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EXPLORING THE RELATIONSHIP BETWEEN INSTRUCTION AND STUDENT PERCEPTIONS OF SELF-EFFICACY AND STUDENT SCIENCE IDENTITY IN BLACK AND LATINO SCIENCE STUDENTS

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EXPLORING THE RELATIONSHIP BETWEEN INSTRUCTION AND STUDENT PERCEPTIONS OF SELF-EFFICACY AND STUDENT SCIENCE IDENTITY IN BLACK AND LATINO SCIENCE STUDENTS

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ABSTRACT

EXPLORING THE RELATIONSHIP BETWEEN INSTRUCTION AND STUDENT PERCEPTIONS OF SELF-EFFICACY AND STUDENT SCIENCE IDENTITY IN BLACK AND LATINO SCIENCE STUDENTS

Yolette Wright

The purpose of this quantitative study was to determine the relationship between Black and Latino high school science students' perceptions of instruction and science identity and to determine if this relationship is mediated by student perceptions of self-efficacy. A second goal of this study was to determine if there is a relationship between the science teacher's years of experience and the students' perceptions of instruction, perceptions of self-efficacy, and science identity. Study participants included 204 Black and Latino high school science students from a suburban high school and their science teachers. The *Student Perception of Classroom Quality Scale* was used to measure student perceptions of instruction. Student science identity was measured using an affinity index while the *General Self Efficacy Scale* was administered to measure students' self-efficacy. The *Teachers' Sense of Self-Efficacy Scale* measured teacher self-efficacy and the *Student Centered Learning Questionnaire for Teachers, 2016* measured teacher instruction. A hierarchical multiple regression analysis was used to determine the relationships between student perceptions of instruction, student perceptions of self-efficacy, and student science identity, as well as the mediation effect of self-efficacy. Significant relationships were found between perceptions of instruction, perceptions of self-efficacy, and science identity. Self-efficacy was found to be a significant mediator of the relationship between student perception of instruction and science identity. No significant relationships were found between teacher self-efficacy or teacher instructional method and student variables. However, a Multivariate Analysis of Variance (MANOVA) revealed that students who had more experienced teachers tended to have greater perceptions of instruction, perceptions of self-efficacy and science identity. These results reinforce the importance of instructional appeal in science. In order to promote self-efficacy and therefore science identity in Students of Color, science instruction should include choice, be relevant to the students, and also be challenging. The results also emphasize the importance of supporting novice teachers as they develop their teaching competencies in order to help them develop instruction which students find appealing.

DEDICATION

I dedicate this dissertation to those who have supported me and inspired me along the way. First to my mother, Millicent Wright, who as a teenager immigrated from Jamaica to the United States to build opportunities for herself and her future children. I also honor my grandmother, Mertella Leach, with this dedication. I am so grateful that she has lived long enough to see me accomplish this goal.

I also dedicate this writing to my sisters Marsha Wright, Esq., and Nicole Wright. My sunshine, Dillon, this is also dedicated to you. I hope that my example inspires you to continue to work hard to fulfill your dreams.

Finally, this dissertation is dedicated in memory of two people who I know would have been celebrating this accomplishment with me. First, to my aunt, Althea Leach, the person who inspired me to take on higher education. Second, to my father Vincent Wright. I know Daddy would have been telling everyone, far and wide, about what his daughter has done.

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Finally, I am grateful for all the students I have ever taught, those I currently teach, and those I will teach in the future. Each day you challenge me to work hard at providing meaningful, inspirational science education. Thank you. And now you may call me Dr. Wright!

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CHAPTER 1: INTRODUCTION

The achievement gap refers to the disparities in educational opportunities for Students of Color in comparison to White students (Coleman, 1966). Various explanations for the science achievement gap have been proposed, including lack of student interest, and negative perceptions of science (Peeterson-Beeton, 2007). Studies have found this lack of interest in science was not intrinsic to Students of Color, but that students who lack prior experience in a given discipline often have low-self efficacy in that same area and are less likely to see things through when given a task (Olszewsk-Kubilius, 2006). As self-efficacy in an area increases, the students' identity in this area also increases (Flowers III & Banda, 2016). Students with a strong science identity are more likely to persist in science (Oseguera et al., 2019). Culturally responsive, student-centered lessons have been shown to improve self-esteem, academic skills, and the value of education among Students of Color (McNerney & Beppu, 2006). The likelihood of teachers using student-centered instruction has been shown to be related to the teacher's sense of self-efficacy and teaching experience (Haymore Sandholtz & Ringstaff, 2014).

Purpose of the Study

The purpose of this nonexperimental study was to determine the relationship between Black and Latino high school science students' perception of instruction and science identity and to determine if this relationship is mediated by student perceptions of self-efficacy. Additionally, this study sought to determine if there is a relationship between science teacher years of teaching and students' perceptions of self-efficacy, students' perceptions of instruction and student science identity. This study also explored how other factors such as the teacher's instructional method, and the teacher's self-efficacy relate to students' perception of instruction, students' perceptions of self-efficacy, and student science identity.

This study aimed to explore these factors which may contribute to the science achievement gap in Black and Latino students. The theoretical framework of social learning theory will be explored to explain the relationships found between perceptions of instruction, science identity, and self-efficacy (Bandura 1971; Bandura et al., 2003).

Theoretical/Conceptual Framework

The theoretical framework guiding the present study was Social Learning Theory (Bandura, 1971). This theory states that learning occurs through observations in the social setting. Through social interactions, the learner observes behaviors in response to stimuli and their outcomes. These observations inform the learner of which behaviors are worth taking on and their success criteria (Brieger et al., 2020). Social interactions help support growth as the learner develops self-efficacy and a sense of identity (Bandura 1971; Bandura, 1977).

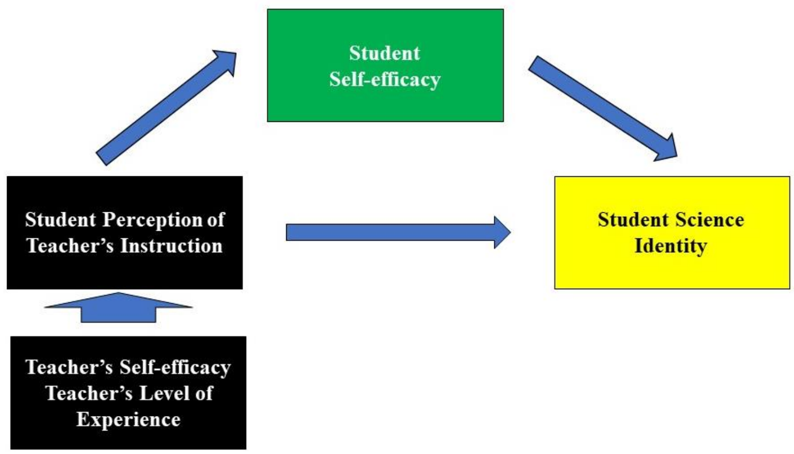
Bandura (1977) defines self-efficacy as an individual's personal belief that they can successfully carry out behavior required to produce a given outcome. The individual's expectation of personal mastery, vicarious experiences and verbal persuasion from others and emotional arousal contribute to self-efficacy beliefs. As self-efficacy in a given area grows, the learner is more likely to take on behavior associated with that identity (Bandura, 1971; Bandura 1977). Therefore, identity, such as science identity, is formed through social interactions (Gee, 2000). Through social interactions, the learner develops an affinity for the norms and practices associated with a particular activity (Gee, 2017; Merolla et al., 2012).

The classroom is a social setting which can provide opportunities to enhance science student self-efficacy and science identity beliefs through classroom instruction. Students perceive instruction which promotes social interactions as being high quality (Horak & Galluzo, 2017; Laforce et al., 2017). Instructional strategies used by teachers can be classified as either student-centered or teacher centered. In student-centered instruction, students are the center of the learning process; influence the content, the activities, materials, and pace of learning; and the teacher is the facilitator (Collins & O'Brien, 2003). Teacher centered instruction is direct instruction by the teacher where there is systematic teaching in small steps and pausing to check for understanding, with the goal of student participation. This type of instruction consists of daily review; presenting new material; graded practice; independent practice; and feedback (Collins & O'Brien, 2003). A teacher’s tendency to use either student-centered instruction or teacher-centered instruction can be affected by the teacher’s level of experience and their own self-efficacy (Sandholtz & Ringstaff, 2014; Swan et al., 2011; Wolters & Daugherty, 2007).

The conceptual framework for the present study, as seen in Figure 1 represents the variables studied and their relationships. The purpose of this study was to determine the relationship between student perceptions of instruction and student science identity, as mediated by student perceptions of self-efficacy. Therefore, the premise of the present study was if students have a positive perception of their teacher’s instruction, science identity will be greater. Since there is a relationship between perceptions of instruction and self-efficacy, it was also the assumption of the present study that greater perceptions of self-efficacy will enhance the effect of student perceptions of instruction on science identity. Additionally, the present study also assumed that factors associated with the teacher, such as their self-efficacy and level of experience would influence the type of instructional strategies used in the classroom. Therefore, this study also aimed to determine if there is a relationship between these factors and student perceptions of instruction, student science identity, or student perceptions of self-efficacy.

Figure 1

Conceptual Framework



Significance of the Study

Beginning in 1970, data from the National Assessment of Educational Progress (NAEP) has been used to assess the national student performance, and since then, the achievement gaps between White and Black and White and Latino/Hispanic students have narrowed (Stanford Center for Education Policy Analysis, 2017). However, according to recent NAEP data, the White-Hispanic achievement gap for twelfth graders proficiency in science has been consistently large (25% in 2009 and 24% in 2015); and the same can be said for the White-Black achievement gap for twelfth grade proficiency in science (34% in 2009 and 36% in 2015) (National Center for Educational Statistics, 2015). Root causes for this gap could be related to interest and persistence in science.

Science identity and self-efficacy are related to an individual's effort and persistence in science (Artino, Jr., 2012; Vincent-Ruz & Schunn, 2018). Therefore, it would be advantageous to build science identity and self-efficacy to improve the educational outcomes in science for Students of Color. Schools have developed self-efficacy programs as part of character education curriculum, however persuasive methods of building self-efficacy are not enough (Bandura et al., 2003). Teachers need to provide authentic mastery experiences to build student confidence and thereby enhancing self-efficacy and promote science identity (Artino, Jr., 2012; Flowers, III & Banda, 2016). The present study is important because it sought to inform educators on the relationships between science instruction and student self-efficacy and science identity. Science instruction can be used as a tool to improve student perceptions of self-efficacy and their science identity to address the science achievement gaps. This study focused on science education because it is the area of the author's expertise.

Beginning in April 2013, the Next Generation Science Standards (NGSS) were completed and have gradually been adopted by states (Achieve, 2019). The NGSS framework emphasizes inquiry-based, student-centered instruction as a means of improving science education throughout the United States. It was the intention of this study to support the NGSS initiative of student-centered instruction by examining how teacher experience and perceptions of self-efficacy related to instruction.

Connection with Social Justice and/or Vincentian Mission in Education

The White-Black and White-Hispanic achievement gaps for twelfth grade science have not shown any significant changes from 2009 to 2015 (National Center for Educational Statistics, 2015). The achievement gaps for Students of Color can lead to disparities in employment opportunities in engineering and technology fields, which are in high demand (Williams A., 2011). In addition to low employment rates other consequences of the achievement gap include lower earnings, poorer health, and higher rates of incarceration amongst Black and Latino populations (McKinsey & Company, Social Sector Office, 2009). The achievement gaps not only negatively affect these populations, but they also have a negative impact on the United States economy. It is estimated that if the achievement gaps for Black and Latino student performance and White student performance had been significantly narrowed the GDP in 2008 would have been $310 billion to $525 billion higher (McKinsey & Company, Social Sector Office, 2009).

The underperformance of Students of Color in science has been attributed to low self-efficacy in science (Olszewsk-Kubilius, 2006). Furthermore, instructional practices have been shown to enhance student self-efficacy and student performance (Chapman & Feldman, 2017; McNerney & Beppu, 2006; Sahin & Top, 2015; Williams, 2011). The current study aims to contribute to the existing body of work addressing Black and Latino student performance in science. It is the expectation that as studies continue to address the achievement gaps in science achievement, there will be greater representation for future Black and Latino students in science and technology fields.

Research Questions and Hypotheses

Research Question 1

Is there a statistically significant relationship between student perception of instruction and student science identity, and can this relationship be mediated by self-efficacy?

H_0: Self-efficacy does not significantly mediate the relationship between student perceptions of instruction and science identity in Black and Latino science students.

H_1: Self-efficacy does significantly mediate the relationship between student perceptions of instruction and science identity in Black and Latino science students.

Research Question 2

How does a teacher's years of experience affect their students' perceptions self-efficacy, perception of instruction and science identity?

H_0: A teacher's years of experience does not significantly affect their students' perceptions of instruction, science identity and perceptions of self-efficacy.

H_1: A teacher's years of experience significantly affects their students' perceptions of instruction, science identity and perceptions of self-efficacy.

Definition of Terms

Science Identity

The aspect of an individual's self which relates to science. This includes the individual's socialization into the norms and discourse of science. (McDonald, 2019; Vincent-Ruz & Schunn, 2018).

Self-Efficacy

The individual's beliefs about his or her ability to produce designated levels of successful performance in events that affect their lives (Bandura et al., 2003).

Student-Centered Instruction

An instructional approach where students are the center of the learning process; influence the content, the activities, materials, and pace of learning; and the teacher is the facilitator (Collins & O'Brien, 2003).

Student Perception of Instruction

A measure of how students perceive their teacher's instruction. The measure includes the constructs of meaningfulness, challenge, choice, and appeal (Gifted Education and Research Institute, 2019; Horak & Galluzzo, 2017).

Teacher-Centered Instruction

A form of instruction where the teacher's role is to provide information directly to the students. Teaching is systematic and completed in carefully planned steps. The teacher pauses to check for understanding, with the goal of student participation. This type of instruction consists of daily review; presenting new material; graded practice; independent practice; and feedback (Collins & O'Brien, 2003). In a teacher-centered classroom, the instructor is the focus, chooses the topics, answers student questions, and is evaluator of student learning (Minter, 2011).

CHAPTER 2: LITERATURE REVIEW

The goal of the present study was to understand the relationship between students' perceptions of instruction, science identity, and self-efficacy. Understanding this relationship will inform educators of factors which may address the Black-White and Latino-White achievement gaps in science (Robinson et al., 2018; Stanford Center for Education Policy Analysis, 2017). Furthermore, addressing student perceptions of self-efficacy in science and student science identity may help to inform as to why there is underrepresentation of Blacks and Latinos in science careers (Jones, 2019). If students experience instruction which is engaging and where they feel successful, then their self-efficacy and science identity will improve (Gentry & Owen, 2004). This study also planned to determine how teachers influence students' perceptions of instruction, their perceptions of self-efficacy, and their science identity. Factors such as teacher self-efficacy and years of teaching experience influence the choice of teaching strategies that a teacher employs (Poulou et al., 2019).

The following literature review outlines and research pertaining to the current topic. It also provides context as to why a more research is needed to understand factors influencing the self-efficacy and science identity of Black and Latino students.

Theoretical Framework

Social Learning Theory

The theoretical framework guiding this study was Bandura's (1971) Social Learning Theory. Learning occurs through an individual's direct experiences with his or her environment or social setting (Bandura, 1971; Brieger et al., 2020). The two main facets of this theory are: learning occurs through observation; and there are mediational processes which enhance learning (Bandura, 1971).

Observational learning occurs through direct observation, modeling, imitation, and feedback from others (Bandura, 1971). Through social interactions, the individual observes behavior of significant adults and peers. These observations allow the individual to learn which behaviors provide positive or negative outcomes (Brieger et al., 2020). These outcomes provide reinforcement which informs the learner's decision of which behaviors should be taken on (Bandura, 1971). The feedback from one's social interactions help the learner develop thoughts which in turn helps them discern which behaviors would beneficial or successful in their social setting (Brieger et al., 2020; Streule & Craig, 2016). These thoughts guide future behaviors for the learner by providing internal reinforcement to motivate (Bandura, 1971).

The role of the model is important in social learning. A model is one who shows the learner either directly or indirectly how activities would or should be done (Bandura, 1971). Modeling provides the learner with a frame of reference for the rewards and consequences of observed behavior (Bandura A, 1971; Sulsky & Kline, 2001). Based on the observed rewards and consequences, the learner decides whether to copy modeled responses to stimuli. For modeling to be effective the learner needs to notice the model's behavior. This happens when the learner is attracted to the model. This attraction occurs when the learner identifies with the model (Streule & Craig, 2016).

The second facet of Social Learning Theory is mediation. Mediation describes the cognitive processes which mediate the learning of observed behavior (Bandura, 1971). One such process is retention. Retention of modeled behavior is also a component of learning through observation (Bandura, 1971). The learner needs to be able to symbolically represent the model and their behavior in their memory. Visual and verbal memories of observations serve as guides to the learner to help the learner with mental rehearsal such that they develop the skill to reproduce the observed behavior (Bandura, 1971; Streule & Craig, 2016). The learner is able to receive feedback on their ability to reproduce the desired behavior through their sense of awareness and also through social interactions with others (Bandura, 1971; Brieger et al., 2020). Through social interactions, the learner then develops self-efficacy, the belief about their ability to successfully complete a behavioral task (Bandura, 1977).

Self-Efficacy

The current study examined the interactions between student perception of instruction, self-efficacy, and science identity. Self-efficacy, an individual's belief in their ability to achieve a desired outcome, drives behavior (Bandura, 1977). A learner's self-efficacy develops as a result of social interactions within their environment. The learner receives feedback from peers and adults in the form of verbal interactions and vicarious observations (Bandura, 1997; Bandura et al., 1974; Lau et al., 2018). Through these interactions, the learner identifies which skills, behavior, and practices they have mastered or is capable of mastering. These mastery experiences lead to higher self-efficacy. As the levels of self-efficacy increase, the individual will develop a greater ability to complete more challenging performance tasks in quantity and in difficulty (Bandura, 1977; Bandura et al., 1982). As the learner's self-efficacy within a given area develops, their identity in this area also grows (Flowers, III & Banda, 2016). Such is the case for science identity. When students identify themselves as science people, they develop affinity for the practices associated with being a science person and are more likely to persist in science. (Gee, 2000; Oseguera et al., 2019).

Science Identity

The present study also aimed to examine science identity through a social learning lens. A result of cognitive development within the social context is the realization of identity, as the individual recognizes their achievements and identifies with a more knowledgeable other (Bandura, 1971; Vygotsky, 1978). Furthermore, the learner needs to identify with others in their environment in order to notice and retain behavior (Bandura, 1971; Streule & Craig, 2016). Identity, for the present study, will be defined according to Gee's identity theory. According to Gee (2000) identity is formed through social interactions and influences how a person behaves within a given context. The components of identity include nature, institutional, discourse and affinity. Nature identity refers to those characteristics which have been inherited. Institutional identity refers to one's position in society. Institutional identity is recognized as one achieves a set of proficiencies or skills associated with a particular field. Discourse identity is a characteristic that the individual recognizes through social interactions with others. Identity also develops through affinity, when a group of individuals share common practices and skills. These four components of identity theory work together to form an individual's identity. They are recognized through social interactions, which enable the individual to assess competencies and thereby recognize their "affiliation within cultures, social groups, and institutions" (Gee, 2005, p. 1).

The present study focused on how identity develops through affinity to science. Affinity identity is chosen by the individual as they decide to participate in a specific activity (Gee, 2000). An activity-based identity relates to skills and practices associated with a given field (Gee, 2017). Through social interactions the individual recognizes the values, actions, norms, beliefs, knowledge, and skills associated with a particular activity and can assess their affiliation with a group (Merolla et al., 2012).

Science identity is one type of activity-based identity. An individual's science identity is related to their participation in formal and informal activities in science (Flowers, III & Banda, 2016). The construct of science identity includes the perceived recognized science identity and personal science identity (Vincent-Ruz & Schunn, 2018). Therefore, science identity includes the individual's perception of themself as a science person and how they believe others see them as it relates to science. Science "identity is a multicomponent construct through which individuals internalize their experience, their context and see themselves as members of social groups and intersect with their personal characteristic" (Vincent-Ruz & Schunn, 2018, p. 9). Social interactions which drive cognitive development and self-efficacy in science, help to develop an individual's science identity. Learners also draw upon their previous personal history, which varies between individuals due to social and cultural factors. Therefore, a learner's personal educational history can influence their potential to develop a science identity. This is important because science identity predicts one's participation in science related activities (Flowers III & Banda, 2016; Merolla et al., 2012; Vincent-Ruz & Schunn, 2018). Students with a strong science identity are more likely to persist in science classes and later science careers.

Perception of Instruction

One of the goals of the present study was to inform about the relationship between student perception instruction and student science identity. When students have a positive perception of instruction, they tend to have greater self-efficacy, which contributes to student science identity (Beck & Blumer, 2021). Student-centered instruction involves students learning by interacting with their environment and developing knowledge through social means (Savery & Duffy, 1995). Students tend to have a greater perception of instruction when instruction occurs through a social context (Horak & Galluzzo, 2017; LaForce et al., 2017). As students interact with one another and their instructor, they receive positive feedback which improves their self-efficacy. These instructional experiences which affect both affective and cognitive domains help to shape and form science identity.

Instructional Methods

The present study also aimed to assess any relationships between teacher instructional methods and student perceptions of instruction and self-efficacy as well as student science identity. Classroom instruction can be categorized as student centered or teacher centered. Student centered instruction incorporates the constructivist idea of learner-centered experiential learning (Jones, 2007). In a student-centered learning environment, learning is autonomous. The student is encouraged to participate in the learning process by either working alone or with peers. The teacher is responsible for engaging learners using high interest topics. The role of the teacher in the student-centered classroom is the facilitator who encourages students to develop their skills. This differs from traditional models where the teacher is the sole source of information. In the student-centered classroom, “the teacher and students are a team working together” (Jones, 2007, p. 25).

Connection to Present Research

The present study fit within the theoretical framework as it explored the relationships between student perceptions of instruction and student perceptions of self-efficacy and science identity. Since learning occurs through social interactions, instructional strategies which allow students to interact with their peers or the teacher promote self-efficacy and science identity. Student-centered instruction provides the learner with the opportunity to interact with others and practice modeled behavior.

The theoretical and conceptual frameworks guided the literature review by discussing studies which explore the factors affecting self-efficacy and science identity. Additionally, the literature review will also examine studies which explore relationships between students’ perceptions of instruction and self-efficacy as well as the relationship between student perceptions of instruction and science identity. Finally, literature review will also inspect studies which investigate how the teacher’s level of experience impacts the teachers’ self-efficacy and their choice of instructional strategies.

Review of Related Literature

The present study focuses on the relationship between student perception of instruction and science identity as mediated by self-efficacy. Student perception of instruction is important as it promotes self-efficacy beliefs and science identity. A teacher’s level experience may provide them with self-efficacy to provide high quality instruction. The following section will review the literature associated with sources of self-efficacy, the relationship between student perceptions of instruction and self-efficacy, science identity, the relationship between perceptions of instruction and science identity, and teacher experience as it relates to teacher self-efficacy and instruction.

Self-Efficacy

The present study aims to determine to what extent self-efficacy mediates the relationship between student perception of instruction and student's science identity. Self-efficacy, the belief in one's ability to achieve a desired outcome, is a determining factor in whether or not someone decides to complete a task and their overall task effort (Bandura et al., 1977). The sources of an individual's self-efficacy are mastery experiences/performance accomplishment; vicarious experiences; verbal persuasion; and emotional arousal (Bandura, 1977).

One study sought to verify if Bandura's proposed sources of self-efficacy had a significant effect on the academic efficacy and self-efficacy for self-regulation beliefs of middle school students (Usher & Pajares, 2006). For this study, 263 sixth graders participated, where 140 were female and 123 were male. The *Sources of Self-efficacy Scale* was used to assess factors influencing self-efficacy (mastery or performance accomplishments, physiological/emotional arousal, social/verbal persuasion, and vicarious experiences) in the participants. Subscales of Bandura's Children's Multidimensional Self-efficacy scale were used as instruments. The *Academic Self-Efficacy Scale*, was used to measure academic self-efficacy while the *Self-Efficacy Scale for Self-Regulated Learning* was used to measure self-efficacy for self-regulation. ANOVA tests were used to determine gender and race/ethnicity differences in the four sources of academic self-efficacy. There were no significant differences in academic self-efficacy or self-efficacy for self-regulation between groups. A multiple regression analysis found that mastery experiences, social persuasion, and physiological state significantly predicted academic self-efficacy. Self-efficacy of self-regulation was significantly predicted by all factors, mastery experiences, vicarious experiences, social persuasion, and physiological state. Therefore, the results of this study were consistent with Bandura's assumptions of the sources of self-efficacy and demonstrate that self-efficacy is related to academic outcomes.

Performance accomplishments refers to personal mastery experiences (Bandura, 1977). These mastery experiences are the greatest contributor to one's sense of self-efficacy because success is instrumental in building personal efficacy expectations, while failures can diminish the level of self-efficacy (Bandura, 1997). Usher and Pajares (2006) also determined that performance accomplishments/mastery experiences were the strongest predictors of academic self-efficacy and self-efficacy of self-regulation.

A meta-analysis of 28 research reports was used to examine the cumulative effects of Bandura's sources of self-efficacy (Byars-Winston et al., 2017). The reports used in this meta-analysis provided quantitative data for one or more samples on all four effects (performance accomplishments, vicarious experiences, social persuasion, and emotional arousal) of self-efficacy in an academic domain. Data from 61 independent samples with 8965 participants (kindergarten to doctoral level) were included in a regression analysis to identify the predictors of self-efficacy. The results of this study found that all four sources significantly predicted an individual's level of self-efficacy. Of the four sources of self-efficacy, personal accomplishments had the had the greatest correlation for the sample as a whole and when the samples were disaggregated by gender, race/ethnicity, and subject matter.

One study examined the effects of having high mastery goals on the negative effects of discrepancy between the individual's perceived standards and performance on academic efficacy in gifted students (Wang et al., 2012). The subjects were 144 students in grades six through twelve. Students were administered the *Almost Perfect Scale* (APS-R) to measure perfectionism; the *Patterns of Adaptive Learning Scales* (PALS) to measure mastery performance approach and academic self-efficacy; and the *Contingent Self-worth on Academics* (CSW-A) to measure self-worth on academic performance. A correlational analysis found a significant correlation between academic efficacy and satisfaction with life as well as a significant correlation between academic efficacy and GPA. A study of the interaction effects for students with a low CSW-A score, the slope of the high mastery line was not significantly different from zero, $t(126) = .49$, $p = .63$, yet the slope of the low mastery line was significantly different from zero, $t(126) = 3.39$, $p < .001$. For students with high CSW-A scores there was no significant difference between slopes. These results indicated that high mastery goals served as a buffer of the maladaptive effect of discrepancy created by perfectionism.

The influence of vicarious experiences on self-efficacy was confirmed in additional studies (Byars-Winston, et al., 2017; Usher & Pajares, 2006). Harrison & McGuire (2006) also proposed to evaluate the effectiveness of vicarious experiences in enhancing efficacy beliefs in rock climbing. Thirty-eight participants, ages six to eighteen were divided into three groups. Each group completed a pretest in the form of a self-regulatory self-efficacy questionnaire related to rock climbing. All groups received verbal instruction on rock climbing. However, one group observed a youth model climbing, another group observed an adult model climbing, and the third group did not observe any task modeling. After receiving instruction and attempting rock climbing, all participants completed another self-efficacy questionnaire. The results indicated that there was a significant increase in self-efficacy post instruction. There was no significant difference in self-efficacy between the groups that observed modeling. However, both modeling groups had significantly higher post-intervention self-efficacy than the group that did not receive observe modeling.

A study involving preservice elementary teachers also attempted to find a link between self-efficacy beliefs and vicarious experiences (Bautista, 2011). Forty-four Early Childhood Education majors, enrolled in a science teaching methods course completed the *Science Teaching Efficacy Belief Instrument B* (STEBI-b) at the beginning of the semester. The STEBI quantitatively measured *Personal Science Teaching Efficacy* (PSTE) and *Science Teaching Outcome Expectancy* (STOE). STOE is a measures the participant's belief that their teaching will have a positive effect on students. Throughout the semester, the participants completed instructional activities and course assignments designed to contribute to personal mastery and vicarious experiences. The vicarious experiences included: effective actual modeling (observation of a classroom teacher); symbolic modeling (watching a video of classroom instruction); self-modeling (watching video of their own classroom instruction and reflecting on it); and cognitive self-modeling (participants imagine themselves performing classroom instruction successfully). At the end of the semester participants completed the STEBI-b again and answered a series of open-ended questions which were designed to qualitatively evaluate the greatest contributor to their self-efficacy beliefs. The results of a paired *t*- test found that pre and post PTSE and STOE significantly increased at the end of the semester.

Therefore, the participants' science teaching self-efficacy improved. Qualitative analysis revealed that the pre-service teachers were more excited, prepared, and confident to teach science. Furthermore, qualitative analysis also revealed that vicarious experiences contributed to self-efficacy beliefs over the course of the semester. Of these vicarious experiences, most reported that cognitive self-modeling and symbolic modeling were the greatest contributors.

As a part of their study, Lau et al. (2018) assessed the sources of math self-efficacy in elementary students in grades three to five. Four hundred forty-two students in an International Baccalaureate (IB) school participated in this study. Students were administered thirteen-item self-efficacy scale and a four-item math self-efficacy scale. The sources of self-efficacy, mastery experiences, vicarious experiences, social persuasion, and emotional state intercorrelated with math self-efficacy. The strongest correlation was found between self-efficacy and social persuasion. A regression analysis also found that social persuasion was the greatest predictor of math self-efficacy. A possible reason for social persuasion having such a strong influence in this study could have been the nature of math instruction. Math instruction, by nature is more social, with students receiving "guidance and feedback from a more experienced learner" (Lau et al., 2018, p. 612).

Perception of Instruction and Self-efficacy

Project Based Learning (PBL) is a form of student-centered instruction in which students gain knowledge and skills by working to answer questions and solve complex problems (Buck Institute for Education, 2021). Various PBL strategies have been incorporated into science education (Laboy-Rush, 2011). Horak and Galluzzo (2017) studied the effect of project-based learning (PBL) on student achievement and student perception of classroom quality. This study examined two groups of students and teachers in a middle school for gifted students: the PBL group and the comparison group. In the PBL group, three teachers participated in professional development to learn how to teach a middle school science unit developed according to the Stepien and Pyke model of PBL (Horak & Galluzzo, 2017). The Stepien and Pyke model of PBL consists of five phases: Inquiry and Investigation; Problem Definition; Problem Resolution; and Problem Debriefing. As part of the professional development, the teachers were able to observe PBL at a summer camp. Additionally, each teacher developed a PBL coaching plan consisting of the skills targeted for development; an outline of possible concepts and questions that might arise during the unit; a list of materials and resources; and a list of assessment options to be used during the unit. The three teachers in the comparison group did not participate in the PBL training. The teachers in the comparison group taught 252 students in total, while the teachers in the PBL group taught 223 students in total.

The PBL instructional unit, *Ferret it Out*, was aligned with the school district's curriculum unit on the environment (Horak & Galluzzo, 2017). In this unit, students were members of the Black Footed Ferret Recovery Implementation Team (BFFRIT). The student teams were tasked with developing a model for ferret reintroduction to the environment and presenting it to the class. In the comparison group, the teachers taught the traditional *Understanding our Environment Unit* consisting of lab activities completed through lecture.

At the end of their respective units, students in the PBL group and the comparison group completed the Student Perceptions of Classroom Quality (SPOCQ) questionnaire

(Horak & Galluzzo, 2017). The SPOCQ questionnaire is a scale for gifted students designed to assess their perceptions using five constructs: meaningfulness; challenge; choice; self-efficacy; and appeal. These constructs are designed to assess the quality of the classroom learning environment. Prior to the start of the units, students in both groups were given a 25-item pre-instruction assessment based on the state's science content exam. Three weeks later the students were given the same assessment as post-test.

An independent samples *t* test compared the pre/post test between groups and SPOCQ data for each school (Horak & Galluzzo, 2017). There was no significant difference between pre-test data between groups ($M_{\text{PBL}} = 17.57$, $SD = 3.20$; $M_{\text{comparison}} = 17.89$, $SD = 2.82$, $p < .01$). However, the mean post-test scores were significantly different between groups ($M_{\text{PBL}} = 23.5$, $SD = 1.40$; $M = 22.54$, $SD = 2.06$, $p <.01$), indicating that the PBL group experienced greater academic gains. The means for each construct of SPOCQ were compared. There was no significant difference for meaningfulness ($M_{\text{PBL}} = 18.22$, $SD = 4.07$; $M_{\text{comparison}} = 18.91$, $SD = 3.74$, $p < .01$) or challenge ($M_{\text{PBL}} = 28.82$, $SD = 5.36$; $M_{\text{comparison}} = 26.53$, $SD = 5.19$, $p < .01$) between groups. However the mean self-efficacy for the comparison group was significantly greater ($M_{\text{PBL}} = 30.67$, $SD = 5.51$; $M_{\text{comparison}} = 32.15$, $SD = 5.09$, $p < .05$). The appeal of instruction was significantly greater for the comparison group as well ($M_{\text{PBL}} = 24.25$, $SD = 5.84$; $M_{\text{comparison}} = 26.31$, $SD = 4.73$, p < .01). Further analysis indicated a strong positive correlation between self-efficacy and appeal ($r_{\text{PBL}} = .614$, p < .01; $r_{\text{comparison}} = .772$, p < .01). Thereby suggesting that the "PBL environment was new for the students and the uncertainty of learning in a new format may have negatively affected their sense of self-efficacy" (Horak & Galluzzo, 2017, p. 40). The construct of choice was significantly greater in the PBL group (M_{PBL} = 26.93, *SD* 5.25; $M_{\text{comparison}}$ = 25.01, *SD* = 4.95, $p < .01$) The results of this study suggest that instruction such as PBL positively impacts students' perceptions of classroom quality and self-efficacy.

The inverse relationship between self-efficacy and negative emotional response was explored in a study involving fifth grade students who participated in an instructional intervention (Griggs et al., 2013). This study, involving 62 teachers and their students from 24 elementary schools sought to determine if the *Responsive Classroom* (*RC*) approach was effective in decreasing the negative association between anxiety and self-efficacy in math and science. The *RC* technique is a social emotional learning program designed improve classroom social environments and facilitate "positive and instructionally productive interactions among teachers and peers" (Griggs et al., 2013). The *RC* curriculum includes antibullying lessons, character education, and school wide incentive programs aimed at enhancing social skills and behavior. Student math and science self-efficacy were measured using the *Academic Efficacy* subscale of the *Patterns of Adaptive Learning Scales* ($\alpha = .78$). Student math and science anxiety were measured using portions of the *Math Anxiety Subscale* of the *Student Beliefs about Mathematics Survey* ($\alpha = .89$). Teachers self-reported their compliance with *RC* using the *Classroom Practices Teacher Survey* (CPTS), a 46 item Likert style survey ($\alpha = .91$). Observations validated teacher compliance by using the *Classroom Practices Frequency Survey* (CPFS).

Based on the results, Griggs et al. (2013) suggested that students with lower self-efficacy had greater levels of math and science anxiety. Although *RC* practices did not significantly affect math self-efficacy, *RC* was found to significantly improve science self-efficacy. Where *RC* practices were implemented, the negative effects of anxiety on self-efficacy were lowered. Results of hierarchical linear modeling revealed a lower anxiety and higher self-efficacy when students were in schools with more teacher reported *RC* practices for math ($\beta = -.68$, $p < .001$) and for science ($\beta = -.76$, $p < .001$). In schools implementing *RC* practices, students were predicted to have self-efficacy scores of 3.06 in comparison to students in schools with fewer *RC* practices, where they were predicted to have self-efficacy scores of 2.95. The results of this study suggest that instructional practices can impact students' self-efficacy by way of decreasing negative emotional arousal.

Science Identity

Science identity is defined as the "aspect of self" that relates to science (McDonald et al., 2019). One study examined the components of science identity and the extent to which science identity predicts a student's overall choices (Vincent-Ruz & Schunn, 2018). A subset of data from the *Activated Learning Enables Success 2015* (ALES15) was collected from 23 seventh grade and 32 ninth grade classes form 19 public schools. The ALES15 is a longitudinal dataset which includes a wide range of demographic attitudinal, and experience measures from two different regions in the USA. Using the data, science identity was measured using a scale designed to identify external components of science identity and to test whether they collaborated with "internal components as a construct" (Vincent-Ruz & Schunn, 2018, p. 4). These components were perceived personal science identity (how they see their own association with science) and perceived recognized science identity (how they believe friends, family, and teachers associate them with science). Components were measured using a four-point Likert scale, with a Cronbach's alpha = .84. The sample was split randomly to create two independent groups to conduct the exploratory and confirmatory factor analyses (EFA). Also, differential item functioning (DIF) analyses were conducted by gender, ethnicity, and age to test for measurement bias or differential functioning by subgroup.

The EFA revealed that perceived personal science identity and perceived recognized science identity closely cohered into one overall identity construct (Vincent-Ruz & Schunn, 2018). The EFA results also indicated that science identity is distinct from other science attitudinal measures often attributed to identity, such as fascination with science, value of science, and competency beliefs. Multiple regression analysis showed that science identity significantly predicted student participation in formal science experiences ($\beta = .15$, $p < .001$) and informal science experiences ($\beta = .27$, $p < .001$). The results also showed that science identity significantly predicted students' science-related choices ($\beta = .22$, $p < .001$).

A study examined the role of efficacy and identity in science career commitment among underrepresented minority students (Chemers et al., 2011). The goal of this study was to test the effect of self-efficacy and science identity as mediators in a model for student commitment to careers in science. This model factors included not only self-efficacy and science identity, but also science support experience; research experience; community involvement; socioemotional and instrumental mentoring; leadership and teamwork self-efficacy; and the outcome measure; commitment to science career. The participants included 665 graduate and undergraduate students from underrepresented minority groups. Participants complete a survey designed to measure the model components. Survey data were grouped according to graduate and undergraduate levels and analyzed using maximum likelihood estimation. The analysis included the normal chi square test, comparative fit index (CFI), nonnormal fit index (NNFI), goodness of fit index (GFI) and root mean square error of approximation (RMSEA).

The results showed an "excellent" fit for the model through multiple pathways for both undergraduate students $\chi^2(10) = 22.20$, $p = .01$, NC = 2.22, CFI = .97, NNFI = .94, GFI = .97, RMSEA = .06 (90% C.I. = .03, .10) (Chemers et al., 2011). There was a significant correlation between self-efficacy and science identity ($r = .24$, $p <.05$). The model indicated that science self-efficacy fully mediated the association between research experience and instrumental mentoring and commitment to science careers. Identity proved to be a mediator of the association between instrumental mentoring and commitment to science careers and science identity was a partial mediator for the same association. For graduate students, the model fit was significant as well $\chi^2(1) = 36.41$, $p < .001$, with a final model fit of $\chi^2(11) = 18.02$, $p = .08$, NC = 1.64, CFI = .99, NNFI = .98, GFI = .99, RMSEA = .04 (90% C.I. = .00, .08). There was also a significant association between self-efficacy and science identity for graduate students ($r = .38$, $p < .001$). Science self-efficacy fully mediated the paths from advanced research experience and socioemotional mentoring; and leadership/teamwork, to commitment to science careers. Identity also partially mediated the association between self-efficacy and leadership/teamwork self-efficacy and commitment.

Perception of Instruction and Science Identity

An individual's science identity can also develop from actual science performance and through content knowledge of science, and recognition as a scientist (Chapman & Feldman, 2017). Chapman and Feldman (2017) examined how students' science identity developed during an algal biofuels project (ABFP). In this study the effects of the participation in authentic science, ABFP, affected the science identity of students marginalized in science (Chapman & Feldman, 2017). This study took place in a science related magnet high school. The twelve participants were all Students of Color in a Marine Science class which participated in the ABFP. During the ABFP, students in the class interacted with two local University Environmental Engineering faculty members. Over the course of two months, students engaged in science activities similar to those practiced by members of the Algal Biofuels Research Group (ABFRG). They also attended graduate student symposiums and a keynote faculty address at the University and toured a research lab. At the end of the ABFP, students presented their findings publicly to the University professors, their teacher, school district administrators, and the authors of the study.

Data were collected from observations, interviews, student journals, videos of presentations, a research skills survey, and a photo-eliciting activity called *Identify-A-Scientist* (IAS) (Chapman & Feldman, 2017). In IAS, participants were asked to identify one person they believed to be the scientists from photos representing different genders, races, and ethnicities. IAS was administered to the students at the end and the beginning of the project. Qualitative data were transcribed, coded, and triangulated to determine how participants were affected by their participation in ABFP. Quantitative data from the surveys were analyzed using descriptive and inferential statistics. Due to the sample size a normal distribution could not be determined, so the Wilcoxon signed rank test was used in order to determine if there were statistically significant differences between pre and post survey responses. A gender and race/ethnicity matched (GEM) score was developed from IAS pre and post data. One point was assigned each time a participant selected a scientist of their own gender and race/ethnicity. Student journals, interview responses and oral presentation were analyzed and evaluated using a four-point rubric (ranging from 0 to 3) to determine science identity. The domains for science identity were recognition, performance, and competence.

A series of data analysis were used to determine authenticity of experience and science identity (Chapman & Feldman, 2017). The responses from the research skills survey and student interviews were used to determine the authenticity of experience. Initially, there was no statistically significant difference between pre and post survey responses due to a “ceiling effect”.” However, when the highest scores were removed and the data were analyzed again, there was a statistically significant increase in student perception that they felt participating in the project was authentic science. Student interview responses also indicated they felt the ABFP was similar to what scientists do, therefore, indicating authenticity of experience.

Further analysis of involved a framework of science identity – recognition, competence and performance (Chapman & Feldman, 2017). Pre-IAS data showed students most often chose a White male as the scientist (42.5%), however post-IAS showed a decrease to 31.7%. A Wilcoxon signed rank analysis of pre and post scores showed that this difference was significant ($n = 12$, $z = 2.36$, $p = .018$) with a large effect size ($r = .68$). Six students showed an increase in their GEM score. Analysis of qualitative data showed ten of the twelve students making connections to their feelings about being a scientist within the context of a scientific practice (level 3) and acknowledgement of themselves as scientists (level 2), therefore recognizing themselves as scientists. Eleven of the twelve students demonstrated level 2 or level 3 competence with their content understanding and science skills. All twelve students reflected level 2 or level 3 performance beliefs in their interview responses and journal entries.

A comparison of students' science identity scores to students' perceptions of authenticity of experience revealed that students' perceptions of authenticity of the experience may be a predictor of science identity (Chapman & Feldman, 2017). Ten of the twelve students reported their experience in ABFP as being authentic also had a moderate or strong science identity score. One student who did not report the experience as being authentic science also had a weak science identity score.

STEM on Stage (SOS) is an enrichment program focused on standards-based student-centered learning through PBL (Sahin & Top, 2015). In SOS students are assigned projects and working in groups of three to four, they develop a solution to an assigned problem. The final product is an investigative report of their work along with a digital presentation. Sahin and Top (2015) investigated the components of successful Science Technology Engineering and Math (STEM) teaching in order to determine how learning occurs in SOS and how it benefited students. The study was done in a high school which had implemented the SOS model for three years. Nineteen students from grades 10-12 participated in semi-structured interviews. Data were analyzed using grounded theory coding and constant comparative analysis.

Findings revealed how the SOS model works (Sahin & Top, 2015). According to students, the SOS model consists of teacher lecturing while asking the students probing questions to encourage student thinking and to also check for student understanding. The lectures were enriched with hands-on activities and student directed teaching. In student directed teaching the students are assigned a project as a group and before the class starts covering content. The group will either teach a lesson on the concept or do a related experiment.

SOS benefited students by increasing student gains in both academic and 21st Century skills (Sahin & Top, 2015). Students experienced academic growth through increased interest in STEM and greater conceptual understanding. Growth in 21st Century Skills was evident as students were confident talking in front of a group; enhanced technology skills through video and website production; found relevance to life and career skills; and enhanced collaboration and communication skills (Sahin & Top, 2015).

Teacher Experience

One aspect the present study is to examine how teacher's years of experience and self-efficacy impact student perception of instruction, student perception of self-efficacy, and student science identity. A longitudinal study aimed to describe the changes in teacher self-efficacy from the student teaching semester to the third year of teaching (Swan et al., 2011). Changes in the three domains of teaching self-efficacy, student engagement, instructional strategies, and classroom management were also observed. The subjects in this study consisted of a cohort of 34 student teachers from a university education program. The researchers used the *Teacher's Sense of Efficacy Scale* (TSES) to measure teacher-self efficacy. The TSES was administered at the conclusion of the student teaching semester and at the conclusion of the participants' first, second and third years of teaching. Of the 34 student teachers, only 17 went on to have teaching jobs. At the end of year one, nine survey responses were collected. In years two and three, 11 survey responses were collected. Only three participants responded for each year. Descriptive statistics and Cohen's *d* were calculated.

The results of this study showed that teacher self-efficacy varies with years of teaching experience (Swan et al., 2011). Mean self-efficacy was highest at the end of the student teaching semester ($M = 7.71$, $SD = .76$). However, the researchers attributed this level to student teachers having the support of mentor teachers which gives them more confidence in their abilities. Teacher self-efficacy was lowest at the end of the first year of teaching ($M = 7.17$, $SD = .73$). There were increases in self-efficacy scores for each domain (student engagement, instructional strategies, classroom management) of teacher self-efficacy from years one to three of teaching. The results of this study show that teacher self-efficacy does change with experience however significant differences were not observed due to the sample size.

One of the goals of another larger study was to compare teachers' sense of self-efficacy as it relates to years of teaching experience (Wolters & Daugherty, 2007). The participants in this study were 1024 teachers from a large suburban school district in Texas. Teachers completed 24 items from the TSES to assess overall teaching self-efficacy and the domains for teaching self-efficacy (instruction, classroom management, and student engagement). Results of a MANOVA test to analyze the self-efficacy domains found a main effect for teaching experience ($\lambda = .93$, $F(9, 2458) = 8.27$, $p < .001$). The between-subjects follow up test found a significant effect for teacher experience and self-efficacy ($F(3, 1012) = 13.04$, $p < .001$, $\eta^2 = .04$). Post hoc analysis revealed that first year teachers reported lower efficacy for instruction than teachers with 1-5 years of experience ($\delta = .30$, $p < .05$), 6-10 years experience ($\delta = .54$, $p < .05$), and 11 years or more of teaching experience (δ =.68, p <.05). Teachers with 1-5 years experience reported-significant lower level self-efficacy for instruction than those with 6-10 years experience (δ = .25, $p < .05$) and teachers with 11 or more years experience (δ = .39, $p < .05$). Post hoc analysis also revealed that lower self-efficacy for management in first year teachers than with 11+ years experience (δ = .50, $p < .05$). Teachers with 1-5 years experience reported lower efficacy for management than teachers with 11 years or more experience (δ = .25, $p < .05$). For self-efficacy of engagement, there was no significant effect as it relates to teacher experience.

The relationship between teacher self-efficacy and teacher practices for teachers was examined in another study (Sandholtz & Ringstaff, 2014). The purpose of this study was to examine the extent to which early elementary teachers' participation in a three-year professional development program would affect teacher self-efficacy and instructional practices. Teachers from sixteen schools participated in pedagogical training in science instruction and connecting science to English Language Arts (ELA) and math. Training took place during a six-day summer institute for each of the three years. Topics in the professional development included science inquiry; scaffolded guided inquiry; developing inquiry-based science units; curriculum mapping; integrating science with math and ELA; strategies for English Language Learners (ELL) and collaboration. Data sources were both qualitative and quantitative. Teachers completed the *Science Teaching Efficacy Beliefs Instrument* (STEBI), a survey used to measure teacher beliefs about effectiveness in teaching science. The STEBI is a 25-item Likert scale which includes the *Personal Science Teaching Efficacy* (PTSE) and the *Science Teaching Outcome Expectancy Scale* (STOE) subscales. Teachers completed the survey at the end of each academic year prior to starting the annual professional development. The researchers also conducted classroom observations of a sample of 20 teachers. Strategic sampling was used so that the classrooms would be representative of the entire groups. During observations they took notes and used a rubric to evaluate lessons on the strategies taught during the professional development. Strategic sampling was also used to identify twelve of the 20 observed teachers for interviews. Interview questions also centered around concepts in the professional development and teacher perceptions of preparedness and beliefs about their effectiveness of science teaching.

Quantitative data were analyzed using a paired sample t-test and there was concurrent triangulation of qualitative and quantitative data (Sandholtz & Ringstaff, 2014). Interview transcripts were electronically coded for content knowledge, self-efficacy, instructional time, use of instructional strategies, and contextual framework. There was a significant increase in teachers' self-efficacy over the course of three years, from year one (t (36) = 4.14, p = .000) to year three (t(22) = 5.94, p = .000). By the end of the program, the percentage of teachers who felt they understood science well enough to teach it increased from 43% to 94% (t(23) = 6.46, p =-.000). Teacher perceptions about their preparedness to engage in science-related strategies increased from 77% to 81%.

Instructional changes also positively correlated with increasing self-efficacy (Sandholtz & Ringstaff, 2014). As self-efficacy increased teachers were more likely to teach science in real-world contexts (r(22) = .521, $p < .05$); engage in hands on instruction (r(22) = .736, $p < .01$); arrange the classroom to facilitate student discussion (r(22) = .581, $p < .01$)); demonstration of science phenomenon (r(22) = . 542, $p < .01$);

ask students to use evidence to support their claims ($r(22) = .500$, $p < .05$); have students design or implement their own investigations ($r(22) = 588$, $p < .05$).

In one study the relationship between preservice elementary teachers' (PETs) sources of self-efficacy and their beliefs about constructivist and traditional beliefs about teaching (Cansiz & Cansiz, 2019). Participants were 151 PETs. Survey instruments included the *Sources of Self-Efficacy Inventory* (SOSI) and the *Teacher Beliefs Survey* (TBS). The SOSI is a 35-item Likert Scale, used to measure the four dimensions of self-efficacy: mastery experiences, emotional arousal, vicarious experiences, and social persuasion. The TBS is a 34-item Likert scale designed to measure teachers' beliefs towards constructivist and traditional teaching approaches. Two multiple regression analyses were completed to assess which self-efficacy component contributes to teaching beliefs.

The results revealed relationships between teaching beliefs and self-efficacy and how the components of self-efficacy predict teaching beliefs (Cansiz & Cansiz, 2019). PETs' beliefs related to constructivist approaches to teaching can be predicted from a combination of self-efficacy sources. Analysis revealed that 18% of the variance in PETs beliefs ($R^2 = .18$) related to their constructivist teaching beliefs. The variance was statistically significant ($F(4, 150) = 8.03$, $p < .001$). The only self-efficacy source that significantly predicted constructivist beliefs was mastery experiences ($\beta = .28$, $p = .017$). Multiple regression analysis also revealed that the four sources of self-efficacy contributed to the prediction of 11% of the outcome variance ($R^2 = .11$) for traditional instruction beliefs. This was significant ($F(4, 150) = 4.32$, $p = .002$). There was a significant positive correlation between emotional arousal and traditional instruction beliefs (β = .14, p = .049). These results suggest that those with high self-efficacy scores due to high levels of mastery experience tend to use more student-centered teaching methods.

Conclusion

Perceptions of self-efficacy and science identity are influenced by social interactions (Bautista, 2011; Byars-Winston et al., 2017; Usher & Pajares, 2006; Vincent-Ruz & Schunn, 2018). These interactions provide confirmation of mastery experiences which provide positive emotional responses to promote self-efficacy beliefs (Byars-Winston et al., 2017; Wang et al., 2012). Teachers can provide instruction which promote science identity and self-efficacy beliefs (Chapman & Feldman, 2017; Griggs et al., 2013; Horak & Galluzzo, 2017; Sahin & Top, 2015). The research does not appear to establish a relationship between the three factors: student perception of instruction, student science identity, and student perception of self-efficacy. The present research extends upon the reviewed research by attempting establish student perceptions of self-efficacy as a mediator of the relationship between student perceptions of instruction and science identity.

The reviewed research indicates that teacher perceptions of self-efficacy, years of teaching experience, and education level impact the teacher's choice of instructional strategies (Cansiz & Cansiz, 2019; Sandholz & Ringstaff, 2014; Swan et al., 2011; Wolters & Daugherty, 2007). This present study aims to contribute to the current body of research by examining how these teacher characteristics impact student perceptions of instruction, science identity, and perceptions of self-efficacy.

CHAPTER 3: METHODOLOGY

The purpose of the present study was to determine if there is a relationship between student perception of instruction and student science identity as mediated by student perceptions of self-efficacy. First the study analyzed the relationships between student perceptions of instruction and self-efficacy and science identity. This study also aimed to determine if a teacher's level of work experience affected student perceptions of self-efficacy and instruction and student science identity.

Methods and Procedures

Research Questions

Research Question 1

1. Is there a statistically significant relationship between student perception of instruction and student science identity, and can this relationship be mediated by self-efficacy?

   H_0: Self-efficacy does not significantly mediate the relationship between student perceptions of instruction and science identity in Black and Latino science students.

   H_1: Self-efficacy does significantly mediate the relationship between student perceptions of instruction and science identity in Black and Latino science students.

Research Question 2

2. How does a teacher's years of experience affect their students' perceptions self-efficacy, perception of instruction and science identity?

H_0: A teacher's years of experience does not significantly affect their students' perceptions of instruction, science identity and perceptions of self-efficacy.

H_1: A teacher's years of experience significantly affects their students' perceptions of instruction, science identity and perceptions of self-efficacy.

Research Design and Data Analysis

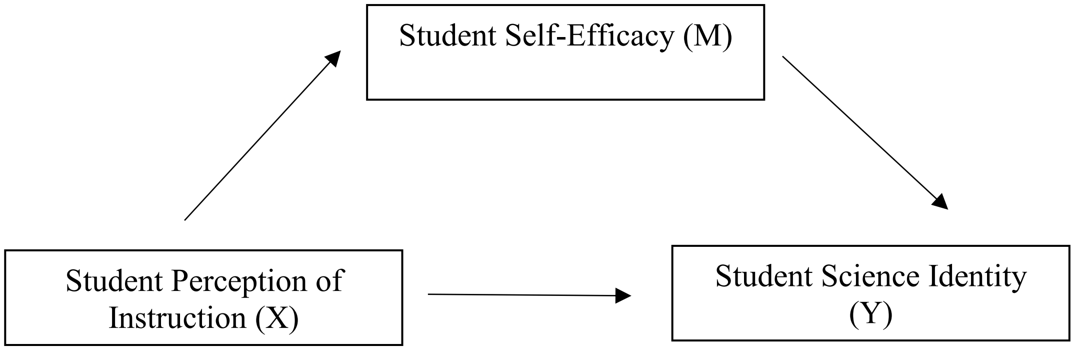
A quantitative research design was chosen for this non-experimental study in order to determine the relationship between student perception of instruction and science identity and the mediation effect of self-efficacy. A quantitative design was also used to determine the relationship between teachers' years of experience and student perception of instruction, science identity, and student perception of self-efficacy. According to Creswell (2014), a quantitative design is appropriate for this study because the goals of the study are to determine correlational relationships between variables and to compare groups rather than developing a theory.

The present study utilized a correlational research design with a mediation model. Correlational research is indicated when attempting to determine the relationship between variables and predicting outcomes (Fraenkel et al., 2012). Although correlational design does not predict causation, a mediation model can be used to test causal behavioral relationships (Baron & Kenny, 1986; Stone-Romero & Rosopa, 2010). Significance was measured at $p = .001$ for each pathway.

Figure 2 shows the model for mediation analysis. A mediation analysis is indicated when one variable may explain the relationship between variables (Fraenkel, Wallen, & Hyun, 2012). Student perception of instruction was the predictor (X), student science identity (Y) was the outcome, and student self-efficacy was the mediator (M).

Figure 2

Model for Mediation Analysis



The second research question explored the how teachers' years teaching, ethnicity, or gender affected student perceptions of instruction, student perceptions of self-efficacy, and student science identity. In this case the teachers' years teaching was the independent variable and the perception of instruction, self-efficacy, and science identity were the dependent variables. A MANOVA analysis will be used to answer this question because there was one categorical independent variable and three continuous dependent variables (Creswell, 2014).

Sample and Population

The participants in this study consisted of secondary science teachers and their students in a suburban high school. School demographic information is in Table 1. The target population for this study was all secondary Black and Latino science students and their teachers in New York State. Convenience sampling was used due to the availability of science teachers and their students (Fraenkel et al., 2012). However, convenience sampling does have its limitations because it is biased and cannot be representative of the population.

Table 1

School Demographic Information

Category	N	%
Gender		
Male	553	53
Female	490	47
Ethnicity		
Black	411	39
Latino	627	60
Asian	4	0
White	1	0
Student Groups		
English Language Learners	252	24
Students with Disabilities	120	12
Economically Disadvantaged	729	70
Homeless	36	3

Note. Adapted from New York State Education Department, 2021.

In this study, there were eleven teacher participants and 204 student participants. Demographic information for student participants is in Table 2. Of these participants, 51% were in ninth grade, 27% in tenth grade, 13% in eleventh grade, and 9% in twelfth grade. Ninety-three students were male, 105 female, and six nonbinary. The study met the experimental guidelines of 30 participants for survey studies (Fraenkel et al., 2012). Demographic information for teacher participants can be found in Table 3. Of the teacher participants, five were male and six were female. All but three teachers were White. The teachers had varying levels of education and experience. One teacher had less than five years teaching experience, while the rest of the teachers had five or more years teaching experience.

Table 2

Student Participant Demographic Information

Category	N	Percentage (%)
Grade Level		
9	103	51
10	55	27
11	28	13
12	18	9
Gender		
Male	93	46
Female	105	51
Nonbinary	6	3
Ethnicity		
Black	61	30
Latino	129	63
Both Black and Latino	14	7
Science Subject		
Living Environment/PreAP Biology	121	59
Earth Science	47	23
Chemistry	16	8
Physics	5	2
College Level Science	13	7
Advanced Placement	2	.1

Table 3

Teacher Participant Demographic Information

Category	N	%
Gender		
Male	5	45
Female	6	54
Ethnicity		
Black	1	9
Latina	1	9
Asian	1	9
White	8	72
Level of Education		
Master's	5	45
Master's +30	4	36
Doctorate	2	18
Years Teaching		
< 5 years	1	9
5 to 10 years	5	45
> 10 years	5	45

Instruments

The data required for this study included information on each science teachers' instructional method (student-centered, teacher centered), teacher demographic information, student demographic information, mean teacher self-efficacy scores, mean student self-efficacy scores, mean student science identity scores, and mean student perceptions of instruction score.

Teachers were administered a two-part survey. In Part 1, Teacher perceptions of self-efficacy were measured using the short form of the *Teachers' Sense of Self-Efficacy Scale.* The purpose of this instrument was to assess the teachers' perceptions of their self-efficacy. The *Teachers' Sense of Self-Efficacy Scale* (TSES) was developed by Megan Tschannen-Moran and Anita Woolfolk Hoy and has a Cronbach's alpha level of .90

(Tschannen-Moran & Hoy, 2001). The survey was used with expressed, written permission from its author.

Part two of the survey involved teacher instructional methods. To assess the teaching method of each teacher, the participating teachers were provided with a survey consisting of items from the *Education Development Center/Nellie Mae Education Foundation (EDC/NMEF) Student Centered Learning (SCL) Questionnaire for Teachers 2016* (EDC/NMEF, 2016). The survey items were taken from the sections of the survey related to classroom instruction and assessment. The maximum possible score for teacher instruction was 110. The closer the score was to the maximum indicated the teacher used more student-centered practices. Cronbach alpha level has been calculated at .80 (Han & Sin, 2018). Expressed written permission from the authors to use the survey in part or in whole was granted under the condition that author cites the source and agree to limit the use of the survey to this doctoral study.

The Student Perceptions survey contained three instruments. Items from the *General Self-Efficacy Scale* (GSE) were the primary means of assessing student self-efficacy. The purpose for selecting this instrument was to assess the students' perceptions of self-efficacy. The GSE is a survey created by Ralf Schwarzer and Matthias Jerusalem (Schwarzer, 2012). The scale assesses the strength of an individual's belief in his or her own self. The instrument was obtained from Schwarzer's website. Permission to use the scale was granted via the website with the requirement that the user appropriately recognizes and cites the source of the scale.

The format of the GSE is a Likert-style attitude scale (Fraenkel et al., 2012). The scale was provided to the participants in the same format created by its author. The instrument had ten items for respondents to rank their level of agreement. The scale for each statement contains four numbers, ranging from 1 (not at all) to 4 (exactly true). The scores for the items were summed to give a total self-efficacy score for each student participant. Recoding is not recommended for this scale (Schwarzer, 2012).

The GSE scale is a subject-completed instrument, specifically designed to be used by either adolescents or adults (Schwarzer, 2012). The scale was written at a 7.5 grade reading level, which was appropriate for the high school aged participants. The scale was designed to be completed within four minutes. In study samples from 23 nations, the Cronbach's alpha score ranged from .76 to .90. The reported difficulties with the GSE scale, mostly occurred when the scale was used to assess the subject's self-efficacy related to specific behavior change. The GSE scale was chosen over other self-efficacy scales due to its length and the reading level.

The portion of the survey assessing students' science identity used items from a math affinity index (Childs, 2017). The index was developed in order to define a measure that was more robust than the index developed by the NCES, which had an (alpha = .65). Each item on the index based on their alignment with math identity – the extent to which students identify with being able to be successful in math and find relevance in it. This definition coincides with the definition of science identity used in this study (Vincent-Ruz & Schunn, 2018). The six-item scale was chosen because of its length and its alpha level of .89. The individual science-identity score was a sum of the item responses on the scale of 1 (not at all) to 4 (exactly true). Permission to use and adapt the math identity index for this study was granted in writing from its author.

The final portion of the student survey assessed the students' perceptions of classroom instruction using items from the *Student Perceptions of Classroom Quality* (SPOCQ) survey (Gifted Education Research and Resource Insititute, 2019). Permission to use the scale in part or whole was granted by its author. The SPOCQ was designed to assess student perceptions of meaningfulness, challenge, choice, self-efficacy and appeal. Survey items pertaining to meaningfulness, challenge, and choice were only selected due to other instruments being used to measure self-efficacy and science affinity, which is related to appeal. The sections of the survey related to meaningfulness, challenge, and choice each have an alpha level of .81 (Gentry & Owen, 2004). Each item has a scale from 1 (strongly disagree) to 5 (strongly agree). The score for each item was summed up to determine an overall student perception of instruction score for each participant.

Procedures for Collecting Data

Prior to receiving St. John's University Institutional Review Board (IRB) approval, the author emailed the superintendents of three districts where the demographic population was mostly Black and Latino. Of those districts, only one superintendent responded. The author then met with the district's superintendent and discussed the purpose of the study and data collection procedures. The superintendent gave preliminary approval for the study to take place in their high school. After receiving IRB approval, the author met with the superintendent again and was given permission to initiate the study.

Once approval was granted, the author approached the teacher participants during a department meeting. She informed them of the nature of the study and told them that they would receive emails inviting them to participate. Teachers were then emailed a description of the study and an invitation to participate. The links to the teacher survey and the student survey were also provided in the message.

Teachers were instructed to complete their survey individually, via Survey Monkey, at their convenience. The responses were automatically compiled on a spreadsheet file that was only accessible by the author. Teacher participants were asked to share the Survey Monkey link to the Student Perceptions survey with students in their classes and have the students complete the survey during class time. The students completed the survey anonymously during class. Student demographic information was collected via the survey. Students were prompted to record their grade, gender, and ethnicity (Black/African American, Latino/Hispanic, or Other ______) and science level (Living Environment/Pre-AP Biology, Earth Science, Chemistry, Physics, college level science, or AP science. In order to match the student surveys with the appropriate teacher, they were asked to provide their teacher's name.

Once data were collected, survey responses were downloaded from Survey Monkey into Microsoft Excel spreadsheets to begin the data coding and scoring processes. Data were coded from nominal to numerical. For example, when coding student grade levels, "1" was used for ninth grade, "2" for tenth grade, "3" for eleventh grade, "4" for twelfth grade.

Scores for teacher self-efficacy and teacher instruction were calculated for each teacher participant. The teacher self-efficacy score was the sum of the item responses from items one to twelve of the teacher survey. Teacher instruction score was a tally of the responses from items 21 to 50 of the teacher survey. Each student participant received scores for self-efficacy, science identity, and perception of instruction based on their responses to the student survey items. The student self-efficacy score was calculated by adding up the responses of items one to ten on the student survey. The science identity score was the sum of responses to items 11 to 16 and student perception of instruction score was the sum of the responses to items 17 to 25. Once data were coded and scored in Microsoft Excel, the information was transferred to SPSS in order to run descriptive and inferential statistics.

CHAPTER 4: RESULTS/FINDINGS

The data were reviewed for coding errors, missing responses, and other mistakes. Twenty-eight student participants were eliminated due to incomplete survey responses and one student was eliminated because they were neither Black nor Latino. Therefore 204 student participants and 11 teacher participants remained. Next a series of descriptive statistics, the mean, standard deviations, and maximum and minimum scores, were calculated. The mean and standard deviation of student science identity, student self-efficacy, student perception of instruction, teacher self-efficacy and teacher instruction scores are reported in Table 4.

Table 4

Descriptive Statistics for Student Participants

	N	Min	Max	M	SD
Student Science Identity Score	204	6	24	15.12	3.925
Student Self Efficacy Score	204	15	40	28.82	4.946
Student Perception of Instruction Score	204	17	45	33.29	5.370
Teacher Self-Efficacy Score	204	76	92	84.23	5.430
Teacher Instruction Score	204	61	86	75.65	7.508

A Pearson correlation analysis was performed, and the results are reported in Table 5. Students' self-efficacy is significantly correlated with student science identity ($r = .54$, $p < .05$) and student perception of instruction ($r = .54$, $p < .05$). There was no significant relationship between student self-efficacy and teacher self-efficacy.

Table 5

Pearson Correlations Among Variable Scores

	1	2	3	4
1. Teacher Self-Efficacy Score	-			
2. Teacher Instruction Score	-.039	-		
3. Student Self-Efficacy Score	-.109	.136	-	
4. Student Science Identity Score	.011	.044	.665**	-
5. Student Perception of Instruction Score	.104	-.037	.453**	.493**

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Research Question 1

Is there a statistically significant relationship between student perception of instruction and student science identity, and can this relationship be mediated by self-efficacy?

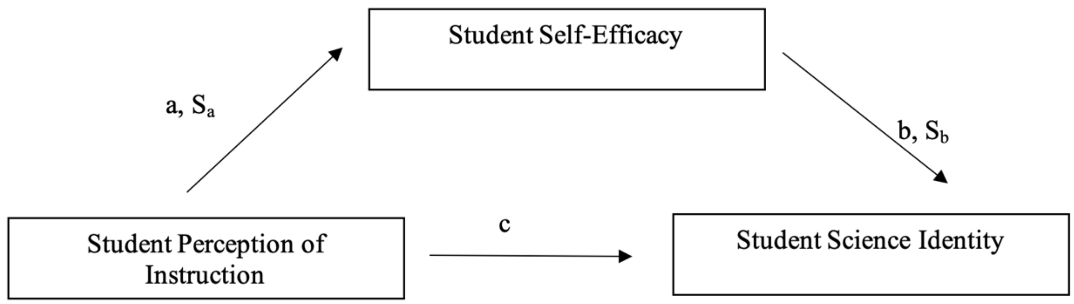
Figure 3 illustrates this research question. In this model, *a* is the raw (unstandardized) regression coefficient for the association between the independent variable and the mediator; S_a is the standard error of *a*; *b* is the raw coefficient for the association between the mediator and the dependent variable (when the independent variable is also the predictor of the dependent variable); S_b is the standard error of *b*; *c* is the raw coefficient for the association between the independent variable and the dependent variable.

H_0: Self-efficacy does not significantly mediate the relationship between student perceptions of instruction and science identity in Black and Latino science students.

H_1: Self-efficacy does significantly mediate the relationship between student perceptions of instruction and science identity in Black and Latino science students.

Figure 3

Simple Mediation Model: Student Science Identity and Perception of Instruction by Self-Efficacy.



According to Baron and Kenny (1986) the following conditions must exist prior to doing a mediation analysis: the independent variable (student perception of instruction) must affect the mediator (self-efficacy); the independent variable (student perception of instruction) significantly affects the dependent variable (student science identity); the mediator (self-efficacy) should also significantly predict the dependent variable (science identity). Additionally, there should also be a significant effect of the mediator on the relationship between the independent variable and the dependent variable (Abu-Bader & Jones, 2021). Therefore, a series of regression analyses were used to determine significant relationships between the aforementioned variables.

Prior to performing the regression analyses, the assumptions (linearity, multicollinearity, independent residuals, homoscedasticity, normal distribution of residuals, no significant outliers) were tested. The relationships between the independent and dependent variables were linear according to the scatter plots. There was no multicollinearity in the data. The values of the residuals were independent as indicated by the Durbin-Watson statistic, which was close to 2. The residual plot was scattered, with no funneling, indicating that the variance of the residuals was constant. Therefore, the assumption of homoscedasticity was met. The P-P plot indicated that the values of the residuals was normally distributed. The Cook's Distance values were all under 1, so there were no influential cases or outliers.

STEP 1

A simple linear regression analysis was calculated to predict the independent variable's (student perception of instruction) effect on the dependent variable (student science identity). Table 6 shows the regression results. The results indicated student perception of instruction was a significant predictor of science identity (t = 8.058, p < .001), with an adjusted R^2 = .240 (p < .001). Also, "c" (unstandardized coefficient = .361) is statistically significant.

Table 6

Regression Analysis of Student Perception of Instruction on Student Science Identity

Variable	B	95% CI	β	t	p
(Constant)	3.119	[.144, 6.094]		2.067	.040
Student Perception of Instruction Score	.361	[.272, .449]	.493	8.058	<.001

Note. R^2 adjusted = .240., CI = Confidence interval for B

STEP 2

A simple linear regression analysis was conducted to examine whether the independent variable's (student perception of instruction) predicted the dependent variable (student self-efficacy). Table 7 shows the regression results. The results indicate student perception of instruction is a significant predictor of student self-efficacy (t =

7.215, $p < .001$), with an adjusted $R^2 = .201$ ($p < .001$). Also, “b” (unstandardized coefficient = .417) is statistically significant.

Table 7

Regression Analysis of Student Perception of Instruction on Student Self-Efficacy

Variable	B	95% CI	β	t	p
(Constant)	14.944	[11.102, 18.786]		7.669	<.001
Student Perception of Instruction Score	.417	[.303, .531]	.453	7.215	<.001

Note. R^2 adjusted = .201, CI = Confidence Interval for B

STEP 3

A two-stage hierarchical multiple regression was conducted with students’ science identity as the dependent variable. Student perception of instruction score was entered as a control at stage 1. The mediator, student perception of self-efficacy score was entered at stage two. The variables were entered in this order because student perception of instruction affects how students develop their perception of their own abilities as scientists, and subsequently their science identity. Intercorrelations between multiple regression variables were reported in Table 5, and the regression statistics are available in Table 8.

Table 8

Hierarchical Multiple Regression Analysis of Student Perception of Instruction on Student Science Identity with Student Self-Efficacy as a Mediator

Variable	β	t	sr^2	R	R^2	ΔR^2
Stage 1				*.493	*.243	*.243
Student Perception of Instruction	.493	8.058*	.045			
Stage 2				*.699	*.489	*.245
Student Perception of Instruction	.242	4.274*	.041			
Student Self-Efficacy Score	.555	9.819*	.045			

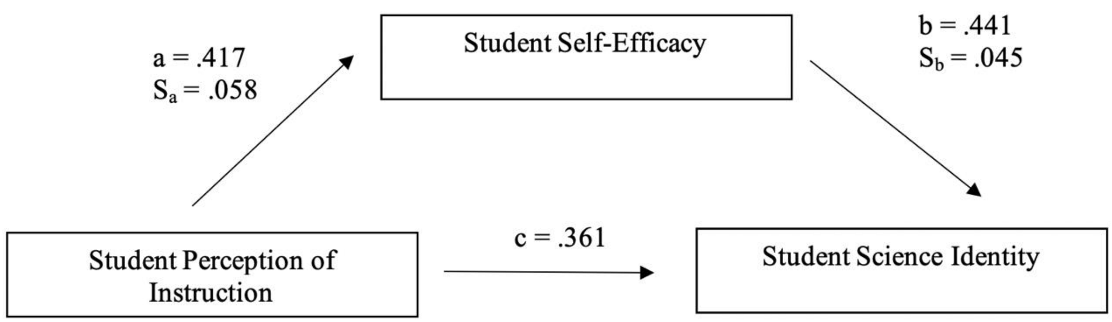
Note. * indicates $p < .001$,

The hierarchical multiple regression revealed that at Stage 1, student perception of instruction contributed significantly to the regression model, *F* (1, 202. = 64.94, $p < .001$) and accounted for 24% of the variation in science identity. Introducing the student perception of self-efficacy score resulted in an additional of 24.5% variation to science identity. This change in R^2 was significant, *F* (2, 88) = 60.10, $p < .001$. When both variables, student perception of instruction and student self-efficacy were included stage two of the regression model, the effect of student perception of instruction decreased as indicated by a change in the standardized coefficient. However, student perception of instruction remains to be a significant predictor. Thus, student self-efficacy is a partial mediator of student perception of instruction on science identity. Student self-efficacy uniquely explains 24% of the variation in science identity. Together, the independent variable and mediator accounted for 48 % of the variance in science identity.

The results of the simple linear regression showed that student perception of instruction significantly predicted student science identity ($b = .361$, $\beta = .493$, $t = 8.058$, $p < .001$). When the mediator, student perception of self-efficacy, was entered into the hierarchical regression analysis, student perception of instruction remained as a significant predictor of student science identity; however, its predictive effect was much weaker (b = .117, β = .242, t = 4.274, p < . 001). The mediator, student self-efficacy, was also found to be a significant predictor for student science identity (b = .441, β = .555, t = 9.819, p < .001). Figure 4 provides a summary of the unstandardized coefficients and their standard errors.

Figure 4

Unstandardized Regression Coefficients and Standard Errors for the Simple Mediation Model



After the three conditions for mediation were confirmed, a Sobel test was used to calculate the Z statistic to determine if student self-efficacy is a statistically significant mediator between student perception of instruction and student science identity (MacKinnon et al., 1995; Sobel, 1982). The formula for the Z value is shown in Figure 5. This formula, proposed by Sobel (1982), is the ratio of the product of “a” and “b” to the standard error. The Sobel test was calculated using a computer calculator at http://quantpsy.org/sobel/sobel.htm . The computed Z score of 5.80 (p < .001) falls outside the Z critical values of ±2.58, thus confirming that the student perception of self-efficacy significantly mediates the relationship between students’ perception of instruction and science identity.

Figure 5

Z value for Sobel Test

$$Z = \frac{a + b}{\sqrt{(b^2 + S_b^2 + a + S_b^2)}}$$

Research Question 2

How does a teacher's years of experience affect their students' perceptions self-efficacy, perception of instruction and science identity?

H_0: A teacher's years of experience does not significantly affect their students' perceptions of instruction, science identity and perceptions of self-efficacy.

H_1: A teacher's years of experience significantly affects their students' perceptions of instruction, science identity and perceptions of self-efficacy.

A one-way multivariate analysis of variance (MANOVA) was conducted to determine differences in student perception of instruction, student science identity, and student perception of self-efficacy as they relate to the teacher's years of experience. Students were grouped according to the teachers' years of teaching experience: novice (≤4), intermediate (5-10), and veteran (>10). The means and standard deviations for student perception of instruction, student science identity, and student self-efficacy scores for each group are shown in Table 9.

Table 9

Means and Standard Deviations for Students when Grouped by Teacher's Experience

	Novice		Intermediate		Veteran	
	M	*SD*	*M*	*SD*	*M*	*SD*
Student Perception of Instruction	31.03	5.208	33.32	5.162	33.99	5.418
Student Science Identity	13.22	3.386	14.92	3.737	15.87	4.024
Student Self-efficacy	26.06	4.048	29.11	4.783	29.50	5.061

Table 10 shows the results of the one-way between-group MANOVA which was performed to explore the differences in students' perception of instruction, science identity, and students' perception of self-efficacy as it relates to their teacher's years of work experience. Overall, there was a statistically significant difference between students based on their teacher's years of teaching on the combined dependent variables (student perception of instruction, student science identity, student perception of self-efficacy): F (3, 199 = 2808), $p < .05$; Wilks' $\Lambda = .023$, $\eta^2 = .977$. When the results for the dependent variables were examined separately, it showed that the teacher's years of experience had a statistically significant effect on student perceptions of instruction [$F(2, 201) = 3.792$; $p < .05$; $\eta^2 = .036$]; student science identity [F (2, 201) = 5.979; $p < .05$; $\eta^2 = .056$], and student perception of self-efficacy [F (2, 201) = 6.357; $p < .05$; $\eta^2 = .059$].

Table 10

Summary Table of One-Way MANOVA for Years Teaching Experience on Perception of Instruction, Science Identity, and Student Perception of Self-Efficacy

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Teacher's Years of Experience	Student Perception of Instruction Score	212.845	2	106.422	3.792	.024*	.036
	Student Science Identity Score	175.648	2	87.824	5.979	.003**	.056
	Student Perception of Self-Efficacy Score	295.426	2	147.713	6.357	.002**	.059
Error	Student Perception of Instruction Score	5641.508	201	28.067			
	Student Science Identity Score	2952.288	201	14.688			
	Student Perception of Self-Efficacy Score	4670.221	201	23.235			

A review of the mean scores indicated that students of veteran teachers have the greatest perception of instruction scores (M = 33.99, SD = 5.418), science identity scores (M = 15.87, SD = 4.024), and perception of self-efficacy scores (M = 29.50, SD = 5.061).

A series of post hoc analyses (Tukey HSD) were performed to examine individual mean difference comparisons (Table 11). The mean perception of instruction (p = .018), student science identity (p = .002), and student perception of self-efficacy (p = .002) scores were significantly lower for students of novice teachers than students of veteran teachers. There were no significant differences between students of intermediate teachers and the other groups.

Table 11

Multiple Comparison post hoc Test for Years Teaching Experience on Perception of Instruction, Science Identity, and Student Perception of Self-Efficacy.

Dependent Variable	Teacher's Years Teaching	Teacher's Years Teaching	Mean Diff	SE	df	*p*
Student Perception of Instruction	Novice	Intermediate	-2.29	1.128	2	.107
		Veteran	-2.96*	1.075	2	.018
	Intermediate	Veteran	-.67	.820	2	.696
Student Science Identity	Novice	Intermediate	-1.70	.816	2	.097
		Veteran	-2.65**	.777	2	.002
	Intermediate	Veteran	-.96	.594	2	.244
Student Self Efficacy	Novice	Intermediate	-3.05**	1.026	2	.009
		Veteran	-3.43**	.978	2	.002
	Intermediate	Veteran	-.38	.747	2	.865

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

CHAPTER 5: DISCUSSION

The purpose of the present study was to determine the relationship between Black and Latino high school science students' perception of instruction and science identity and to determine if this relationship is mediated by student perceptions of self-efficacy. Additionally, this study sought to determine if there was a relationship between science teachers' years of teaching and students' perceptions of self-efficacy, students' perceptions of instruction, and student science identity. In this chapter, the results of the quantitative analysis of the data obtained from the participants' survey responses will be discussed. Implications of these results, how the results relate to the prior research, study limitations and recommendations for future research and practice will also be reviewed.

Implications of Findings

The research questions which guided the current study were:

1. Is there a statistically significant relationship between student perception of instruction and student science identity, and can this relationship be mediated by self-efficacy?
2. How does a teacher's years of experience affect their students' perceptions self-efficacy, perception of instruction and science identity?

The present study found a relationship between student perception of instruction and student science identity in Black and Latino science. Furthermore, it was found that student perceptions of self-efficacy enhanced this relationship. These results indicate that the type of instruction provided in the science classroom does matter in terms of developing student beliefs about their abilities in science. Teachers need to provide instruction which promotes self-efficacy because it enhances the effect of instruction on science identity. When students learn within a social context, self-efficacy beliefs and therefore science identity improve.

Based on this study's findings, student perception of instruction is key to promoting self-efficacy beliefs and science identity. In the perception of instruction portion of the student survey, higher scores were associated with students being able to choose how to demonstrate learning and choice in topic of study. Higher perception of instruction scores were also given when students felt their course connected to society and the real world. Additionally, higher perception of instruction scores were also reported when students felt challenged and that they were using critical thinking skills. Therefore, science educators should promote student autonomy and facilitate relevant and rigorous instruction in their classes.

To make instruction more appealing to students, science teachers need to provide opportunities for student inquiry, collaboration, and problem solving. This echoes Dewey's (1938) pedagogical philosophy of experiential learning. Students need to be provided with experiences which arouse curiosity, strengthen initiative, and "sets up desires and purposes that are sufficiently intense to carry a person over different places in the future" (Dewey, 1938, p.38). Creating appealing instruction starts with how the topics are introduced. The teacher can start a lesson or instructional unit by introducing phenomena or a real-world problem. Students should be given the opportunity to pose their own questions as they relate to the problem presented to them and teachers can use these questions to guide instruction. Another method of incorporating student choice into instruction would be to give students a choice of topics to explore, where they may work on independent projects to meet the goals of the unit. Throughout an instructional unit, the teacher should incorporate student-centered learning activities where students can exchange ideas, develop theories, and receive feedback from one another. Such activities may include a jigsaw lesson, think pair share, a gallery walk, experimental design, or an interactive word wall (Scott & Samson, 2017). Teachers may also use the NGSS framework for instruction as a guide for developing instruction (NGSS Lead States, 2013). This framework provides guidance for project-based instruction, where students observe phenomena, pose questions related to their observations, research answers to their questions, and develop models and explanations for their observations. This model for instruction would be appealing for students because it allows for choice, relevance, and challenge.

When science teachers provide instructional opportunities which students find more appealing, science education is happening withing the social context. As teachers incorporate student-centered learning activities in their practice, students acquire science skills through discourse with peers and their teachers (Horak & Galluzo, 2017; Jones, 2007). Students working collaboratively can learn ways to problem solve and receive coaching from their peers and teacher. They can practice the skills and behaviors associated with science, whether it be when they are carrying out investigations or when sharing what they learned from reading an article during a jigsaw lesson. Furthermore, the students learn from each other through observation. For example, in the classroom, students might observe a more successful group's approach to carrying out an experiment and decide to follow that method and gain success. The interactions in the student-centered classroom support social learning as students learn through direct observation, modeling, imitation, and feedback (Bandura, 1971) These learning experiences will then inform student self-efficacy beliefs in science.

When teachers design lessons which allow students choice, are relevant to students' lives and are challenging, they allow students to practice being a scientist. It is important to note that in the field, scientists observe phenomena in the natural world, ask questions about their observations, and then gather evidence to develop models and explanations to explain phenomena. Prior to their intervention, Chapman and Fledman (2017) found that Students of Color were more likely to identify White males as scientists. However student-centered instruction, through PBL allowed students to change their perceptions of who could be a scientist. As Students of Color see themselves and their peers working like scientists, they begin to understand that science can be for them, thus enhancing their science identity. Since student science identity is dependent upon their perception of instruction, the characteristics of an effective science teacher should be addressed.

In the present study, teacher perceptions of self-efficacy and teacher perceptions of instruction did not significantly relate to student perception of instruction, student perception of self-efficacy, nor student science identity. This could have been due teachers not having enough self-awareness or understanding of their own teaching competencies. They may not have had a strong understanding of what constitutes high quality teaching. Although confidentiality was guaranteed, the teacher participants may have also been reluctant to report that they did not frequently use best practices. Finally, a teacher's perception of instruction could have been embedded within the student variables. A path analysis could be used to further identify factors contributing to these results (Fraenkel et al., 2012).

Significant relationships between teacher experience and student perception of instruction, student perception of self-efficacy, and student science identity were discovered. Students who had science teachers with more than ten years of teaching experience were found to have the highest scores for perception of instruction, science identity, and perceptions of self-efficacy. The results of this study also suggest that at somewhere between five and ten years of experience, science teachers start to become proficient in delivering instructional experiences which enhance student perceptions of instruction, science identity, and self-efficacy. These results indicate that experienced teachers become more aware of instructional strategies which appeal to students and are more likely to implement them in their classrooms.

A science teacher's ability to provide instruction that is more appealing to students may develop over time through reflection, exposure, and immersion. A science teacher's competency can grow as they reflect upon their own personal experiences in the classroom (Danielson, 2011; National Board for Professional Teaching Standards, 2014). Most teachers have had lessons which went well and those which could have gone better. Personal reflection on classroom experiences allows teachers to identify the strategies which had the significant impact on student learning and which ones did not work so well. Exposure to professional development and collaboration with colleagues may also enhance a teacher's ability to provide appealing instruction as well (Sandholtz & Ringstaff, 2014). Professional development and collaboration with colleagues will inform teachers of best practices in the science classroom. Additionally, collaboration with colleagues may enable teachers to learn more about the students in the school where they are working. Immersion in the culture of the school and the community could also explain why students of more experienced teachers have greater perceptions of instruction, perceptions of self-efficacy and science identity. The majority of teacher participants in this study were White, yet their Black and Latino students were able to report a positive perception of instruction. Perhaps the teachers who have worked with Black and Latino students for some time have cultural knowledge of the student population and their community. They may be able to develop science instruction that is more culturally relevant than the novice teachers, thus enhancing student appeal.

In order to develop the instructional competencies of novice science teachers, they should receive structured mentoring. Districts should adopt a mentoring program based on the model in Oceanside, New York (Gilrein & Wolfe, 2016). Mentoring should take place over the first three or four years of their career, similar to how medical resident is mentored and guided by a more experienced physician. In this scenario, the novice science teacher would be paired with an accomplished veteran teacher who would provide coaching to the newer teacher. The mentor would be able to assess the needs and strengths of the novice teacher through informal, nonevaluative observations, and collaborative planning sessions. The mentor teacher in turn, could also solve as a model by allowing the new teacher to observe their instruction. Finally, the mentor would also serve as a school culture guide for the new teacher, by sharing the cultural nuances of the students. New York City has also developed a mentoring program for novice teachers, where model teachers and peer collaborative teachers provide coaching, collaboration, and feed back to teachers in need of additional support (New York City Department of

Education, 2022). Mentoring programs not only help to develop novice teachers, but they also help with teacher retention (Podolsky et al., 2016). Support and funding for such mentoring programs could be available from state legislatures. New York State has reserved two million dollars per year from 2018-2023 to fund the *Mentor Teacher Internship Program* (New York State Education Department, 2019).

In addition to mentoring novice teachers, schools and school districts need to make efforts to recruit and retain veteran teachers. New York State developed the *Teachers of Tomorrow* program in 2000 to address the teacher shortages in school (New York State Education Department, 2019). This program allowed schools which were under review, low performing, or those experiencing teacher shortages to apply for funding to provide a pay incentive for up to four years for new hires.

Relationship to Prior Research

The results of the present study extend upon the reviewed research by establishing student perceptions of self-efficacy as a mediator of the relationship between student perceptions of instruction and science identity (Chapman & Feldman, 2017; Chemers et al., 2011; Griggs et al., 2013; Horak & Galluzzo, 2017; Usher & Pajares, 2006). Through instruction, which incorporates student choice, and that is rigorous and relevant, students develop an understanding of their competencies in science. As students become more adept at the skills and practices associated with being a science person, their science identity grows.

The positive relationship between student perception of instruction and student perceptions of self-efficacy echoes the findings which showed that academic interventions can impact student self-efficacy beliefs (Griggs et al., 2013; Usher &

Pajares, 2006). Additionally, these findings also support the previous correlation between student self-efficacy and appeal of student-centered instruction (Horak & Galluzzo, 2017). The significant relationship between student perceptions of instruction and science identity supports findings which show that student-centered, project-based instruction impacts science identity in science Students of Color (Chapman & Feldman, 2017). The results of the present study also support prior associations between self-efficacy and science identity (Chemers et al., 2011).

The results of the present study also expand upon prior research related to teacher experience and instruction (Cansiz & Cansiz, 2019; Sandholtz & Ringstaff, 2014; Swan, Wolf & Cano, 2011; Wolters & Daugherty, 2007). Although there was no significant relationship found between teacher perceptions of instruction or teacher perceptions of self-efficacy and the variables related to students (perceptions of self-efficacy, science identity, perception of instruction), teacher experience significantly impacted student variables. Students of veteran teachers tended to have greater perceptions of instruction, science identity and perceptions of self-efficacy. These results show a relationship to prior findings which showed that more experienced teachers tend to use student-centered instruction which is more appealing to students (Cansiz & Cansiz, 2019; Sandholtz & Ringstaff, 2014).

Limitations of the Study

Possible threats to internal validity include maturation and history. Student participants in this study ranged from grades nine to twelve. Older students may have had more experience in science, and therefore have had more time to develop their perceptions of instruction, perceptions of self-efficacy, and science identity. Additionally, this study took place during the COVID-19 pandemic. Instruction during the pandemic varied from in-person to remote to hybrid. This variation likely presented instructional challenges for teachers. Despite their years of work experience, teachers were challenged with providing science instruction during unfamiliar circumstances. Additionally, if students were learning remotely, they may not have had the same level of social interactions as they would have with in-person instruction. Therefore, their perception of instruction may also have been related to the convenience of doing school from home. For those who were learning in person, their perception of instruction could have been related to smaller class sizes due to pandemic safety protocols. The reduced class sizes may have allowed for more personal interaction with teachers, thus enhancing their perception of instruction.

A threat to external validity could have been sampling and self-reporting of data. Convenience sampling was used for this study; therefore, it was not randomized. The study took place in only one school; therefore, it is a challenge to generalize these results to the entire population of Black and Latino science students. Also, because the study took place in one school, the sample of science teachers was too small to find significance with respect to teacher self-efficacy or teacher perception of instruction. Although a survey instrument was used to measure teacher perceptions of instruction, the teachers self-reported responses to survey items may not have accurately reflected their instructional practices.

Recommendations for Future Practice

The theoretical framework chosen for the present study postulated that learning through social interactions can influence student science identity, by way of enhancing self-efficacy. Self-efficacy was found to be a mediator of perceptions of instruction and student identity. This relationship is important as student self-efficacy and science identity may address the achievement gaps between Black and Latino students and their White counterparts in science, as well as address the underrepresentation of People of Color in science. Instruction which students find appealing enables them to learn through the social learning practices of direct observation, modeling, imitation, and feedback from others. These interactions then in turn build self-efficacy, which influences science identity. Therefore, it is important for science educators to provide students with ample opportunities for student-centered learning. Project based learning is one way in which this goal can be achieved.

In order for teachers to develop their instructional practices, they need experience and guidance. School leaders need to provide opportunities for professional development, coaching, and collaboration between science teachers. Social Learning Theory can also be applied to teachers (Williams, 2017). Teachers can learn to develop their teaching practices through observing each other, collaborating on lessons, and receiving feedback from one another. Furthermore, school districts should adopt teacher mentoring programs where effective veteran teachers are partnered with new teachers during their probationary periods.

Recommendations for Future Research

Future research should replicate the current study on a larger scale, by taking place in multiple schools with similar populations of Black and Latino students. This will allow for more generalizability of results and will allow for significance to be reached in teacher variables. Furthermore, a larger scale study will enable researchers to disaggregate data by grade level. Then the relationship between perceptions of instruction and student science identity as mediated by student perceptions of self-efficacy can be compared to see if this relationship changes as students advance in school.

Future studies should also include teacher observations by the researcher. This will provide a more objective measure of teacher instruction rather than just self-reported data. Also, it is recommended that an experimental study be conducted in the future. Such a study would involve teacher professional development on instructional strategies which emphasize social learning. Then student perceptions of instruction, student perceptions of self-efficacy, and student science identity should be measured pre- and post-intervention. This type of study could determine if teacher coaching will be able to further enhance the relationships between these variables.

Conclusion

The achievement gap in science has persisted over time and has been a contributing factor to the underrepresentation of Blacks and Latinos in science careers. The author of the present study is a veteran science educator of Black and Latino students who aimed to find a not only a means of improving student performance in science, but to also encourage student persistence in science. The results of this study demonstrate that this gap in achievement is not necessarily endemic to Students of Color. Instead, it reinforces the need to for educators to practice pedagogy that is appealing and interesting to their students. By recognizing how instruction affects student perceptions of self-efficacy and science identity, educators can understand how to encourage interest in science among Students of Color.

APPENDIX A: STUDENT PERCEPTIONS SURVEY

Student Perceptions Survey

Thank you for participating in this study. This study wants to find out about your beliefs about yourself in science class (self-efficacy) and your opinion about science class in general.

Personal Information: Circle the choice which best describes you.

Grade Level:	9	10	11	12	
Gender:	Male	Female	Non-Binary		
Ethnicity:	Black/African American	Hispanic/ Latino	Both Black and Hispanic	Other (please specify)____	

Which science class are you currently taking?

Living Environment/Pre-AP Biology	
Earth Science	
Chemistry	
Physics	
College Level Science	
Advance Placement Science	

Complete the following survey related to your beliefs about yourself in **science class**.

Part 1

	Not at all true	Barely true	Moderately true	Exactly true
1. I can always manage to solve difficult problems if I try hard enough.	1	2	3	4

2. If someone opposes me, I find means and ways to get what I want.	1	2	3	4
3. It is easy for me to stick to my aims and accomplish my goals.	1	2	3	4
4. I am confident that I could deal efficiently with unexpected events.	1	2	3	4
5. Thanks to my resourcefulness, I know how to handle unforeseen situations.	1	2	3	4
6. I can solve most problems if I invest the necessary effort.	1	2	3	4
7. I can remain calm when facing difficulties because I can rely on my coping abilities.	1	2	3	4
8. When I am confronted with a problem, I can usually find several solutions.	1	2	3	4
9. If I am in a bind, I can usually think of something to do.	1	2	3	4
10. No matter what comes my way in class, I'm usually able to handle it.	1	2	3	4
11. I see myself as a science person.	1	2	3	4
12. Others see me as a science person.	1	2	3	4
13. I am confident that I can do an excellent job on science assignments.	1	2	3	4
14. I am certain I can understand the science textbook.	1	2	3	4
15. I am confident I can do an excellent job on science tests.	1	2	3	4
16. I can master the skills taught in this science course.	1	2	3	4

Part 2

Complete this portion of the survey which has to do with your activities in science class.

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
17. I am given choices regarding how to show the teacher what I have learned.	1	2	3	4	5
18. I find my class assignments a good challenge.	1	2	3	4	5
19. My teacher makes a connection between the course material and society.	1	2	3	4	5
20. I am given lots of choices in my class.	1	2	3	4	5
21. This class content is an appropriate challenge for me.	1	2	3	4	5
22. I am encouraged to pursue subjects that interest me in my class.	1	2	3	4	5
23. In my class, I explore real issues that affect the world around me.	1	2	3	4	5
24. I use my critical thinking skills in my class.	1	2	3	4	5
25. I can relate the material discussed in this class to my daily life.	1	2	3	4	5

APPENDIX B: TEACHING SELF-EFFICACY AND INSTRUCTION QUESTIONNAIRE

Teaching and Self-Efficacy and Instruction Questionnaire

The purpose of this study is to study the effect of teacher instructional strategies on student self-efficacy in science and student academic performance and to explore the relationship between teacher self-efficacy and instructional methods.

Thank you for participating in this study.

Part 1

<u>Directions</u>: Please indicate your opinion about each of the questions below by choosing any one of the nine responses in the columns on the right side, ranging from (1) "None at all" to (9) "A Great Deal" as each represents a degree in the continuum.

Please respond to each of the questions by considering the combination of your *current* ability, resources, and opportunity to do each of the following in your present position.

	None at all		Very Little		Some Degree		A Great Bit		A Great Deal
1. How much can you do to control disruptive behavior in the classroom?	1	2	3	4	5	6	7	8	9
2. How much can you do to motivate students who show low interest in school work?	1	2	3	4	5	6	7	8	9
3. How much can you do to calm a student who is disruptive or noisy?	1	2	3	4	5	6	7	8	9
4. How much can you do to help your students value learning?	1	2	3	4	5	6	7	8	9
5. To what extent can you craft good questions for your students?	1	2	3	4	5	6	7	8	9
6. How much can you do to get children to follow classroom rules?	1	2	3	4	5	6	7	8	9
7. How much can you do to get students to believe they can do well in school work?	1	2	3	4	5	6	7	8	9
8. How well can you establish a classroom management system with each group of students?	1	2	3	4	5	6	7	8	9
9. To what extent can you use a variety of classroom strategies?	1	2	3	4	5	6	7	8	9

10. To what extent can you provide an alternative explanation or example when students are confused?	1	2	3	4	5	6	7	8	9
11. How much can you assist families in helping their children do well in school?	1	2	3	4	5	6	7	8	9
12. How well can you implement alternative teaching strategies in your classroom?	1	2	3	4	5	6	7	8	9

13. What is your gender?	Male Female	16. What level do you teach?	Elementary Middle School High School
14. What is your racial identity?	African American White, Not Hispanic Other	17. What is the context of your school?	Urban Suburban Rural
15. What subject matter do you teach?	All (Elementary/Self-contained) Math Science Language Arts Social Studies	18. What is highest your level of education?	Bachelors Masters Masters +30 Masters +60 Doctorate
19. What grade level(s) do you teach?			
20. How many years have you taught?			

Part 2

<u>*Directions*</u>: Please indicate your opinion about each of the questions below by choosing any one of the responses in the columns on the right side.

In your classroom over the past year, *how often do you provide instruction that:*	Never	Occasionally	Often	All the time
21. REQUIRES COLLABORATION (students interact with peers as part of classroom learning, rely on help and support from classmates to complete assignments, and/or receive and use feedback from peers to revise work).	1	2	3	4
22. REQUIRES PERSONLIZATION (students have input on the design and	1	2	3	4

goals of classroom learning, have personalized pathways to college/career readiness, have choice over how to demonstrate proficiency, and/or work at their own pace to master content.				
23. REQUIRES CRITICALTHINKING OR PROBLEM SOLVING (students work on tasks with no single correct answer, apply previously learned content to new problems and new contexts, and/or support ideas with evidence.	1	2	3	4
24. REQUIRES STUDENT SELF-REGULATION AND ACADEMIC TENACITY (students have opportunities to demonstrate persistence, assess the quality of their own work as they proceed, and or modify the approach when faced with obstacles to achieving long-term goals.	1	2	3	4
25. REQUIRES ANYWHERE/ANYTIME LEARNING (students participate in learning outside the school day/school building, e.g. blending learning, flipped learning, virtual learning, and/or ELOs sch as internships or service learning).	1	2	3	4

Of the assessment methods listed below, please indicate the three that are most important for assessing student proficiency in your classes. Indicate the methods you would rank as the first, second and third most important.	1st most important	2nd most important	3rd most important
26. Traditional quizzes or tests.	1	2	3
27. Portfolio submissions and accompanying rationale	1	2	3
28. Classroom participation	1	2	3
29. End-of-course or end-of-term exams	1	2	3
30. Extended (more than a week long) individual projects.	1	2	3
31. Extended (more than a week long collaborative projects)	1	2	3
32. Daily homework and daily check-ins	1	2	3
33. Journals, Lab books or Notebooks	1	2	3
34. Student presentation to class	1	2	3
35. Student presentation at a public event or to a panel of students, teachers,	1	2	3

administrators, and/or community members.				
Please rate the following instructional activities for how important they've been to your instruction in this school (check one box in each row).	Unimportant	Minimally important	Quite important	Most important
36. Lead a class of students doing an investigation or activity that demands complex reasoning or problem solving	1	2	3	4
37. Provide instruction through extended formal presentation or lecture.	1	2	3	4
38. Facilitate a whole-class discussion where students present ideas or give/receive feedback.	1	2	3	4
39. Organize and facilitate a student-led activity.	1	2	3	4
40. Provide students with in-depth guidance on the content or organization of their work.	1	2	3	4
41. Answer procedural questions individual or group work and/or help students stay on task	1	2	3	4
42. Ask open-ended questions to promote engagement with big ideas.	1	2	3	4
43. Give written feedback on student work	1	2	3	4
44. Give oral feedback on student work	1	2	3	4
45. Have students explore alternative methods for solving/conducting investigations.	1	2	3	4
46. Modify or adjust instruction based on informal classroom assessments.	1	2	3	4
47. Model for students how to approach a problem or task.	1	2	3	4
48. Use technology to personalize instruction.	1	2	3	4
49. Differentiate activities or instruction to meet individual student needs.	1	2	3	4
50. Make connections between content and/or activities and students personalized learning plans of pathways.	1	2	3	4

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