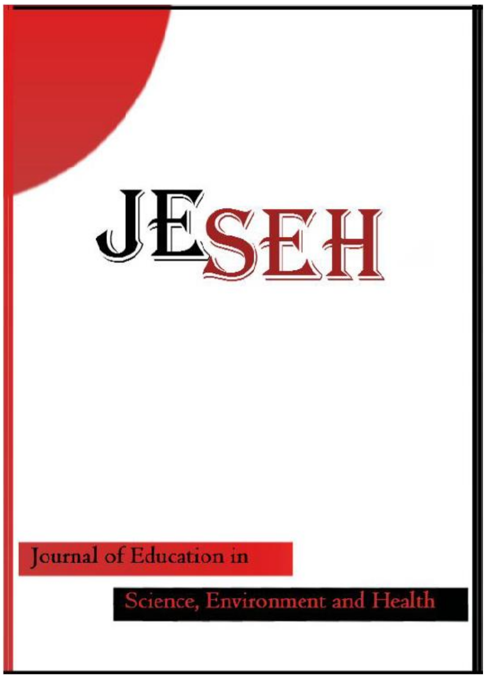

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Conceptual Change Inquiry Curriculum and Traditional Lecture Approach: Preservice Teacher’s Perceptions of Learning

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Abstract

A quasi-experimental treatment control group design was used to investigate the effect of a conceptual change curriculum, Multi-Step Inquiry approach, on students’ perception of their learning in a science classroom. This started with the development of a workbook that explicitly focused on conceptual understanding, followed by the development and validation of an inventory to explore students’ perceptions of learning. Interpretation of data involved the use of inferential and descriptive statistics. The inferential statistics included *t*-tests, ANOVA, Pearson correlations, and regressions. Cohen’s *d* effect sizes facilitated further interpretation of the data. The analysis shows potential for the Multi-Step Inquiry to improve students’ perceptions. These results provided room for recommendations for both research and teaching.

Introduction

The Next Generation Science Standards (NGSS) has proposed that American science education must put little focus on rote memorization while encouraging understanding and application as opposed to memorization of facts devoid of context (NGSS, 2013). According to NGSS, it is not just the content that matters, but how that content is obtained and applied. This is possible when students have sufficient opportunities to interact with the content in a meaningful way. One way to ensure that students have opportunities to effectively interact with learning materials is by teaching through inquiry. According to the National Research Council (NRC-Olson & Loucks-Horsley, 2000), in an inquiry class, students have opportunities to respond to scientific questions, obtain evidence through investigations, and explain and defend their explanations. In all this, the students are building up their communication skills. Therefore, inquiry teaching is a convincing tool to better fulfill the goals of the NGSS because students obtain knowledge while also making connections between the disciplinary core ideas, and the scientific and engineering practices.

Elementary teachers have a vital role of ensuring the effective implementation of the NGSS. As such, science educators entrusted with training these teachers need to find innovative ways to prepare the teachers for their job. This starts with providing modeling of effective instruction in the science classes for the pre-service teachers (PSTs). PSTs who experience effective inquiry instruction are likely to continue this with their students. In this study, we developed an inquiry approach termed Multi-Step Inquiry (MSI), specifically for conceptual change. The Multi-Step inquiry has the following features: (1) explicit discussion of misconceptions, (2) development of an investigation to address the misconceptions, (3) experimentations, (4) discussion of the concepts for the second time, and (5) writing misconception focused essays. This paper, therefore, is the evaluation of the effectiveness of this approach on improving pre-service teachers’ perception of learning of science.

Conceptual Change

Marton and Säljö (1976) describe learning as either surface or deep. In surface learning, the focus is on rote memorization and there is a lack of connections among learned content, while in deep learning, the focus is on critically examining information and making necessary connections among content parts (Houghton, 2004). Haitte (2012) asserts that though rote memorization can be the foundation for some content, teachers must strive to get their students a deeper understanding of the content. Further, Lombard (2018) acknowledged the interdependence between effective learning and active learning. In this case, students must actively gain knowledge through answering deep questions, conducting meaningful hands-on activities, and reflecting on the meaning of these activities. Following are the behaviors that are prevalent in active learning.

1. Learning involves the active construction of meaning by the learner.
2. Learning facts ("what"– declarative knowledge) and learning to do something ("how"–procedural knowledge) are two different processes.
3. Individuals are likely to learn more when they learn with others than when they learn alone.
4. Meaningful learning is facilitated by articulating explanations, whether to oneself, peers, or teachers. (Michael, 2006).

According to Hewson (1992), conceptual change can mean that a learner has changed his or her mind or the material has made more sense to that learner. This is only possible when the student actively interacts with the learning materials. Conceptual change involves exchanging an existing idea with a new scientifically acceptable idea. This will be impossible if the student does not believe in this new idea. Posner and colleagues describe three important processes that may lead to an effective conceptual change:

1. there must be dissatisfaction with existing conception,
2. the new conception must be intelligible, and
3. the new concept must appear initially plausible (Posner, Strike, Hewson, & Gertzog, 1982).

As a result of the steps proposed by Posner et al. (1982), students are better confronted with information that can challenge their existing ideas only by actively participating in the learning process. Rote learning, whose hallmark is a teacher telling a passively listening student to memorize information, can become less believable in the mind of that student. Instead of students saying, 'our teacher said so', they should say, 'we understand it that way.' Therefore, it is crucial that students have a better perception of their learning in a conceptual change curriculum. For example, Ramaila and Ramnarain (2014) asked students about their perceptions of various types of learning indicating deeper and surface approaches. The deeper approaches included, "intention to understand oneself, relating ideas (constructive learning), and use of evidence" while the surface approaches include "memorizing without understanding, unreflective studying and fragmented knowledge, and unthinking acceptance" (p. 444). Students had higher scores for the deeper approaches than the surface learning approaches.

Koon and Murray (1995) assert that indicators of learning are not restricted to conceptual understanding but also to students' perceptions of the learning itself. Important indicators of students' perceptions include their perception of improved critical thinking, and interpersonal and intrapersonal capabilities among others (Koon & Murray, 1995). Research has shown that students' perceptions usually positively correlate with other learning outcomes in both cognitive and affective domains (Fraser, 2015). As a result, improving students' perceptions of their learning may also improve these other learning outcomes. This calls for teachers to develop curriculums that will enhance students' perception of their learning and the learning process.

Studies about Students' Perception

Improving learning outcomes is the major goal of education. One way this can be done is by ensuring that students have a positive perception of their learning. There has been ongoing research that has investigated the association between students' perceptions and other learning outcomes. Studies have shown relationships between students' perceptions and classroom performance (Ahmed, Taha, Al-Neel, & Gaffar, 2018; Odutuyi, 2012). Odutuyi (2012) found that the students' perceptions of the nature of teacher-student interaction patterns in high school chemistry were positively associated with classroom performance. The same study also showed that there was a significant positive association between students' perceptions and attitudes toward chemistry. Ahmed et al. (2018) similarly found a positive association between students' perceptions and academic performance in a cross-section of high school grades. Ahmed et al. (2018) proposed intrinsic elements found in positive students' perceptions, such as motivation and better study habits, as the factors that affected performance. Lizzio, Wilson, and Simons (2002) stated these sentiments earlier through their study, which found that students with more positive perceptions had deeper approaches to studying than those with negative perceptions of their learning environment. Further, An, Hannum, and Sargent (2007) found that students perception of classroom engagements had a positive significant correlation with engagement and performance.

They further found that students who had positive perception of their classroom engagement had less disciplinary problems.

Researchers have worked to improve students' perception of their learning. For example, Majerich and Schmuckler (2007) compared an active inquiry using demonstrations to traditional lecture with fewer demonstrations. These authors found that students had better perceptions of the inquiry than the traditional lecture class. Further, Rahman, Sarkar, Gomes, and Mojumder (2010) found that students liked cooperative and collaborative learning environments because these environments "provide students more opportunity to work deeply, increase the quality of work because the task can be distributed according to individual's skill, and make students co-construct their ideas, hence a clarity in understanding is possible" (p. 39). Duran, McArthur, and Van Hook (2004) investigated the impact of an inquiry college physics class on students' perceptions and found significantly more positive perceptions than those in the traditional lecture class. Another study by Hoskins and Gottesman (2018) used "CREATE (Consider, Read, Elucidate hypotheses, Analyze and interpret the data, Think of the next Experiment)" (p. 1) instructional approach to improve students' perceptions of a biology course. There was a significant shift from novice-like views to expert-like views within a semester of using CREATE. Similarly, Kazempour, Amirshokoohi, and Harwood (2012) instituted an inquiry in an undergraduate biology course, which enhanced students' perceptions. For instance, students indicated that they had a better understanding of the scientific process and the inquiry part improved their skills in collaboration work. These results agree with those by Lee and Kim (2018) who found that students had a better perception of learner-centeredness in a flipped inquiry classroom, characterized by academic debates, and observed significant changes in perceptions of both higher and lower-performing students. Further, Treesuwan and Tanitterapan (2016) found that students felt that learner-centered approaches encouraged interactions among students and improved their confidence in discussing their understanding with peers. In this study, we developed a Multi-Step Inquiry approach to improve learning outcomes such as students' perceptions of their learning of science. We, therefore, investigated the impact of the Multi-Step Inquiry on students' perceptions of learning in a science classroom. We further investigated the relationship between students' perceptions and conceptual understanding. We answered the following research questions:

- What is the impact of the MSI on students' perceptions of learning in a science classroom?
- What is the influence of perceptions and prior knowledge on students' conceptual understanding?

Method

The Intervention

For an intervention, we used an instructional module that focused on dealing with misconceptions. In this module, the misconceptions were discussed at the beginning and the end of the lesson. In between these discussions, inquiry activities were conducted to address these misconceptions. The inquiry activities involved developing investigations to address the misconceptions and carrying out these activities. The instructional module covered three physical science topics: (1) forces and motion, (2) heat and temperature, and (3) electricity. To cement conceptual understanding, students were given a list of misconceptions and asked to research and write about these misconceptions. A complete description of the MSI can be found in (Mataka & Taibu, 2020).

In the control group, the instructors taught using power point, experimentation, and group discussions. However, there was little emphasis on specific concepts in these group discussions. To elicit students' understanding of specific concepts, the instructor proceeded by emphasizing whole-class discussions. Unlike in the treatment group, the control group did not use the misconceptions instruction module. Nevertheless, the contact time between the two groups was almost similar. We will use the introduction of free fall as an example. Students were given several questions that elicited misconceptions about free fall. These questions were discussed in groups and each group came up with responses to these questions. Then the students were asked to plan an experiment that would help them answer some of the questions. The teacher guided the planning process. In the end, the teacher provided the students will balls of different masses and asked them to plan how they could use those balls to investigate the concept of free fall. The students planned their experiment with assistance from the teacher. After carrying out the experiments, each group presented to class their findings and a class discussion ensued. Then the class watched a YouTube video on free fall, followed by a demonstration of free fall from the instructor using a vacuum tube. Later, the students worked on detailed questions in their groups to check their understanding. At the end of the unit, the students wrote an essay that included several questions on free fall as shown in table 1. The traditional approach in the control group involved power point presentations by the instructor, experimentations, and group discussions of lab activities and specific concepts after the presentation, and students writing individual assignments. Notable differences were that no conception essay assignments were available. Instead, students were assigned a homework activity. Further, students were not required to discuss ways to investigate their conceptions, and there were no individual group discussions of specific conceptual questions. Instead, the instructor sought understanding from the whole class through verbal questions and from individuals using a short in-class assignment. Further, this section did not use the prepared misconception module. An effort was made to ensure an equal amount of contact time for both groups. Table 2 distinguishes the two instructional approaches for the two groups. These two approaches are described in table 1. The first author taught both treatment and control classes in Fall 2017, Spring and Fall 2018, and Spring 2019.

Table 1. Instructional approaches between experimental and control classes

Activities	Control	MSI
Preview discussions	• Whole class check of general previous knowledge through instructor oral questioning. • The questions focus on science misconceptions. • Teacher gets answers from different students. • Teacher introduces the day's activities	• Individual group discussions of written conceptual questions. • Group presentation of their conception to the whole class • In these presentations, students provide reasons for their answers. • Groups are asked to propose investigations that can help answer the conceptual question under consideration.
Experimental activities	• Students get involved in activities including experiments, demonstrations, or YouTube videos.	• Students are engaged in experiments, demonstrations, or YouTube videos specifically tailored to addressing misconceptions.
Post activities	• Groups present their results and conclusions to the whole class • Class summarizes the findings • The teacher verbally asks questions related to important concepts from the experiment to individuals in the class. • Teacher presents a PowerPoint addressing important concepts of the lesson. • Students write a short in-class assignment that addresses the class activity and check their changes in conception.	• Groups present their results and conclusions to the whole class • Class summarizes the findings • Another group discussion, revisiting the previous conceptual questions • Groups reflect on any changes to their earlier conceptions as they discuss. • Individual group discussion of added conceptual questions with teacher guidance • Whole class discussion of conceptual questions.
Essay	• A written individual homework assignment	• Conceptual essay

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The Instrument

We developed an instrument called "Perceptions of Learning" (See Appendix) based on the literature review that describes what skills and knowledge students must learn (Houghton, 2004; Lombard, 2018; Majerich &

Schmuckler, 2007). We also looked at other evaluation surveys like those created by the Foundation for Critical Thinking (https://www.criticalthinking.org/). The 'Perceptions of Learning' items were intended to measure students' views about learning in the physical science for PSTs class. When developing the instrument, the authors thought about what an effective classroom would look like. An effective classroom is where a student is able to understand the material being taught and teachers encourage the students to demonstrate this understanding. According to Houghton (2004), an effective classroom must have "clear goals and intellectual challenge; independence, control and active engagement; and learning from students" (p. 6). Baker, Miller, and Timmer (2018) also put appropriate student engagement as part of an effective classroom. Therefore, an effective classroom is where students can demonstrate understanding by answering open-ended questions, being given a chance to teach their colleagues, being able to provide reasons for their responses. Students can be engaged with the material individually or with colleagues. In an effective classroom, the students must feel that they have opportunities to learn on their own but also collaboratively (Michael, 2006). Therefore, the instrument has questions related to students' engagement. Further, Stern and Algren (2002) proposed that science curriculum assessments must focus on students' understanding and how the instructional activities address the goals of the class. Students must feel confident about their understanding of the material. Therefore, this instrument has questions that focus on students' views of their understanding and application. In addition, Barr (2016) asserts that an effective learning environment encourages involvement, satisfaction, and individualization. This implies that students must actively participate in instructional activities while enjoying the class and being independent. As a result, the instrument has focused on students' perceptions of their conceptual understanding, ability to apply, ability to work collaboratively, and the suitability of the materials for the course. All these activities align with a theory proposed by Kearsley and Shneiderman (1998), Engagement Theory, which defines engaged learning where "student activities involve active cognition processes such as creating, problem-solving, reasoning, decision making, and evaluation" (p. 20). Engagement theory further encourages instruction that provides meaning to the material being learned. These are issues being addressed by the instrument.

One of the researchers developed the instrument and sent it to the co-researcher to make suggestions. The instrument was then later sent to two science educators for face validity. Then we used the instrument to collect data from 72 participants in Fall 2017, Spring and Fall 2018, and Spring 2019 semesters. All the Institutional Review Board (IRB) processes were addressed. After collecting the data, we investigated how variables within the instrument related to the constructs that we sought using confirmatory factor analysis. The analysis came up with three factors that we named, (1) Individual Learning and Application (ILA), (2) Higher-Order Learning (HOL), and (3) Views on Group Engagement (VGE). We used varimax rotation for loading because we wanted to maximize the variance of the loadings and also its popularity (Abdi, 2003). Using the Varimax rotation, nine items out of eighteen loaded on factor 1, five items loaded on factor 2, and four items loaded on factor 3. Table 2 shows the factor loadings.

Table 2. Factor analysis

Item #	ILA	HOL	VGE
1	0.734		
2	0.714		
3	0.576		
4	0.691		
5		0.684	
6			0.664
7			0.714
8		0.746	
9		0.768	
10		0.722	
11			0.540
12	0.723		
13	0.650		
14			0.751
15	0.643		
16	0.663		
17	0.700		
18		0.590	
Alpha	0.90	0.87	0.80

We also tested the reliability of the instrument and found a Cronbach's α of 0.93. Further tests of each factor resulted in the alpha value of 0.90 for factor 1, 0.87 for factor 2, and 0.80 for factor 3, all of which are acceptable. We further tested the items using a split-half correlation with Spearman-Brown Correction. The correlation coefficient between even and odd items was 0.90. After the Spearman-Brown correction, the correlation coefficient changed to 0.95, which is high. This shows that the instrument strongly measures what it is intended for. We collected data on student conceptual understanding (pre and post) using a concept inventory developed by the Mataka and Taibu (2020)

Participants

We used convenience sampling for our research because data were collected from students who attended a physical science class for pre-service teachers. Seventy-two pre-service elementary teachers from a Northwestern USA college participated in the study. Over 90 percent of the participants were female. These participants enrolled in a physical science class for pre-service elementary teachers at this college during Fall 2017 (N = 22), Spring 2018 (N = 16), and Fall 2018 (N = 20) and Spring 2019 (N = 14) semesters. As a result, the sample was convenient. The control group came from Fall 2017 and Spring 2019, while the treatment group came from Spring and Fall 2018. The participants had very little background in college science but were introduced to physical science in middle and high school. Of these participants, 36 were in the experimental group and 36 were in the control group. We sought human subject review board approval to ensure adherence to proper research ethics.

Data Analysis

We analyzed the data using Minitab. Data analysis involved the use of both descriptive and inferential statistics. Kolmogorov-Smirnov test was used to establish the normality of the data while Levene's test established equality of variances. Pearson correlation was used to show relationships among different variables, while multiple regressions were used to show the influence of predictors.

Results and Discussion

Comparison of Perceptions between Experimental and Treatment Groups

To fulfill the requirements of parametric tests, we used Kolmorov-Sminorv (KS) tests to check for normality of data. The KS value was 0.08 (*p* = 0.63), indicating a normal distribution, and consequently justified the use of parametric analysis. We then used Levene's test to determine score variances for the experimental and control groups. Based on this test, the two groups had equal variances (*p* = 0.21). Therefore, the two groups were compared using independent *t*-tests assuming equal variances. Table 3 presents the mean scores, the *p*-value, and Cohen's *d*. Note that the total score for a given completed survey was computed by adding up the Likert scale numbers circled by a particular student. Based on the *t*-test, the experimental group had significantly higher perceptions mean score than the control group (*t* = 2.95; *p* = 0.004). A large Cohen's *d* (*d* = 0.70) shows that this difference also had practical significance.

Table 3. Control and treatment groups' mean Perception of Learning scores

Group	N	Mean (out of 90)	SD	t	p	d
Experimental	36	71.14	9.28	2.95	0.004	0.70
Comparison	36	63.50	12.44			

As stated earlier, the analysis of the Perceptions of Learning instrument resulted in three factors: ILA, HOL, and VGE. Table 4 presents the mean scores of each of the three categories for the treatment and control groups. We tested to determine if there were any differences in the way students responded to each of the three categories using one-way ANOVA. Results indicate that there was no significant difference among the three mean scores for the control group (F = 3.08, $p > 0.05$). A significant difference was observed for the treatment group (F = 4.04, $p < 0.05$). A Bonferroni posthoc test indicated that experimental group students had significantly higher perceptions about group engagement (VGE) than individual learning and application (ILA), and higher-order learning attributes (HOL).

Using the same table, we conducted an analysis to determine if there is a difference between the treatment and the control groups in each of the three categories. The treatment group had higher perceptions in all three categories than the control group. The *t*-test showed that these differences were significant in all three categories.

Table 4. Comparisons based on test categories (Mean scores are out of 5)

	Control	Treatment	*t*-test *p*-value
ILA	3.44 ± 0.71	3.87 ± 0.56	< 0.05
HOL	3.43 ± 0.88	3.89 ± 0.60	< 0.05
VGE	3.84 ± 0.77	4.22 ± 0.61	< 0.05
ANOVA *p*-value	> 0.05	< 0.05	

Relationships among prior Knowledge, Students' Perceptions, and Conceptual Understanding

It is important to understand the implication of higher perceptions toward other important outcomes in a science classroom. As such, we carried out an investigation to determine if there is a relationship between perceptions and conceptual understanding. In this case, we collected pre- and post-tests to measure conceptual understanding. Then we used Pearson correlations to investigate the following relationships: prior knowledge (pre-test) and the posttest, perceptions and the post-test, prior knowledge and the conceptual change, and perceptions and the conceptual change. The conceptual change score is a result of the subtraction of the pretest score from the posttest score. Table 5 shows the results of multiple correlations. The results show there was a significant positive relationship ($r = 0.35$) between prior knowledge and the post-test performance. However, there was a nonsignificant negative relationship ($r = -0.23$) between prior knowledge and conceptual change. The results further showed a positive and significant ($r = 0.36$) relationship between perceptions and the post-test. This indicates that students with higher perceptions of their learning had higher post-test and conceptual change scores.

Table 5. Pearson correlations

	Pretest	Perceptions	Post-test	Conceptual change
Pretest	1			
Perceptions	-0.001	1		
Posttest	0.35**	0.35**	1	
Conceptual change	-0.23	0.36**	0.83**	1

**The relationship is significant

The Predictive Influence of Perceptions' and Prior Knowledge's on Conceptual Understanding

We investigated relationships between the two predictors; perceptions and prior knowledge, to the posttest score, and the same predictors to the conceptual change using regression analysis. In both cases, perceptions and prior knowledge are our independent variables while the post-test and conceptual change are our dependent variables. Table 6 shows the results of the regression model. The adjusted R-squared ($R^2 = 0.22$) indicates that the model explains 22% of the variance in posttest performance. This means that the combined effect of prior knowledge (pretest) and students' perceptions accounted for 22% of the variances in posttest performance. The beta coefficient for perceptions ($\beta = 0.43$, $p < 0.05$) shows that for every unit increase in students' perceptions, posttest performance increases by 0.43 points. Further, the beta coefficient for prior knowledge ($\beta = 0.61$, $p < 0.05$) shows that for every unit increase in prior knowledge, the posttest performance increases by 0.61 units. The results show that perceptions have a significant positive association with post-test performance when the prior knowledge (pretest score) is held constant. A similar, association is observed between prior knowledge (pretest score) and the post-test performance when perceptions scores are held constant.

Table 6. Posttest scores using predictors perceptions and prior knowledge

Term	Coefficient	SE Coeff	t-value	P-value	Adj R-sq
Constant	6.47	3.38	1.91	0.060	0.22
Perceptions	0.43	0.13	3.30	0.002	
Prior Knowledge	0.61	0.18	3.37	0.001	

Table 7 shows the results of a regression model for conceptual change when perceptions and prior knowledge are predictors. The adjusted R-squared ($R^2 = 0.16$) indicates that the combined effects of perceptions and prior knowledge account for 16 percent of the variance in conceptual change. The beta coefficient for perceptions ($\beta = 0.43$, $p < 0.05$) shows that for every unit increase in students' perceptions, conceptual change increases by 0.43 units. In contrast, the beta coefficient for prior knowledge ($\beta = -0.38$, $p < 0.05$) shows that for every unit increase in prior knowledge, the posttest performance decreases by 0.38 units. The results thus show that perceptions have a significant positive association with conceptual change while prior knowledge has a significant negative association with the conceptual change.

Table 7. Conceptual change using predictors attitude and prior knowledge

Term	Coefficient	SE Coeff	t-value	P-value	Adj R-sq
Constant	6.47	3.38	1.91	0.060	0.16
Perceptions	0.43	0.13	3.30	0.002	
Pre	-0.39	0.18	-2.11	0.038	

Discussion

Looking at the results, a significant difference was observed between the treatment and control groups. Further, the observed large effect size ($d = 0.7$) indicates that this difference also has practical significance. This study has shown that students taught using MSI had a better perception of their learning in the science classroom than those taught using the traditional approach. This is likely because the MSI provided a challenging environment for the students and enabled them to take ownership of the learning process. The MSI involved activities that encourage meaningful conceptual change (Mataka & Taibu, 2020) by letting the students explore concepts, develop an investigation to address misconceptions, carry out the experiment, and revisit the concepts. Further, giving students a chance to discuss these concepts in the essay form solidifies their understanding. Therefore, this observed improvement is unsurprising. In addition, students in MSI were given opportunities to collaborate with colleagues in making sense of the activities. As observed by Rahman et al. (2010), collaborative and cooperative environments enable students to distribute work based on skills and thus enhance understanding. Results from this study align with others who found that various forms of inquiry improved students' perceptions (Hoskins & Gottesman, 2018; Kazempour, Amirshokoohi, & Harwood, 2012; Majerich & Schmuckler, 2007; McArthur & Van Hook, 2004). Further, Houghton (2004) stated that providing intellectual independence and letting students learn from each other can improve their perceptions. In the conceptual change curriculum used in this study, students were allowed to explore concepts individually through conceptual essays and individual class activities while also collaboratively working on classroom problems. This enabled students to become independent while also learning from each other. This observation can also be, as Barr (2016) stated, a result of students' satisfaction with their learning environment due to being given opportunities to work with the learning materials individually and collaboratively. Further, the activities in the conceptual change inquiry course provided students with deeper and meaningful learning. Ramaila and Ramnaria (2014) found that students had a higher perception of deeper learning than surface learning. This may add to the observed improvement in the conceptual change inquiry in this study. In addition, the instructional approach used in this study may have improved students' interactions and confidence in their own learning as observed by Treesuwan and Tanitterapan (2016).

Looking at the results of factor analysis, three factors were observed. The factor analysis provided a chance to compare students' perceptions based on these three different categories; ILA, HOL, and VGE. There was no significant difference among the three factors in the control group based on ANOVA. However, a significant difference was observed in the treatment group; specifically, students had better views of group engagement (VGE) than the individual learning (ILA) and higher-order learning attributes (HOL). This is expected because the MSI focused on group interactions as the students engaged in the activities. Unsurprisingly, the treatment group performed significantly better than the control group in all three categories.

Results of the correlation studies show that, indeed, perceptions have a positive significant relationship with both conceptual understanding and change in conceptual understanding. We also investigated the relationship between prior knowledge, conceptual understanding, and change in conceptual understanding. Although prior knowledge had a significant positive correlation with conceptual understanding, there was a nonsignificant negative correlation with conceptual change. Further, regression studies indicated that students' perceptions had a significant positive contribution to both conceptual understanding and conceptual change. Prior knowledge, however, had a significant positive contribution to conceptual understanding only. A significant negative contribution was observed between prior knowledge and conceptual change. This is unsurprising because students who already know the material will tend to have a smaller increase in knowledge than those who know less. It also means that students who performed poorly during the pretest were able to close the gap with their colleagues. These results also imply that students' perceptions are more important in predicting changes in conceptual understanding than prior knowledge. This is likely due to the enthusiasm to learn that comes with positive students' perceptions. Students with positive perceptions would likely put more effort into the learning process and are more likely to improve their conceptual understanding. This aligns with the conclusion by Ahmed et al. (2018) who suggested that intrinsic elements found in positive students' perceptions, such as motivation and better study habits, are the factors that affect performance. This is echoed by Lizzio, Wilson, and Simmons (2002) who found that students with more positive perceptions had deeper approaches to studying than those with negative perceptions of their learning environment. These results also show that providing students a favorable learning environment can result in improvement in their perception of learning regardless of prior knowledge.

Recommendations

This study enhances the need for innovating inquiry teaching approaches that can improve students' perceptions of their learning. The study has shown that MSI is one of those techniques that has been shown to enhance students' perceptions. Furthermore, the study has shown why it is crucial to improve students' perceptions. The contribution of perceptions to both conceptual understanding and conceptual change provides a way for teachers to find effective approaches that can enhance students' understanding. In addition, the instrument in this study can be used to obtain information about students' perceptions of their learning and thus help both science education researchers and teachers understand their students better.

Limitations

This research occurred through several semesters to ensure that a relatively larger sample was obtained. Researchers, thus, tried their best to ensure that students were given similar experiences based on whether they were in treatment or control groups.

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Appendix

Name____ Date_____________

Perceptions of Learning

Rate the activities on a **five-point** scale depending on how much they helped you as follows.
1 (Not much) -------- 5 (Very much)

No	Statement	Rating				
1	To what extent did the class activities improve your learning?	1	2	3	4	5
2	To what extent did the class activities make you change your understanding of science concepts?	1	2	3	4	5
3	To what extent can you apply the knowledge you have learned using activities in this class?	1	2	3	4	5
4	To what extent can you teach someone based on the activities in this class?	1	2	3	4	5
5	To what extent did the materials encourage independent learning?	1	2	3	4	5
6	To what extent did the activities encourage thinking?	1	2	3	4	5
7	To what extent did the activities enable you to communicate your understanding to your colleagues?	1	2	3	4	5
8	To what extent did the activities encourage questioning skills?	1	2	3	4	5
9	To what extent were the activities able to make you distinguish what you know from what you don’t know?	1	2	3	4	5
10	To what extent did the activities encourage synthesis of information.	1	2	3	4	5
11	To what extent did the class activities encourage your engagement in class?	1	2	3	4	5
12	To what extent did the class activities provide opportunities for making sense of the science activities?	1	2	3	4	5
13	To what extent can you describe the materials as learner centered?	1	2	3	4	5
14	To what extent did the activities encourage collaborative (group) work?	1	2	3	4	5
15	How do you rate the effectiveness of activities in this class?	1	2	3	4	5
16	How appropriate are the activities for this class?	1	2	3	4	5
17	How likely are you to use some of these activities in your future endeavors?	1	2	3	4	5
18	How did the activities meet the goals of the class?	1	2	3	4	5