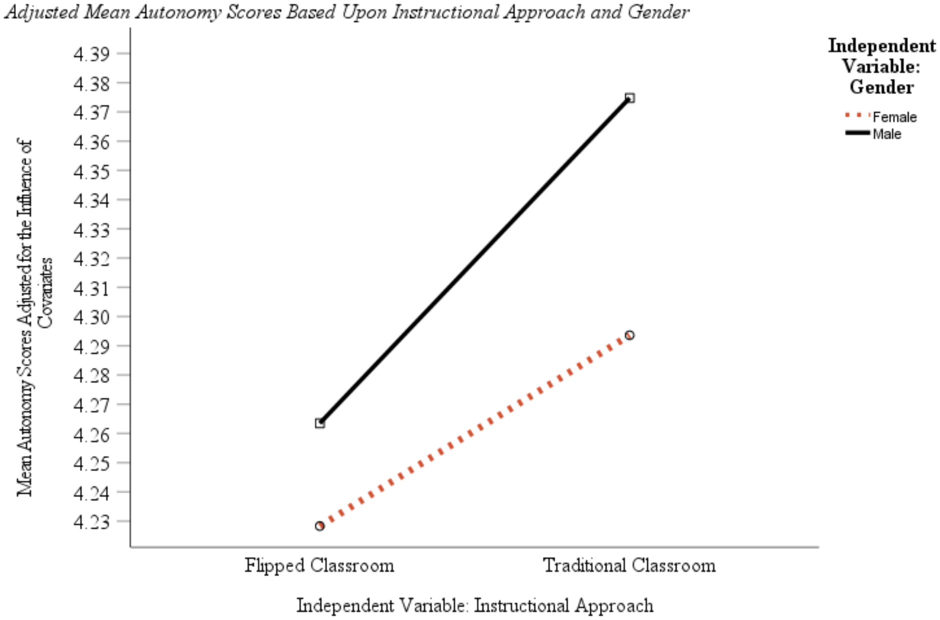
The purpose of the first two-way ANCOVA test was to analyze students' perceived autonomy in flipped and traditional classrooms. Analysis of Q-Q plots and box plots showed one outlier. Analysis of histograms as well as Shapiro-Wilk's test revealed that the dependent variable (students' autonomy scores) was normally distributed for each level of the independent variables ($p>.05$). Analysis of between subject effects revealed that the homogeneity of regression slopes for the interaction between gender and instructional approach was met ($p>.05$), and Levene's test results revealed that the homogeneity of variance assumption was also met ($p>.05$). Matrix scatter graphs showed a balance of scores of the covariates around the dependent variables for each level of the independent variables.

The mean autonomy score of females was lower than that of males in both the traditional and the flipped group. The mean autonomy score of females in the flipped group was $m= 4.23$ in comparison with $m= 4.28$ in the traditional group. The mean autonomy scores of males in the flipped group was $m= 4.30$ which was also lower than that of males in the traditional group at $m= 4.38$. A mean of 4 or higher, according the A-BNQ's autonomy subscale, indicates that students perceived the instructional environment as somewhat supportive of their autonomy. Figure 3 presents the mean autonomy scores of students after adjusting for the influence of the covariates.

Results of this two-way ANCOVA test revealed that while controlling the covariates prior knowledge of chemistry, students' academic achievements, and students' self-regulation orientations, there was no statistically significant difference between students’ perceptions of their autonomy based upon the instructional approach or student genders. This means that females and males’ perceptions of their abilities to control the way they learn and make decisions about their learning while enrolled in the traditional or the FCs did not significantly vary as represented by Table 3. The current researcher accepts the null hypothesis for this ANCOVA test.

Figure 3

Adjusted Mean Autonomy Scores Based Upon Instructional Approach and Gender



Note: Covariate: Relative Autonomy Index Scores = -1.09, Covariate: Prior Knowledge = 73.24, Covariate: Preassessment = 44.87

Table 3

The Difference in Students' Perceptions of Autonomy Based Upon the Instructional Approach and Gender

Predictor	Type III Sum of Squares (*SS*)	Df	Mean Square (*MS*)	*F*	*P*	Partial Eta Squared (Partial η2)
A-SRQ: RAI	1.518	1	1.518	2.044	0.157	0.024
Prior Academic Achievement in Chemistry Test	0.009	1	0.009	0.012	0.913	0.000
Prior Knowledge of Chemistry (Pretest)	0.063	1	0.063	0.085	0.772	0.001
Instructional Approach	0.143	1	0.143	0.193	0.662	0.002
Gender	0.061	1	0.061	0.082	0.776	0.001
Interaction Effect (Instructional Approach x Gender)	0.010	1	0.010	0.013	0.910	0.000
Error	61.668	83	0.743			

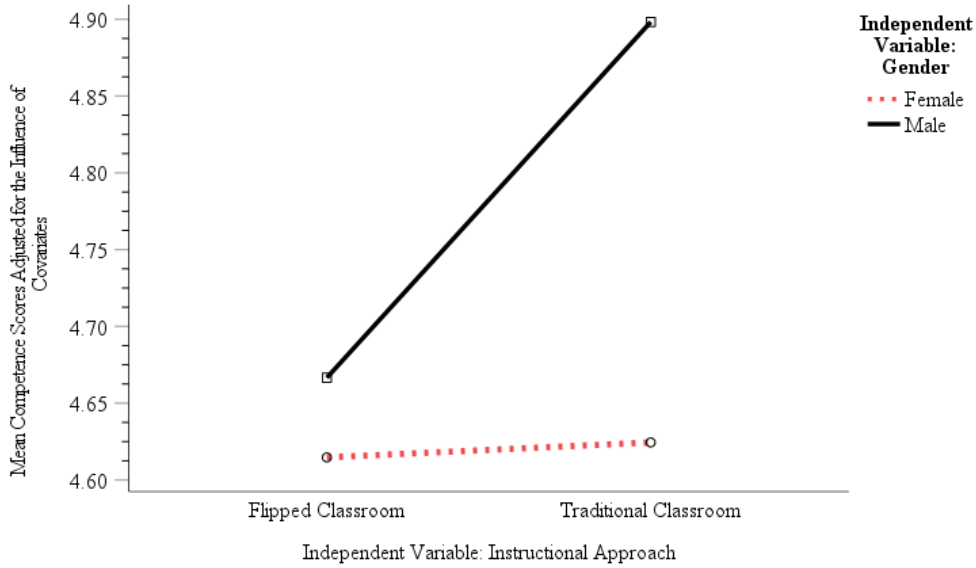
The purpose of the second two-way ANCOVA test was to analyze students' perceived levels of competence in flipped and traditional classrooms. Analysis of Q-Q plots and box plots showed no outliers. Analysis of histograms as well as Shapiro-Wilk's test revealed that the dependent variables (students' competence scores) was normally distributed for each level of the independent variables ($p>.05$). Additionally, Levene's test results revealed that the homogeneity of variance assumption was met $p>.05$. Matrix scatter graphs showed a balance of scores of the covariates around the dependent variables for each level of the independent variables.

The mean competence score of females was lower than that of males in both the traditional and the flipped group. The mean competence score of females in the flipped group *m*= 4.61 was higher than the mean competence score of females in the traditional group *m*= 4.60. The mean competence scores of males in the flipped group *m*= 4.72 was lower than that of males in the traditional group at *m*= 4.91. When adjusted for the influence of the covariates, the mean competence scores of students are slightly different as shown in Figure 4.

Results of the second two-way ANCOVA test revealed that while controlling the covariates prior knowledge of chemistry, students' academic achievements, and students' self-regulation orientations, there was no statistically significant difference between students' perceptions of their competence based upon the instructional approach or student gender. These results indicate that females and males' perceptions of their skills and knowledge of chemistry in flipped and traditional classrooms do not significantly vary as presented by Table 4. The current researcher accepts the null hypotheses for this ANCOVA test.

Figure 4

Adjusted Mean Competence Scores Based Upon Instructional Approach and Gender



Note: Covariates appearing in the model are evaluated at the following values: Covariate: Relative Autonomy Index Scores = -1.09, Covariate: Prior Knowledge = 73.24, Covariate: Preassessment = 44.87

Table 4

The Difference in Students' Perceptions of Competence Based Upon the Instructional Approach and Gender

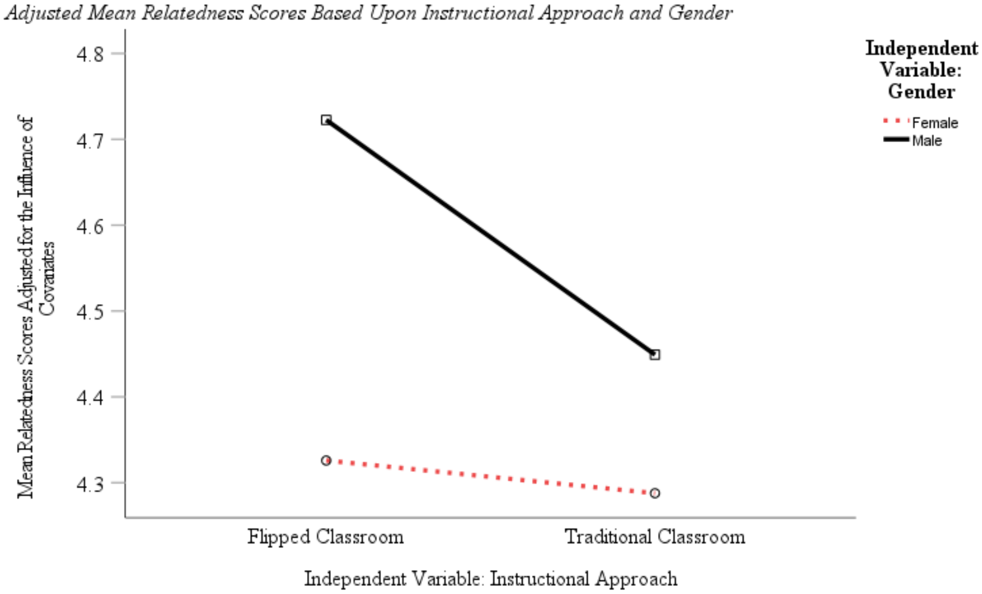
Predictor	Type III Sum of Squares (*SS*)	df	Mean Square (*MS*)	*F*	*P*	Partial Eta Squared (η2)
Intercept	48.745	1	48.745	60.090	0.000	0.420
A-SRQ: RAI	3.689	1	3.689	4.548	0.036	0.052
Prior Academic Achievement in Chemistry Test	0.101	1	0.101	0.125	0.725	0.002
Prior Knowledge of Chemistry (Pretest)	0.028	1	0.028	0.035	0.852	0.000
Instructional Approach	0.267	1	0.267	0.330	0.567	0.004
Gender	0.476	1	0.476	0.586	0.446	0.007
Interaction Effect (Instructional Approach x Gender)	0.224	1	0.224	0.277	0.600	0.003
Error	67.330	83	0.811			

The purpose of the third two-way ANCOVA was to analyze students' perceptions of relatedness in flipped and traditional classrooms. Analysis of Q-Q plots and box plots showed no outliers. Analysis of histograms as well as Shapiro-Wilk's test revealed that the dependent variable (students' relatedness scores) was normally distributed for each level of the independent variables ($p>.05$). Also, Levene's test results revealed that the homogeneity of variance assumption was also met ($p>.05$). Matrix scatter graphs showed a balance of scores of the covariates around the dependent variables for each level of the independent variables.

The mean relatedness score of females was lower than that of males in both the traditional and the flipped group. The mean relatedness score of females in the flipped group *m*= 4.30 was higher than the mean relatedness score of females in the traditional group *m*= 4.28. The mean relatedness scores of males in the flipped group *m*= 4.78 was higher than that of males in the traditional group *m*= 4.46. When adjusted for the influence of the covariates, the mean relatedness scores of students were very slightly different as shown in Figure 5.

Figure 5

Adjusted Mean Relatedness Scores Based Upon Instructional Approach and Gender



Note: Covariates appearing in the model are evaluated at the following values: Covariate: Relative Autonomy Index Scores = -1.09, Covariate: Prior Knowledge = 73.24, Covariate: Preassessment = 44.87

Results of the third two-way ANCOVA test revealed that while controlling the covariates prior knowledge of chemistry, students' academic achievements in chemistry, and students' self-regulation orientations there was no statistically significant difference between students' sense or relatedness based upon the instructional approach or student gender. This means that females and males' perceptions of their affiliation to a group and sense of belonging while enrolled in the traditional or the FCs did not significantly vary as represented by Table 5. The current researcher accepts the null hypotheses for this ANCOVA test and accepts all the null hypotheses associated with the first research question.

Table 5

The Difference in Students' Perceptions of Relatedness Based Upon the Instructional Approach and Gender

Predictor	Type III Sum of Squares (*SS*)	df	Mean Square (*MS*)	*F*	*P*	Partial Eta Squared (η2)
Intercept	38.993	1	38.993	38.986	0.000	0.320
A-SRQ: RAI	3.329	1	3.329	3.329	0.072	0.039
Prior Academic Achievement in Chemistry Test	0.073	1	0.073	0.073	0.787	0.001
Prior Knowledge of Chemistry (Pretest)	0.337	1	0.337	0.337	0.563	0.004
Instructional Approach	0.446	1	0.446	0.446	0.506	0.005
Gender	1.397	1	1.397	1.397	0.241	0.017
Interaction Effect (Instructional Approach x Gender)	0.253	1	0.253	0.252	0.617	0.003
Error	83.016	83	1.000			

Part 2: The Academic Achievement of High School Students in Chemistry

Research Question

2- How does the instructional approach in conjunction with student gender influence high school students' academic achievement in Chemistry while controlling the covariates students' prior knowledge of chemistry, prior academic achievement in chemistry, and students' self-regulation orientations?

Hypotheses

Each of the following hypotheses was tested while controlling the covariates presented in the research question.

H_{02a}: There will be no significant difference in the means of students' scores on a chemistry post-assessment, as measured by a researcher-created test, based upon the instructional approach (traditional or FC).

H_{02b}: There will be no significant difference in the means of students' scores on a chemistry post-assessment, as measured by a researcher-created test, based upon student gender.

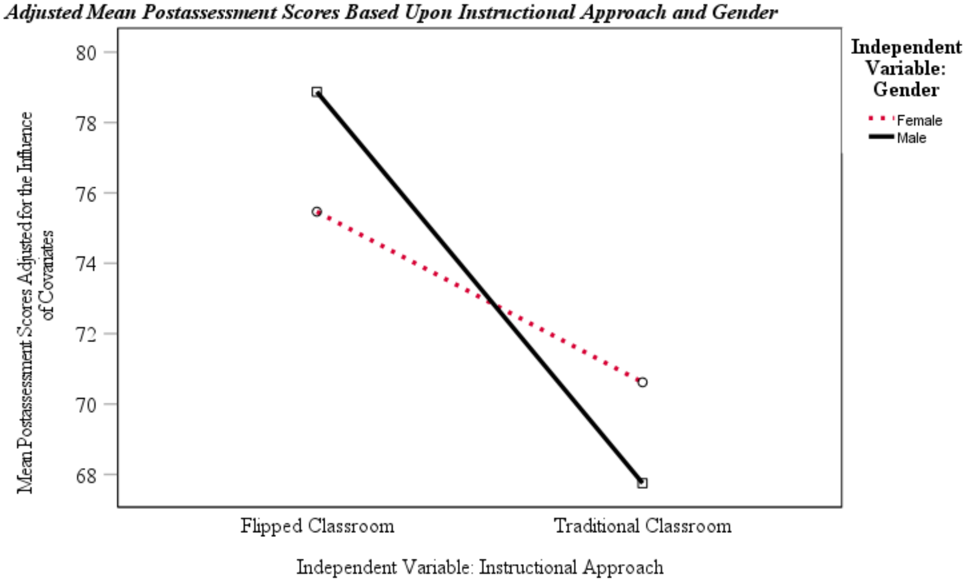
H_{02c}: There will be no interaction effect of the instructional approach and gender on the means of students' post-assessment scores as measured by a researcher-created test.

A two-way ANCOVA test was conducted to investigate the second research question's hypotheses. Analysis of Q-Q plots and box plots showed no outliers. Analysis of histograms as well as Shapiro-Wilk's test revealed that the dependent variables (students' post-assessment scores) was normally distributed for each level of the independent variables (*p*>.05). Analysis of between subject effects revealed that the homogeneity of regression slopes for the interaction between the instructional approach and gender was met (*p*>.05) and Levene's test results revealed that the homogeneity of variance assumption was also met (*p*>.05). Matrix scatter graphs showed a balance of scores of the covariate around the dependent variables for each level of the independent variables.

The mean score of females on the post-assessment in the FC was slightly lower than the mean score of males, however, in the traditional classroom, the mean score of females on that same post-assessment was higher than that of males. Females in the traditional classroom on average, scored lower on the post-assessment than females who learned the same chemistry unit in the flipped class. The mean post-assessment score of females in the flipped group was m= 73.97 in comparison with m= 71.28 in the traditional group. The mean post-assessment score of males in the flipped group was m= 80.00 which was also higher than that of males in the traditional group (m= 68.69). When adjusted for the influence of the covariates, the mean post-assessment scores of students were slightly different as shown in Figure 6.

Figure 6

Adjusted Mean Postassessment Scores Based Upon Instructional Approach and Gender



Note: Covariate: Relative Autonomy Index Scores = -1.09, Covariate: Prior Knowledge = 73.24, Covariate: Preassessment = 44.87

Results of this two-way ANCOVA test revealed that while controlling the covariates prior knowledge of chemistry, students' academic achievements, and students' self-regulation orientations, there was a statistically significant difference between students' post-assessment scores based upon the instructional approach. Students in the FC achieved significantly higher scores on the post-assessment than students who enrolled in the traditional classrooms, thus the current researcher rejects the first hypothesis pertaining to the second research question (There is no significant difference in the mean scores of the chemistry post-assessment based upon the instructional approach); approximately 7.4% of the variability of the mean scores of students on the post-assessment was accounted for by the instructional approach. On the other hand, the current researcher accepts the second and third hypotheses and posit that there is no significant difference between the mean scores of students on the post-assessment based upon gender, and no interaction effect between the independent variables on students' post-assessment scores. Table 6 shows that when the current researcher controlled for the covariates, zero percent of the variability in post-assessment mean scores was accounted for by gender.

Table 6

The Difference in Students' Posttest Scores Based Upon the Instructional Approach and Gender

Predictor	Type III Sum of Squares (*SS*)	df	Mean Square (*MS*)	*F*	*P*	Partial Eta Squared (η2)
Intercept	596.347	1	596.347	3.372	0.070	0.039
A-SRQ: RAI	52.033	1	52.033	0.294	0.589	0.004
Prior Academic Achievement in Chemistry Test	2385.801	1	2385.801	13.491	0.000	0.140
Prior Knowledge of Chemistry (Pretest)	4149.217	1	4149.217	23.462	0.000	0.220
Instructional Approach	1170.984	1	1170.984	6.621	0.012	0.074
Gender	1.305	1	1.305	0.007	0.932	0.000
Interaction Effect (Instructional Approach x Gender)	179.443	1	179.443	1.015	0.317	0.012
Error	14678.400	83	176.849			

CHAPTER 5: DISCUSSION

The purpose of the current study was to investigate how the instructional approach and gender influence students' perceptions of their autonomy, competence, and relatedness, and influences their academic achievements in high school chemistry. The current study took place during a global pandemic when the need to utilize technology to deliver instruction was heightened; students attended school in person two days per week and learned through virtual meetings with their instructors for the remainder of the week. During the study period, the current researcher observed that interactions between students was low, social distancing was enforced, and hands-on learning was limited to simulated laboratory investigations. In this chapter, the current research will discuss the connections between the findings of the current study, the SDT, and prior research; also, the current researcher will indicate the study's limitations, and make several recommendations for future researchers and practitioners.

Interpretation of Results and Connections to Prior Research

The first objective of the current research was to investigate how the instructional approach in conjunction with gender contribute to the satisfaction of high school students' psychological needs while learning chemistry. The results of three different two-way ANCOVA tests indicated that there were no statistically significant main effects of instructional approach or gender on students' perceived levels of autonomy, competence, or relatedness. Ryan and Deci (2002) posit that students experience autonomy when they feel that they are in control of the activities they perform, and that they have the freedom to make choices relevant to their learning. Several studies (Clark 2015; Glynn, 2013) have suggested that learning from instructional videos in a FC setting is preferred by students because such activity allows them to take control of their learning (students can replay the videos as many times as they want) and choose when to learn. There are several possible explanations for why the results of the current research do not align with prior research. First, despite evidence that learning from instructional videos satisfies students' needs for autonomy, Deci and Ryan (2000) posit that students' motivation is central to all learning; for example, if students are not motivated to learn from online videos, or display negative attitudes towards independent learning, it is unlikely that watching online videos would satisfy their psychological needs. In the current study, the means of students RAI scores ranged from -.64 to -1.25; this indicates that prior to the study, students were not highly motivated to perform actions for intrinsic reasons. Second, Låg and Saele (2019) reported that students benefited more from the FC environment when teachers measured their preparation at the beginning of class. In the current study, teachers did not test students' preparations for class and did not monitor whether they watched the instructional videos. Perhaps future research can investigate whether students' perceived autonomy improves when they enroll in FCs that test their knowledge of the assigned videos. Third, a two-week intervention period may not have been sufficient for students to adapt to learning under the FC method and learn independently. Perhaps implementing the FC over a longer period would yield different results.

Theoretically, the FC model satisfies students' needs for competence and relatedness however, findings from this study indicate otherwise. Deci and Ryan (2000) suggest that students may experience competency and relatedness when they are provided with positive feedback while solving problems and feel supported by a group of caring individuals. The FC model is defined as an instructional approach which directs students to learn curriculum concepts at home by using online resources, so that more class time can be allocated for students' interaction, feedback, and problem solving (Bergman & Sams, 2012). In the current study, students' interactions were very low, and their perceived levels of competence and relatedness did not significantly vary based upon the instructional approach or gender. It is possible that students levels of anxiety influenced their levels of interactions and perceived relatedness. Students in the FC may have experienced elevated levels of anxiety and low competence because they did not learn effectively from the instructional videos. Also, the current study took place during a global pandemic which elevated students stress and anxiety levels (Aiyer, Surani, Gil, Ratnani, & Sunesara, 2020). According to Cai & Liem (2017), students with higher levels of anxiety are less likely to persist through challenges than others. Students in the current study were out of school for six-months prior to the intervention due to COVID-19 restrictions. Teaching and learning towards the end of last year varied significantly and during the beginning of the current school year, teaching was 100% online. The variation of instruction from traditional to online to hybrid, along with other personal and family stressors related to the pandemic, may have negatively influenced students' psychological needs.

The findings from the current study are contrary to Zainuddin and Perera (2019)'s study which suggested that the FC did support English language learners' autonomy, competence, relatedness, and achievements in university level English classrooms. There are a few possible explanations to justify why the results of the current study do not align with Zainuddin's study. First, the sample chosen for Zainuddin and Perera (2019)'s study is comprised of students who were enrolled in English classrooms where the primary focus was to develop students' language and communication skills, however, the current study was comprised of high school students enrolled in general chemistry classrooms. According to Deci and Ryan (2002), individuals are more likely to experience autonomy, competence, and relatedness when they pursue intrinsic goals; perhaps learning a new language is perceived as more valuable to students than learning chemistry. Second, the current study took place in a high school setting with high school students, on the other hand, Zainuddin and Perera's study took place in a university campus and the participants were university level students. The level of maturity, internalization, and persistence of high school students may be significantly different from that of university level students. There are developmental and experiential differences which could influence how students perceive the FC as supportive of their psychological needs.

The second objective of the current research was to investigate the variation of students' achievements based upon gender and the instructional approach. Data from the National Science Foundation's website indicate that females are less likely to major in physical sciences thus there is a need to increase their achievement and interest in science and engineering (NSF, 2017). Theoretically, the FC may be perceived as supportive of female students' achievements in science. Peterson and Brockman (2011) suggested that optimal female performance in science correlates with low levels of anxiety, high self-efficacy, and high levels of motivation; this could be achieved in a FC environment when students learn in the comfort of their homes, repeatedly review concepts through instructional videos, and receive feedback and guidance from others in a caring classroom environment. Additionally, Halpern and colleagues provided extensive evidence that females perform optimally in science when the classroom environment permits them to interact with each other to receive and give feedback, interact with objects through laboratory activities, and make connections using various resources. In the FC model, interactions between students is encouraged and students are expected to make connections between information they learned from home and during class to solve problems. Contrary to theoretical beliefs, findings from the current study indicates that male participants who learned under the FC model performed better on the post-assessment (*m*= 80.00%) than males in the traditional classroom (*m*= 68.69%) and all female participants (FC *m*= 73.97%; traditional classroom *m*=71.28%), however, the results were insignificant. The current researcher suggests that the unequal number of male and female participants in each group may have influenced these results. Additionally, this variation of results may have also been due to operational barriers as suggested by Lo, Lie, and Hew in 2018; it is unknown whether male and female students had equal access to reliable internet connections or a quiet space to learn effectively from home.

Prior research indicates that implementation of the FC model may support students' academic achievement in various subjects (Låg & Saele, 2019; Strelan, Osborne & Palmer, 2020), however, Glynn (2013) indicates that there is no significant difference in students' achievements in flipped or traditional high school chemistry classrooms based upon the instructional approach or student gender. Empirical evidence from the current study indicates that the mean post-assessment score of students in the FC was significantly higher than the mean score of students in the traditional classroom. The current researcher argues that unlike students in the traditional classroom, students in the FC may have gained a clearer understanding of the curriculum because they were able to rewind and replay instructional videos. Results from Glynn's (2013) interview analysis support this claim and suggest that students in the FC understand the material better while watching videos. The variation of the findings between the current study and Glynn (2013)'s study may be due to teacher experience and some characteristics of the setting. In Glynn (2013), the researcher acted as the teacher of both flipped and traditional classes; the researcher also reported having no official training in teaching science "I will acknowledge that in the last few years I have not been as innovative and exploratory in my teaching as I was at the start of my career… I had no official training in the methods of science teaching, I taught myself to teach chemistry". In the current study, the participating teachers were both certified by NYS to teach chemistry at the high school level and each had at least 20 years of experience in teaching the subject. Additionally, the FC teacher was very familiar with the FC model and used it in the past with her students. On the other hand, Glynn (2013)'s study took place in a physical classroom where the teacher and students met face-to-face; the teacher was able to monitor students' learning during the entire class period and directed them to perform certain tasks which he perceived as beneficial for their learning. In the current study, most of the participating students attended classes from home and there was no way to ensure that they were all engaged in the same class activity at the same time; students could have muted the teacher and engaged in other learning activities that they perceived as interesting and supportive of their achievements in chemistry.

In summary, the current researcher argues that many variables could have influenced the findings of the current study. The COVID-19 global pandemic has affected the learning of nearly 1.6 billion students worldwide (UNESCO 2020). The last time participating students attended school in person was nearly six months prior to the beginning of the current study; this may have influenced their sense of affiliation and level of interactions with each other. The current researcher observed that students' peer interactions were very low, hence students did not receive enough feedback from their peers and their sense of competence suffered. Transitioning from traditional instruction to online instruction and hybrid instruction may have elevated students' levels of stress and anxiety which may have negatively affected their overall psychological wellbeing and the achievements of female students in the FC. According to Peterson and Brockman (2011) females who performed poorly in science, displayed higher levels of anxiety than females who perform well in science. Lastly, the duration of the current study may not have been long enough for high school students to adjust to the flipped approach and manage to learn independently.

Limitations

There are several limitations to the current study related to sampling, data collection, and the interaction of history and implementation. The sample size was sufficient for the statistical analyses employed for the current study, however, the numbers of female and male students were not equal within each group of participants. The underrepresentation of male students may have masked possible gender differences.

In terms of data collection, the current study relied heavily on students' abilities to recall their sense of autonomy, competence, and relatedness after the intervention. Students may not have been able to recall information towards the end of the study thus their self-reported responses to the A-BNQ items may have been inaccurate. Garcia and Murphy (2015) indicated that some level of bias may occur when students are asked to reflect on experiences they may or may not remember clearly. Additionally, the current study took place during global pandemic crisis which was reported to have caused a widespread of anxiety among school-age students (Aiyer et al., 2020). Students were not able to attend school for an extended period prior to the commencement of the study and the duration of the intervention may not have been sufficient for students to adjust to learning in school again. The results of the current study do not indicate whether the FC instructional approach could potentially satisfy students' psychological needs during a normal school year.

Threats to Statistical Conclusion Validity

A possible threat to the statistical conclusion validity was low statistical power. A total of 90 students (26 males) from two different high schools participated in this study and the current researcher did not randomize the sample. To control for this threat, the researcher managed to choose a sample from two comparable schools that were located within a reasonable distance from each other and within the same school district. Students in both schools came from the same community and there were no statistically significant differences in the means of students' scores on any of the preassessments. Additionally, there were two different teachers who implemented the FC instructional approach which poses a possible low reliability of treatment. To control for this threat, the current researcher chose two comparable teachers who are both females with similar years of teaching experience and met with them prior to the intervention to ensure that they understood their roles in the study, and that they can utilize technological resources to deliver instruction effectively.

Threats to Internal Validity

An internal threat to the validity of the current quasi-experiment was the presence of several factors that may have influenced students' academic achievement. Some students may have received support from tutors or parents while studying at home. One cannot say with a great deal of certainty that the instructional approach that is followed by the instructor or students' gender were the only factors that influenced students' academic achievements. The researcher could not control how much tutoring a student received after school therefore this was a limitation to this study. Nevertheless, the researcher reduced the impact of such limitation by asking both participating teachers to make themselves available at least once per week for a forty-minute period to provide students with additional tutoring and teach them effective study strategies.

Threats to External Validity

A possible threat to the external validity of the current study was the interaction between setting and treatment. The current study took place in two large suburban high schools which each has a student population of approximately 1000 students. The findings of this research cannot be generalized to other schools which student populations are significantly smaller.

Implications for Future Research

The current researcher suggests several recommendations for future researchers. First, implement the FC over a longer period to allow students more time to adjust to this instructional model and learn independently. Second, measure students' perceptions of autonomy, competence, and relatedness in real time using the experience sampling method to gain a better understanding of which activity contributes the most to satisfaction of students' psychological needs and supports their achievement. Csikszentmihalyi and Larson (2014) assured the reliability of the experience sampling method and suggested that it is an effective way to reduce bias which may result from the inability of research participants to recall information after the intervention. Third, conduct a mixed methods study that triangulates data from different resources to obtain a better perspective of how the FC model influences high school students' psychological wellbeing and learning in physical science classrooms. Suter (2006) suggests that the use of a mixed methods research design provides researchers with a deeper understanding of how the implementation of innovative practices can influence current problems. Fourth, implement various models of the FC design and investigate which model is most beneficial for high school students. Fifth, investigate the influence of the instructional approach on students' critical and analytical thinking skills by using pre/post assessments that contain short response and essay questions.

Implications for Future Practice

The current study indicates that the FC instructional approach positively influences high school students' achievements in chemistry despite its implementation during a global pandemic and a time of political unrest.

For Teachers

To achieve similar students' achievement results, the current researcher recommends that teachers prepare clear and concise online resources for students to use when learning at home, foster a safe and stress-free learning environment, and encourage students' interactions during class activities. The FC teacher in the current study was very familiar with the FC method and has implemented it for years prior to the study, thus she had plenty of resources made to help students learn from home. The current researcher agrees with Lo and Hew (2017) suggestions and recommends that teachers develop classroom material in stages to reduce workload. Lastly, the current researcher recommends that teachers implement the FC method over a longer period of time to help students adapt to this model of learning.

For School Leaders

The current researcher recommends that school building and district leaders support and encourage teachers to implement innovative strategies in their classrooms. School leaders may support teachers by providing them with positive/constructive feedback, and access to computer devices, high speed internet connections, and subscriptions to online websites so they can effectively differentiate instruction to support students' different learning styles. Administrator may also support teachers by facilitating teacher interactions to encourage innovation in the classroom; for example, administrators may schedule a common planning time for all teachers to collaborate and discuss various ways to educate struggling students. Lastly, administrators may also support teachers by providing them with professional development opportunities to improve their technological and communication skills; such professional development may include workshops on how to create and embed questions in instructional videos, workshops on how to hold students accountable for learning online, and opportunities to learn how to support students social and emotional wellbeing online and in-person.

For Curriculum Developers

The current researcher recommends that curriculum developers create content that align with students' interests (for example: by making various connections to music, sports, and current issues) to help teachers facilitate more effective classroom discussions. Curriculum developers may also support students' learning by providing supplemental material and making them available online to support students with special needs and English language learners. Lastly the current researcher recommends that curriculum developer create interactive learning resources such as simulated lab activities or online games which present a variety of questions that align with the skills of a diverse student population.

Conclusion

Findings from the current study extended researchers knowledge of the implications for implementing the FC model on secondary school male and female students. While there were some limitations to this study, the researcher took various measures to control for several factors that could influence the study findings; despite researchers' efforts, there was no way to control the influence of the global pandemic on students' psychological states. Furthermore, the current researcher made several recommendations to improve teaching and learning and extend research. More research is necessary to further investigate the influence of implementing a theory-based FC design in high school, and investigate which FC design is most beneficial for students.

APPENDIX A: IRB CERTIFICATION

ST. JOHN'S UNIVERSITY

Federal Wide Assurance: FWA00009066

Mar 2, 2020 12:04 PM EST

PI: Jordan Salhoobi
CO-PI: Rene Parmar
Ed Admin & Instruc Leadership

Re: Expedited Review - Initial - **IRB-FY2020-379** *INVESTIGATING WHETHER THE FLIPPED CLASSROOM INSTRUCTIONAL APPROACH AND STUDENTS' MOTIVATION INFLUENCE CHEMISTRY ACHIEVEMENTS IN HIGH SCHOOL*

Dear Jordan Salhoobi:

The St John's University Institutional Review Board has rendered the decision below for *INVESTIGATING WHETHER THE FLIPPED CLASSROOM INSTRUCTIONAL APPROACH AND STUDENTS' MOTIVATION INFLUENCE CHEMISTRY ACHIEVEMENTS IN HIGH SCHOOL*. The approval is effective from March 1, 2020 through February 28, 2021

Decision: Approved

PLEASE NOTE: If you have collected any data prior to this approval date, the data must be discarded.

Selected Category:

Sincerely,

Raymond DiGiuseppe, PhD, ABPP
Chair, Institutional Review Board
Professor of Psychology

Marie Nitopi, Ed.D.
IRB Coordinator

REFERENCES

Abeysekera, L., & Dawson, P. (2015). Motivation and cognitive load in the flipped classroom: Definition, rationale and a call for research. *Higher Education Research & Development*, *34*(1), 1–14. doi:10.1080/07294360.2014.934336

Aiyer, S., Surani, S., Gil, Y., Ratnani, I., and Sunesara, S. (2020). *COVID-19 Anxiety and Stress Survey (CASS) in High School and College Students due to Corona Virus Disease 2019*. doi:10.1016/j.chest.2020.08.312

Baker, J. W. (2000). The "classroom flip": Using web course management tools to become the guide on the side. In J. A. Chambers (Ed.), *Selected papers from the 11th International Conference on College Teaching and Learning,* 9–17. Jacksonville, FL: Florida Community College at Jacksonville.

Bergmann, J., & Sams, A., (2012). *Flip your classroom: Reach every student in every class every day*. Washington: International Society for Technology in Education.

Betihavas, V., Bridgman, H., Kornhaber, R., & Cross, M. (2016). The evidence for 'flipping out': A systematic review of the flipped classroom in nursing education. *Nurse Education Today*, *38*, 15–21. doi:10.1016/j.nedt.2015.12.010

Cai, E. Y. L., & Liem, G. A. D. (2017). 'Why do I study and what do I want to achieve by studying?' Understanding the reasons and the aims of student engagement. *School Psychology International, 38*(2), 131–148.

Chis, A. E., Moldovan, A.-N., Murphy, L., Pathak, P., & Muntean, C. H. (2018). Investigating Flipped Classroom and Problem-based Learning in a Programming Module for Computing Conversion Course. *Educational Technology & Society*, *21*(4), 232–247.

Clark, K. R. (2015). The Effects of the Flipped Model of Instruction on Student Engagement and Performance in the Secondary Mathematics Classroom. *Journal of Educators Online*, *12*(1), 91–115.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates Publishers.

Creswell, J. (2015). *Educational Research Planning, Conducting, and Evaluating Quantitative and Qualitative Research*. New York: Pearson.

Csikszentmihalyi M., & Larson R. (2014). Validity and reliability of the experience-sampling method. In M., Csikszentmihalyi (Ed.), *Flow and the Foundations of Positive Psychology,* 35–54. Berlin: Springer Netherlands. doi:10.1007/978-94-017-9088-8_3

Deci, E. D., & Ryan, R. M. (2002). *Handbook of self-determination research.* New York: University of Rochester Press.

Deci, E. L, & Vansteenkiste M. (2004). Self-determination theory and basic need satisfaction: understanding human development in positive psychology. *Research in Psychology*. *27* (1), 23–40.

Deci, E. L., & Ryan, R. M. (2000). The "What" and "Why" of Goal Pursuits: Human Needs and the Self-Determination of Behavior. *Psychological Inquiry*, *11*(4), 227. doi:10.1207/S15327965PLI1104_01

Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin, 125,* 627–668.

Deci, E. L., Ryan, R. M., Gagné, M., Leone, D. R., Usunov, J., & Kornazheva, B. P. (2001). Need satisfaction, motivation, and well-being in the work organizations of a former Eastern bloc country: A cross-cultural study of self-determination. *Personality and Social Psychology Bulletin, 27*(8), 930–942. doi:10.1177/0146167201278002

Desy, E. A., Peterson, S. A., & Brockman, V. (2011). Gender differences in science-related attitudes and interests among middle school and high school students. *Science Educator, 20*(2), 23–30.

Dettweiler U., Ünlü A. (2015). *Testing the reliability and validity of a reduced Academic Self-Regulation Questionnaire (SRQ-A) in a mixed-methods approach.* doi:10.13140/RG.2.1.4375.4400

Donaldson, T. S. (1968). Robustness of the F-test to errors of both kinds and the correlation between the numerator and denominator of the F-ratio. *Journal of the American Statistical Association, 63*(322), 660–676. doi:10.2307/2284037

Flumerfelt, S. & Green, G. (2013). Using Lean in the Flipped Classroom for At Risk Students. *Journal of Educational Technology & Society, 16*(1), 356-366. Retrieved February 2, 2021, from http://www.jstor.org/stable/jeductechsoci.16.1.356

Glynn Jr, J. (2013). *The Effects of a Flipped Classroom On Achievement and Student Attitudes In Secondary Chemistry*. Bozeman, Montana: Montana State University.

Grypp, L., & Luebeck, J. (2015). Rotating Solids and Flipping Instruction. *Mathematics Teacher*, *109*(3), 186–193.

Hailikari, T., Nevgi, A., & Lindblom-Ylänne, S. (2007). Exploring alternative ways of assessing prior knowledge, its components and their relation to student achievement: a mathematics-based case study. *Studies in Educational Evaluation, 33,* 320–337.

Halpern, D. F., Aronson, J., Reimer, N., Simpkins, S., Star, J. R., Wentzel, K. (2007). *Encouraging girls in math and science.* Washington, DC: Institute for Educational Sciences, United States Department of Education.

Halpern, D., Benbow, C., Geary, D., Gur, R., Hyde, J.S., & Gernsbacher, M.A. (2007). The science of sex differences in science and mathematics. *Psychological Science in the Public Interest, 8*(1), 1–51.

Jang, H., Reeve, J., & Deci, E.L. (2010). Engaging students in learning activities: It is not autonomy support or structure but autonomy support and structure. *Journal of Educational Psychology*, *102*, 588–600. doi:10.1037/a0019682

Juuti, K., Lavonen, J., Uitto, A., Byman, R., & Meisalo, V. (2010). Science teaching methods preferred by grade 9 students in Finland. *International Journal of Science and Mathematics Education*, *8*(4), 611–632. doi:10.1007/s10763-009-9177-8

Kozma, R. B. E. (2003) *Technology, Innovation, and Educational Change: A Global Perspective*. Eugene, OR: International Society for Educational Technology (ISTE).

Kuhfeld M., Soland, J., Tarasawa, B., Johnson, A., Ruzek, E., & Liu, J. (2020). Projecting the potential impacts of COVID-19 school closures on academic achievement. *Ed Working Paper,* 20–226. Annenberg Institute at Brown University. doi:10.26300/cdrv-yw05

Låg, T., & Sæle, R. G. (2019). Does the flipped classroom improve student learning and satisfaction? A systematic review and meta-analysis. *AERA Open, 5*(3), 1–17. doi:10.1177/23328 58419 8

Lage, M., Platt, G., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. *Journal of Economics Education, 31*(1), 30–43.

Lavasani, M. G., Mirhosseini, F. S., Hejazi, E., & Davoodi, M. (2011). The Effect of self-regulation learning strategies training on the academic motivation and self-efficacy. *Procedia - Social and Behavioral Sciences, 29*, 627–632.

Leo, J., & Puzio, K. (2016). Flipped Instruction in a High School Science Classroom. *Journal of Science Education and Technology*, *25*(5), 775–781. doi:10.1007/s10956-016-9634-4

Liem, G. A. D., & Chong, W. H. (2017). Fostering student engagement in schools: International best practices [Editorial]. *School Psychology International, 38*(2), 121–130. doi:10.1177/0143034317702947

Lo, C. K., & Hew, K. F. (2017). A critical review of flipped classroom challenges in K-12 education: Possible solutions and recommendations for future research. *Research and Practice in Technology Enhanced Learning*, *12*, 4. doi:10.1186/s41039-016-0044-2

Lo, C. K., Lie, C. W., & Hew, K. F. (2018). Applying “First Principles of Instruction” as a design theory of the flipped classroom: Findings from a collective study of four secondary school subjects. *Computers & Education*, *118*, 150–165. doi: 10.1016/j.compedu.2017.12.003

Lord, S. M. & Camacho, M. M. (2007). Effective teaching practices: Preliminary analysis of engineering educators. F3C-7. doi:10.1109./FIE.2007.4417881

Love, B., Hodge, A., Grandgenett, N., & Swift, A. W. (2014). Student learning and perceptions in a flipped linear algebra course. *International Journal of Mathematical Education in Science and Technology*, *45*(3), 317–324. doi:10.1080/0020739X.2013.822582

Mason, G. S., Shuman, T. R., & Cook, K. E. (2013). Comparing the Effectiveness of an Inverted Classroom to a Traditional Classroom in an Upper-Division Engineering Course. *IEEE Transactions on Education*, *56*(4), 430–435. doi:10.1109/TE.2013.2249066

McNally, B., Chipperfield, J., Dorsett, P., Fabbro, L., Frommolt, V., Goetz, S., … Rung, A. (2017). Flipped classroom experiences: Student preferences and flip strategy in a higher education context. *Higher Education (00181560)*, *73*(2), 281–298. doi:10.1007/s10734-016-0014-z

NASEM (National Academies of Sciences, Engineering, and Medicine). (2018). *Science Literacy: Concepts, Contexts, and Consequences*. Washington, DC: The National Academies Press.

NCES (US Department of Education, National Center for Education Statistics). (2020). *PISA 2018 US Results*. Retrieved December 20, 2020, from https://nces.ed.gov/surveys/pisa/pisa2018/pdf/PISA2018_compiled.pdf

New York State Education Department. (2018). *New York State Regents Examination in Chemistry 2017 Technical Report*. Albany, NY: NYSED. Retrieved December 18, 2020, from http://www.p12.nysed.gov/assessment/reports/2017/chem-17.pdf

NSF (National Science Foundation). (2017). Intentions of freshmen to major in S&E fields, by race or ethnicity and sex. Retrieved January 5, 2021, from https://www.nsf.gov/statistics/2017/nsf17310/static/data/tab2-8.pdf

OECD. (2016). PISA 2015 Results (Volume I): Excellence and Equity in Education. Paris: OECD Publishing, doi:10.1787/9789264266490-en

Olson, S., & Riordan, D. G. (2012). Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics. Report to the President. Retrieved January 2, 2021 from https://eric.ed.gov/?id=ED541511

Pallant, Julie. (2010). *SPSS survival manual: a step by step guide to data analysis using SPSS.* Maidenhead: Open University Press.

Patall, E. A., Cooper, H., & Robinson, J. C. (2008). Parent involvement in homework: A research synthesis. *Review of Educational Research 78*(4): 1039–1101.

Persky, A. M., & McLaughlin, J. E. (2017). The Flipped Classroom – From Theory to Practice in Health Professional Education. *American Journal of Pharmaceutical Education, 81*(6), 118. doi:10.5688/ajpe816118

Potvin, P., & Hasni, A. (2014). Interest, motivation and attitude towards science and technology at K-12 levels: A systematic review of 12 years of educational research. *Studies in Science Education, 50*(1):85–129. doi:10.1080/03057267.2014.881626

Reeve, J., Deci, E. L., & Ryan, R. M. (2004). Self-determination theory: A dialectical framework for understanding the sociocultural influences on student motivation. In D. M. McInerney & S. Van Etten (Eds.), *Research on sociocultural influences on motivation and learning: Big theories revisited, 4*, 31–59. Greenwich, CT: Information Age Press.

Reychav, I., & McHaney, R. (2017). The relationship between gender and mobile technology use in collaborative learning settings: an empirical investigation. *Computers & Education*, *113*, 61–74.

Ryan, R. M. (1995). Psychological needs and the facilitation of integrative processes. *Journal of personality, 63,* 397–427.

Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology, 57,* 749–761. doi:10.1037/0022-3514.57.5.749

Schultz, D., Duffield, S., Rasmussen, S. C., & Wageman, J. (2014). Effects of the flipped classroom model on student performance for advanced placement high school chemistry students. *Journal of Chemical Education, 91*(9), 1334–1339. doi:10.1021/ed400868x

Sheldon, K. M., & Filak, V. (2008). Manipulating autonomy, competence and relatedness support in a game-learning context: New evidence that all three needs matter. *British Journal of Social Psychology, 47*, 267–283.

Strelan, P., Osborn, A., & Palmer, E. (2020). The flipped classroom: A meta-analysis of effects on student performance across disciplines and education levels. *Educational Research Review, 30,* 100314. doi:10.1016/j.edurev.2020.100314

Suter, W. N. (2006). *Introduction to educational research: A critical thinking approach.* Thousand Oaks, CA: Sage Publications.

UNESCO. (2020). Why the World Must Urgently Strengthen Learning and Protect Finance for Education. Retrieved December 12, 2020 from https://en.unesco.org/news/why-world-must-urgently-strengthen-learning-and-protect-finance-education.

Vansteenkiste, M., Niemiec, C., & Soenens, B. (2010). The development of the five mini-theories of self-determination theory: an historical overview, emerging trends, and future directions. In T. Urdan, & S. Karabenick (Eds.), *The decade ahead. Advances in motivation and achievement,* 16, 105–166. United Kingdom: Emerald Publishing.

Wara, E., Aloka, P. J., & Odongo, B. C. (2018). Relationship between Cognitive Engagement and Academic Achievement among Kenyan Secondary School Students. *Mediterranean Journal of Social Sciences 9*(2), 61–72.

Webb, M. E. and Cox, M. J. (2004). A review of pedagogy related to information and communication technology. *Technology, Pedagogy and Education*, *13*(3), 235–286.

Zainuddin, Z., & Perera C. J. (2019). Exploring students' competence, autonomy and relatedness in the flipped classroom pedagogical model. *Journal of Further and Higher Education, 43,* 115–126.

Zirkel, S., Garcia, J., & Murphy, M. (2015). Experience-Sampling Research Methods and Their Potential for Education Research. *Educational Researcher, 44*(1), 7–16.

Vita

Name	Jordan Salhoobi
Baccalaureate Degree	Bachelor of Science, City University of New York, Lehman College Major: Anthropology, Biology, and Chemistry Minor: Mathematics
Date Graduated	May, 2009
Other Degrees and Certificates	Master of Science, City University of New York, Lehman College Major: Science Education
Date Graduated	May, 2012