Journal of Turkish Science Education, 2022, *19*(2), 622-640.
DOI no: 10.36681/tused.2022.141

Journal of Turkish Science Education
http://www.tused.org
© ISSN: 1304-6020

Conceptual Change Framework of Instruction (CCFI): An Instructional Model in Teaching Eclipses

Naomi Madaiton[1], Maria Eloiza Tomaquin[2], Eric Jhay Visitacion[3], Jenny Rhea Villaver[4], Jea Marie Malingin[5], Sherwin Nacua[6], Dharel Acut[7], Marchee Picardal[8]

[1]*College of Teacher Education, Cebu Normal University, Philippines,* ORCID ID: *0000-0002-7791-1131*
[2]*College of Teacher Education, Cebu Normal University, Philippines,* ORCID ID: *0000-0001-6738-9629*
[3]*College of Teacher Education, Cebu Normal University, Philippines,* ORCID ID: *0000-0002-2983-7571*
[4]*College of Teacher Education, Cebu Normal University, Philippines,* ORCID ID: *0000-0003-3154-1400*
[5]*College of Teacher Education, Cebu Normal University, Philippines,* ORCID ID: *0000-0003-0961-1310*
[6]*College of Teacher Education, Cebu Normal University, Philippines,* ORCID ID: *0000-0002-9866-4977*
[7]*Sotero B. Cabahug FORUM for Literacy, Cebu, Philippines; DOST-National Research Council of the Philippines (Division VIII), Philippines, dharel.acut@g.msuiit.edu.ph,* ORCID ID: *0000-0002-9608-1292*
[8]*College of Teacher Education, Cebu Normal University, Philippines; DOST-National Research Council of the Philippines (Division I), Philippines*, ORCID ID: *0000-0002-7257-6776*

ABSTRACT
A wide array of conceptual change strategies attempted to address students' persistent alternative conceptions, yet there remained ubiquitous struggles of teachers teaching abstract and highly contentious science concepts. This study investigated the effectiveness of the novel Conceptual Change Framework of Instruction (CCFI) in teaching eclipses among Grade 7 learners (n:40) in a private school in Cebu, Philippines. Using an embedded mixed-method design, a pretest-posttest method with the integration of a two-phased semi-structured interview with students measured the extent of the effect of an intervention on students' understanding, conception, and learning experiences. Quantitative results suggested that students' level of understanding significantly improved after exposure to the instructional model, as evident in their mean gain scores. Students in the experimental group scored above the passing grade compared to those in the control group. Moreover, thematic analysis revealed that students' demonstrated a conceptual change in their conceptions of eclipses from naïve understanding to scientifically accurate concepts. They also signified the efficacy of the CCFI in facilitating positive learning experiences through various engaging teaching strategies. Thus, science teachers may consider the use of CCFI among the array of instructional models in teaching science concepts to enhance conceptual understanding and positive learning experience.

ARTİCLE INFORMATION
Received:
21.08.2021
Accepted:
07.04.2022

KEYWORDS:
Conceptual change, instructional model, conceptual understanding, science education, astronomy education.

To cite this article: Madaiton, N., Tomaquin, M.E., Visitacion, E.J., Villaver, J.R., Malingin, J.M., Nacua, S., Acut, D. & Picardal, M. (2022). Conceptual change framework of instruction (CCFI): an instructional model in teaching eclipses. *Journal of Turkish Science Education*, *19*(2), 622-640.

Introduction

Learning abstract and highly contentious science concepts such as astronomy requires reconstruction of counterintuitive conceptions to a more robust scientific conceptual understanding.

One of the challenges in science education is the conceptualization of students' full understanding of science concepts presented to them. In astronomy, for example, difficult terms often lead to poor understanding (Konicek-Moran & Keeley, 2015). Essential astronomical concepts (i.e., eclipses) play a significant role in thoroughly understanding the nature of science that allows rational thinking to make them lifelong independent learners (Slater & Gelderman, 2017). As a subject taught in schools, astronomy is difficult for students because it requires them to comprehend and acquire abstract understanding of the dynamic and interdependent relationships of the things and events that occur in a multidimensional space (Barnett et al., 2013). Construction of essential conceptual understanding can be influenced by various factors such as complexity and level of difficulty of the subject (Barnett et al., 2013), types of instructional materials and students level of engagement (Karsh & Patan, 2016), and personal beliefs and students' prior knowledge (Dorsah & Okyer, 2020). All these factors may contribute to the development of alternative conception. An alternative conception is an idea, understanding and view of an individual about something that is not congruent to the widely accepted scientific meaning (Slater et al., 2018) of which students may have had prior to entering schools (Türk et al., 2012). These cognitive structures and experiences may impede the assimilation of new concepts (Gafoor & Akhilesh, 2010) by students.

A person makes sense of his world by providing explanations to interpret what is happening around him in a way that is consistent with his own experiences and what he knows (Slater et al., 2018). Students' perceptions on topics related to Astronomy have piqued the interest of numerous scholars because of its ability to depend on students' first-hand observation and the information provided by others (Bernstein, 2013). Interestingly, students usually have to rely on what others tell them rather than their first-hand observation on some topics in this field because learning astronomical concepts goes beyond what we see in our naked eyes. Topics such as the formation of the universe, the tilt and rotation of the earth, the phases of the moon and eclipses to name a few have remained contentious to students' understanding (Bernstein, 2013). Students fail to establish a conceptually cohesive interpretation of eclipses (Kavanagh et al., 2005) and it persists even after they have reached higher education (Pundak, 2016). Comins (2001) revealed that many of his students in college misunderstood the reason for lunar phases and the occurrence of eclipse, assuming that lunar phases are triggered by the Earth's shadow.

Conventionally, at various stages in the K-12 curriculum, teaching topics concerning the origin of the phases of the moon and the existence of eclipse used meticulously designed examples and diagrams (Barnett & Morran, 2002). However, a large number of learners were unable to grasp the occurrence of the eclipse by the time they left traditional schools. In such a situation, educators are compelled to consider alternative methods of teaching these principles (Prather et al., 2004). Layng (2013) suggested that it has to be guided with examples and properties of a particular concept. Some went as far as designing instruction to assess students' awareness and remove myths regarding the umbra, eclipses, and moon phases (Karsli & Patan, 2016). Unfortunately, students may have developed intuitive and explanatory framework about these phenomena before the formal lesson in school, which makes it a barrier to full scientific conception. To illustrate, it has been a prevailing superstitious belief among some Filipinos in the countryside that watching an eclipse while a woman is pregnant would cause harm to the baby which was not proven to be true at all (NASA, 2017). Even now, with all the wide and sophisticated available information, some people still believe that this is true. Folkloric tales about a moon-eating dragon called "Bakunawa" said to eat the moon during lunar eclipses has caused serious misconceptions among students that persists even up to the present. Across educational levels, the most commonly held alternative conception is the eclipse model used as a tool to understand the phases of the moon (Nazé & Fontaine, 2014). Yalcin et al., (2012) found out that students have particularly faced difficulties in understanding the mechanism behind lunar phases and lunar eclipse. In another study of Karsli & Patan (2016), students revealed their alternative conception about lunar eclipse such that the sun is located in the middle of the earth and the moon. It is evident that alternative conceptions exist and they must be addressed early on (Karsli & Patan, 2016). These ideas do not just hinder learning, but could also mix up with new knowledge that can create a confusing outcome (Dorsah & Okyer, 2020).

Among the greatest challenges of education is being able to establish a full conceptual understanding rather than a partial and shallow recognition of subject matters that are susceptible to misconceptions (Taber, 2019). Acut & Latonio (2021) utilized stellarium-based activity to improve Grade 11 students' performance in topics related to astronomy. The strategy held promising results on students' understanding of the motion of celestial bodies such as the sun, moon and stars as they rise, navigate the sky, and set. Dorsah & Okyer (2020) found out that students' personal belief and alternative conception of science concepts have affected students' conceptual understanding on certain topics, including the study of eclipses. Exposure to a more engaging, fun and interactive learning environment (Karsli & Patan, 2016) and fostering collaboration and communication among students can enable them to develop deeper understanding of the topic contrary to memorizing facts (Barnett et al., 2013). Thus, teachers must be able to develop teaching practices that would encourage collaboration and interaction among students in learning eclipses. Moreover, if students were able to perceive the importance of the subject matter to them and how this knowledge could be applied to practical situations, it would increase students' positive attitude towards learning the topic and eventually lead to improved learning abilities (Karsli & Patan, 2016).

Among the leading instructions and methods used to eliminate misconceptions of science concepts is the conceptual change approach. Students' prior knowledge of a concept has a lot to do with their learning process. Hence, recognizing the conceptual structures of students when planning for classroom activities and teaching strategies is imperative (Gafoor & Akhilesh, 2010). Teachers must not only think of how to teach the topic, but must also take into account what students already know about the topic. Conceptual change is rooted from Thomas Khun's "paradigm shift" on the history and philosophy of science in 1962. A learning process that involves changes of an existing conception which serves as the starting position for the construction of accurate and strong scientific understandings (Barnett et al., 2013). Conceptual understanding has varying definitions. Mills (2016) defined it as the ability of the students to form and combine meaningful and functional integrated ideas and facts as opposed to rote memorization. It characterizes students being able to acquire knowledge that is sufficient for transfer from what is learned inside the classroom to the multi-faceted world (Moser & Chen, 2016). On a more holistic perspective, Vosniadou & Mason (2012) attributed conceptual understanding to a change of attitude and values related to a particular concept that has the tendency to arouse strong emotions, personal perceptions and biases. Ultimately, this kind of instruction has a significant impact on how well the students understand a concept and explain a particular phenomenon (Konicek-Moran & Keeley, 2015). Learning is effective and enduring when learners are able to recognize the significance and apply the lesson to the real world.

Several researches have suggested that when students are facilitated through a conceptual change instruction framework with the aid of 3-D models and engaging simulation, they tend to let go of their alternative conceptions and/or misconceptions and develop a more robust understanding about eclipses (Barnett et al., 2013). In teaching eclipses through conceptual change, one could also use context-based approach as it is suggested that it is effective in eliminating students' alternative conceptions and/or misconceptions as it helps students connect science concepts to the context in daily life (Karsli & Patan, 2016). Recently, a novel study of Picardal (2019) presented an emergent six stages of conceptual change framework of instruction in promoting scientific knowledge of science concepts grounded from science teachers' experiences in teaching highly contentious concepts of evolution theory at the secondary level of education. These stages are (1) recognition, (2) reinforcement, (3) relevance, (4) restructuring, (5) reflection and (6) enrichment. While the proposed framework holds encouraging contribution to science education, it has yet to establish empirical evidence of the extent of effectiveness to the learning outcome at the classroom setting on the aspects of promoting conceptual understanding and conceptual change. This study tested out a novel instructional model called conceptual change instructional framework (CCFI) (Picardal, 2019) to address prevailing alternative conceptions on eclipses that involve a series of instructional procedures hypothesized to promote conceptual understanding among students. More specifically, this study examined the different aspects of the instructional model using varied teaching strategies embedded in every stage of the model as implemented in the lesson plan. Hence, this study intends to answer all these questions:

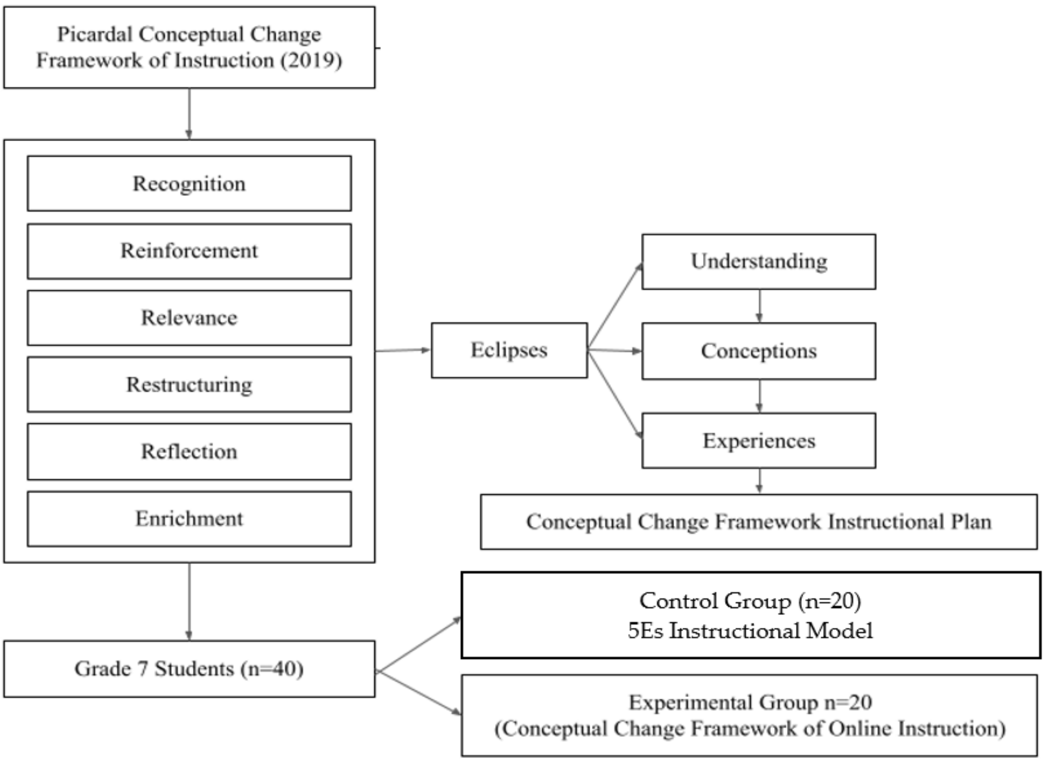
1. What is the level of understanding of students on eclipses before and after the implementation of the respective instructional plan in both control and experimental group?
2. What are students' conceptions on eclipses before and after the intervention?
3. What are students' experiences with the lesson about eclipses after the intervention in both control and experimental group?

Theoretical-Conceptual Framework

The focus of this study is to investigate the efficacy of conceptual change framework instructional model in promoting scientific understanding in teaching eclipses. Through the conceptual change framework of instruction of Picardal (2019) as an instructional model in teaching science lessons (i.e., eclipses), the six stages were incorporated in the lesson plan. The six stages of this instructional model are as follows: (1) recognition, (2) reinforcement, (3) relevance, (4) restructuring, (5) reflection, and (6) enrichment. In the recognition stage, the teachers investigated what the students knew about the topic. In the next stage, the reinforcement, teachers used instructional materials that can make their lesson understandable and enjoyable. In the relevance stage, the teachers used localized examples and situations that are relevant to students to bridge the gap between the learner's context and science concepts. In the fourth stage, the teacher gave the students the freedom to restructure old concepts and new information obtained to allow students to own their learning through feedback and encouraged critical thinking.

Figure 1

Theoretical-Conceptual Framework of the Study



The next stage is when the student is given the opportunity to reflect upon their learning by looking into the application of the concepts to real life. In the context of instruction, this last stage constitutes the ways students enrich their understanding of the concept by either practice or reinforcement through supplementary materials. The implementation of the lesson was delivered by the cooperating teacher. Prior to the instruction, the cooperating teacher was thoroughly oriented and briefed on the process of the implementation of every stage of the lesson plan.

Through a mixed-method approach the understanding, conception, and experiences of the students about eclipses before and after integration of the CCFI instructional model were determined. Students were assessed through pretest and posttest measures to determine whether there is a significant difference in their level of understanding and they were interviewed to describe their conceptions and learning experiences before and after the instruction.

Methodology

Research Design

This study employed embedded mixed method design utilizing a pretest-posttest method with the integration of a two-phased semi-structured interview (Byrne and Humble, 2007). The control group was exposed to traditional teaching instructions and the lesson with the CCFI intervention administered to the experimental group. The pretest-posttest method gauged the effect of the intervention on students' levels of understanding on eclipses while the semi-structured interview explored their conceptions of the topic and their learning experiences before and after the implementation of the instructional model.

Research Environment, Respondents, and Sampling Techniques

The intervention was conducted at a private school in Cebu City, Philippines. Due to the imposed restrictions brought by the pandemic, this school holds online classes. The teacher utilized an online platform in the implementation of the intervention. Respondents of this study were grade seven students (n=40). These students have an age range of 12-13 years old and belong in the middle class families. There are 20 students that were assigned randomly in the control group that conducted the usual way of instruction that utilized the 5Es instructional model. The other 20 students belonged in the experimental group exposed to the CCFI instructional model in teaching eclipses. The selection of the participants for each study group was done through maximum variation sampling. Maximum variation sampling is a special type of sampling where it considers and includes a wide range of extremes. Two sections were selected and were exposed to their identified methods of teaching according to which group they belong for a period of two weeks. The duration of the intervention excluded the administration of pretest, posttest, and interview. This time frame is based on the standard time-allotment stipulated in the K to 12 science curriculum for specific competencies.

Research Instruments

For the quantitative aspect of this study, it utilized the researcher-made 25-item test to measure the level of students' understanding on eclipses. This test was content validated and pilot tested with a Cronbach’s alpha value of 0.76. In the qualitative phase, the research instrument used was a semi-structured interview guide to explore their conception and learning experiences before and after the instruction. The interview guide contained fifteen questions, which were validated by at least three content experts teaching Earth Science. The researchers also utilized a lesson plan in teaching eclipses with the integration of the six stages in the conceptual change framework for the experimental group and a 5E instructional model for the control group. The format of the lesson plan was structured and adopted completely from Picardal (2019). However, in her study, the framework was not validated in the classroom setting. This makes this study the first to implement the generated framework in the actual teaching and learning process.

Conceptual Change Framework of Instruction

The Recognition Stage

This is the first stage of the CCFI process. During this stage, the teacher stimulates the prior knowledge of the students to determine the students' alternative and correct conceptions. Before the discussion, the teacher should be aware of what the students know about the topic of eclipses. Knowing the students' alternative conceptions will assist the teacher in addressing how to dispel their alternative conceptions or reconstruct their existing ideas. The teacher showed pictures of eclipses to the students and asked a series of questions. The questions were a. Are these images familiar to you? b. Have you seen this phenomenon? c. What are your thoughts about these images? d. What do you think these images are? The teacher was able to determine whether or not the students had prior knowledge of what an eclipse was and what it looked like by asking these questions. The teacher was also able to draw out the conceptions of the students about eclipses.

The Reinforcement Stage

After the recognition of the students' prior knowledge of the topic, reinforcement comes in. This is the stage where the teacher should establish the basic concepts of the topic accurately, debunk misaligned and alternative conceptions, and reinforce what is already correct and accurate from students' self-acquired understanding of the topic. In this stage, the teacher should present and highlight the essential and scientifically accurate concepts of the lesson by making or implementing some activities that will make the lesson understandable and enjoyable. In short, students must be engaged in unfolding the enduring understanding about a certain topic. At this stage, they must learn, relearn and unlearn the necessary things in order to construct and establish a more robust accurate conceptual understanding about the topic.

As to the created lesson plan, the reinforcement stage or activity was the online charades. In the online charades that displayed a set of characters or pictures, requiring students to guess the phenomena. This activity was enjoyable as students were very active in finding the association from the presented characters to arrive at the correct answer. From this activity, students were able to arrive at the correct answers in a very engaging and creative way. The activity transformed them to become active and intentional learners where through this experience the essential concepts they gained significant learning experiences from it.

The Relevance Stage

In the relevance stage, the teachers used localized examples and situations that are relevant to students to bridge the gap between the learner’s context and science concepts. The teacher utilized common examples and circumstances that apply to students and that they can apply in real-life situations. In setting up the relevance of the lesson, teachers must include the general connection of the lesson and the real-world scenarios. This stage employed varied visuals and hands-on exercises. For comprehension to occur, it is important to give drills and connect them to something they have encountered as an outline. Discussion of the eclipses topic happened at this stage. The teacher showed a PowerPoint presentation of the topic and presented two video clips about lunar and solar eclipses. At this stage, students understood the mechanism of eclipse phenomena. Local events of eclipses were also presented and the different superstitious beliefs of the community about it. The teacher encouraged students to share about the superstitious beliefs they know and if they have watched solar or lunar eclipse then processed their alternative framework from that of the scientific accurate and accepted concepts.

The Restructuring Stage

In the fourth stage, the teacher gave the students the freedom to restructure old concepts and new information obtained to allow students to own their learning through feedback and encouraging critical thinking. The teacher restructured the alternative conceptions and new information acquired by giving students the freedom to explore, reconstruct and empower their learning. The teacher created a set of classroom activities for students to examine and assess their current beliefs, as well as to comprehend how are these beliefs, whether rational or irrational (or valid or invalid) according to the expected learning outcome. Students worked in groups to participate in a Jamboard organized by the teacher and distributed the formulated link to every group. Students accessed their respective links, allowing them to participate and collaborate with their peers. Students had to present a creative illustration that summarizes their understanding of how lunar and solar eclipses occur. Then, one group representative presented the group's work to the class and the teacher gave some comments and inputs to every presented output to validate their learning and progress.

The Reflection Stage

Reflection is being able to contemplate the lesson instruction (Picardal, 2019) and the situations presented on hand. The reflection phase of the CCFI designed lesson plan exhibits the depth of students' capacity in formulating meanings and the process of understanding eclipses and its significance to real-life situations. This phase featured a series of questions that enhanced students' assimilation of the topic including previous alternative conceptions. Depending on the type of students and topic, the teacher could modify the activity so as long as the students could reflect on their previous beliefs with the acceptance of scientifically accepted knowledge and information. The questions reflected on the lesson design engaged students to a deeper discernment of concepts and its application to real life. Hence, students were able to develop competence in explaining conceptually challenging topics like eclipses. Consequently, it improved their understanding of the lesson, academic performance and perception of the significance of the lesson to the physical world.

The Enrichment Stage

In the context of instruction, this last stage constitutes the ways students enriched their understanding of the concept by either practice or reinforcement through supplementary materials. The enrichment stage is where the students do learner-centered homework or seatwork to make them more engaged in learning. The presented activity was a problem-solving case. Students were allocated enough time (3 days) to explore more and investigate further the case provided to them. The goal of the activity for the students is to eliminate the misconception of "bakunawa" related to the occurrence of lunar eclipses and to their mothers and grandmothers. The student must explain the occurrence of the lunar eclipse to eliminate the misconception related to eclipses. The given activity conveys and manifests students' mastery of the topic. The stage aimed to simulate their learning experience to promote critical thinking and problem-solving skills.

Research Procedure

Before conducting the pretest, all the necessary permits and documents were secured to ensure that required ethical clearance and protocols were followed. The pretest was administered to students in both the experimental and control group to establish their initial conceptions on the topic eclipses and to gauge their level of prior knowledge. Afterwards, the integration of the conceptual change framework of instruction was implemented to the experimental group while the control group had their business-as-usual lesson delivery. The cooperating teacher checked and implemented the lesson plan designed according to the conceptual change framework of instruction. The duration of the implementation of the intervention was two weeks as stipulated in the science curriculum guide. Administration of posttest followed three days after the instructional intervention. Selected students (n=8 per group) voluntarily participated in the semi-structured interview to share their experiences in the lesson and their learning experiences all throughout the intervention. All data collection procedures including test and interview were done virtually using Google forms and Google Meet, respectively. All interview sessions were conducted using English as the medium of communication since the school strictly imposed English Only Policy (EOP).

Data Analysis

Students' scores in the pretest and posttest were analyzed using descriptive statistics such as mean and standard deviation to establish their level of understanding of the concepts. To gauge if there was a significant change in their understanding before and after the instruction between the control and experimental groups, t-test for dependent samples and t-test for independent samples were employed, respectively. Prior to the computations of the differences of the scores of the students, normality tests were computed to know if the data are normally distributed.

Table 1

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk			Skewness		Kurtosis	
	Stat	df	Sig.	Stat	df	Sig.	Stat	Std. Error	Stat	Std. Error
ControlGroupPretest	.155	20	.200*	.910	20	.063	-.156	.512	-.839	.992
ExpGroupPretest	.160	20	.192	.945	20	.300	-.208	.512	-1.129	.992
ExpGroupPosttest	.134	20	.200*	.958	20	.502	-.136	.512	1.216	.992
ControlGroupPosttest	.149	20	.200*	.950	20	.367	-.404	.512	-.655	.992

Note. [a]. Lilliefors significance Correction, *. This is a lower bound of the true significance

In terms of Kurtosis and Skewness, data are nomally distributed. For Shapiro-Wilk values, the data are approximately normally distributed since the p-values are above 0.05, keeeping the null hypothesis.

Statistical analysis and treatment were done using the software Statistical Packages for Social Sciences (SPSS) 26. Thematic analysis (Braun & Clarke, 2006) was used to analyze the qualitative data from the semi-structured interviews to determine students' conceptions and experiences in the eclipse lesson before and after the implementation of their respective instructional plans. The criteria in coding students' conceptions on eclipses were the following themes namely, the process of eclipses, its occurrence and accuracy of conception. Regarding their learning experiences with the instruction, statements pertaining to activities or tasks they performed during the instruction, influence to students' learning gains, and perception on the level of engagement and difficulty were noted and put into record.

Ethical Considerations

In conducting research, ethical considerations must be ensured so that proper data gathering procedure would be followed. Ethical considerations guarantee the research findings' dependability and validity. This study strictly adhered to research ethics protocols as evidenced in the CNU-ERC certification (779/2021-04 Madaiton).

Findings

This study generally investigated the effectiveness of a novel instructional model called Conceptual Change Framework of Instruction (CCFI) in the teaching of eclipses to students' understanding, conceptions, and experiences.

Students' Levels of Understanding

Using the *t*-test for independent samples, both groups underperformed in their pretest (μ=12.20; SD=3.66 and μ=12.90; SD=4.39). This low performance is based on the standard set by the Department of Education which is below 75%. These results indicate that students from both groups have a low level of knowledge and conceptual understanding about the topic eclipses. After the implementation of the instruction, both groups' mean scores significantly increased (μ=15.65; SD=5.38 and μ=19.35; SD=2.21). However, the experimental group scored better corresponding to 77.40% which is above the passing score compared to the control group 62.60% score.

Table 2

Pretest and Posttest T-Test Scores for Students' Level of Understanding

Group	Passing Score	Pre-test Mean	SD	Post-test Mean	SD
Control	19	12.20	3.66	15.65	5.38
Experimental	19	12.90	4.39	19.35	2.21

Results from the table above indicate that the conceptual change framework of instruction was effective as an instructional model in the development of the conceptual understanding. As to the counterpart 5Es instructional model, there was still a significant effect to their understanding but unexpectedly lower than the ideal.

Comparison of Students' Pretest and Posttest Levels of Understanding

Table 3 shows that there were a significant mean gain in students' levels of understanding before and after instruction in both groups. The experimental group has a higher mean gain (μ=6.45; SD=4.68; p= .00) than the control group (μ=3.45; SD= 3.35; p=.04). It can be gleaned that both instructional models were effective for students' development of conceptual understanding on eclipses but favorable results were evident to students exposed to CCFI.

Table 3

Mean Gains İn Students' Levels of Understanding on Eclipses

Group	Pretest Mean	Posttest Mean	Mean Gain	SD	t-value	p-value
Control	12.20	15.65	3.45	3.35	2.17*	.04
Experimental	12.90	19.35	6.45	4.68	6.16*	.00

Note. Significant at $\alpha = 0.05$

Comparison of Effect of the Instructional Model to Students' Understanding

Both the conceptual change framework of instruction in the experimental group and the conventional 5Es instructional model in the control group were effective, but based on the mean gain values indicated above, the conceptual change framework of instruction had a greater effect than the counterpart. According to the p-value of .025, the null hypothesis should be rejected, indicating that there is a significant difference between the mean gain of the experimental and control groups, which also suggests that the difference of 3.00 between the mean gains of both groups is significant. This suggests that the conceptual change framework of instruction is significantly more effective than the conventional 5E instructional model. As to the standard deviation, the control group had a more consistent gain score (SD=3.35) than the gain score in the experimental group (SD=4.68).

Table 4

Comparison of Mean Gain of Students' Level of Understanding

Group	Mean Gain	SD	Difference	t-value	p-value
Control	3.45	3.35	3.00	2.330	.025
Experimental	6.45	4.68			

Note. Significant at $\alpha = 0.05$

Table 4 clearly showed that the conceptual change framework of instruction has a significantly greater effect compared to the conventional 5Es. This significant greater effect may be attributed to students being actively engaged even on an online modality. Moreover, students' prior knowledge was recognized and they were given activities for them to reconstruct or examine their conceptual structures.

Students' Conceptions about Eclipses Prior to Instruction in Both Groups

Alternative conceptions in understanding the occurrence of eclipses are widespread among secondary students (Karslı & Patan, 2016). Thus, the following interview results supported the claim that there are certain misconceptions prevailing in understanding eclipses.

Table 5

Themes and Formulated Meanings of Students' Alternative Conceptions about Eclipses

Themes	Formulated Meanings	Frequency	Sources
Incorrect alignment of celestial bodies	Solar eclipse happens when the Earth is in between the sun and moon	4	P5, P12, P2, P7
	Lunar eclipse occurs when the moon blocks the sunlight	2	P5, P10
	Eclipses occur when the sun, moon and Earth share the same orbit	4	P4, P9, P13, P5
	Lunar eclipse occurs when the sun covers the moon	6	P9, P3, P5, P6, P12, P15
Doubts about eclipses' mechanisms	Confusions about the difference between a full moon and a lunar eclipse	6	P2, P3, P5, P6, P12, P15
	The uncertainty on how the moon can block the sun	3	P2, P8, P3
Inaccurate effects of eclipses	Eclipse produces radiation that could harm the human's circulatory system	3	P3, P9, P10
	Eclipse can change human behaviour	2	P2, P8
Inaccurate occurrence of eclipse	Eclipses happen regularly	3	P8, P9, P11
	Eclipse occurs when the moon and sun collides	5	P9, P13, P5, P2, P10
	Eclipses is only about the sun and the moon	2	P4, P11

Table 5 shows the themes and formulated meanings of students' alternative conceptions on how eclipse occurs in both control and experimental groups before the implementation of their respective intervention.

Incorrect Alignment of Celestial Bodies

Based on the student participants' responses to the interview questions, there are several alternative conceptions to students' understanding about eclipses. Common to these conceptions is centered on the alignment of the earth, moon, and sun during the occurrence of lunar and solar eclipse, one that was also mentioned in the study of Karslı & Patan, 2016. Students' responses included:

> *"(…) lunar eclipse occurs when the sun would be covering the moon" (P5)*
> *"Lunar eclipse happens when the moon is covering the sun."(P9)*
> *"(…) during a solar eclipse, the Earth will face the sun and cover the moon." (P12)*

These students' alternative conceptions were said to be common among students when it comes to learning how an eclipse occurs. The same compelling reason why teachers must address this early on in the discussion (Karsli & Patan, 2016).

Doubts about Eclipses' Mechanisms

Aside from the alternative conceptions of students about the occurrence of eclipse, there are also some factors affecting students' complete and coherent understanding on this subject matter and that is the uncertainties of students surrounding eclipse. Some student participants mentioned that it is difficult to understand the distinction between a full moon and a lunar eclipse. Response included:

> *"I cannot really describe the difference between a full moon and a lunar eclipse."(P10)*

Indeed, students experience difficulties in explaining the difference between these two events since they are uncertain about its existence in the first place. Moreover, one student also mentioned about the difficulty to develop a logically and scientifically based reasoning as to how the moon was able to block the sun's light during a solar eclipse. Response included:

> *"I don't know how it happens but I think it's because of the movement and the orbit because it's not really about the size."*

Inaccurate Effects of Eclipses

Conversely, another student also mentioned a common and prevailing alternative conception about the amount of radiation an eclipse would produce. This alternative conception is related to the idea that the body could be harmed by the radiation emitted by an eclipse (NASA, 2017). However, according to NASA's statement, the occurrence of solar eclipse is entirely harmless and that the radiation produced by the sun during a solar eclipse has no significant effect on a person's health. Meanwhile, one response included:

> *"(…) during a solar eclipse there is a lot of radiation and it could possibly affect the living creatures on Earth. I think the circulatory system of humans would also be affected because of radiation."*

This prevailing alternative conception has been very resistant despite the advancement of science and mostly is caused by false information from the environment and existing beliefs of the students (Dorsah & Okyer, 2020) that are said to cause alternative conceptions in students' understanding on topics like eclipses.

Inaccurate Occurrence of Eclipse

Despite the fact that how eclipse occurs is quite simple to understand, consistent reports from the discipline-based astronomy education research state that the students find difficulty with the creation of a logical understanding of the topic eclipse (Kavanagh et al., 2005; Slater & Gelderman, 2017) Hence, the results presented confirmed students' prevailing alternative conceptions regarding the occurrence of eclipse. There were students who also mentioned that an eclipse occurs regularly and that the moon and sun collide during an eclipse. On the other hand, some students' from both groups stated that such occurrence was due to the effect of planetary motion or when the earth, moon, and sun systems are together in the same orbit. Students' erroneous explanations clearly showed that truly students have not yet developed a strong, conceptually cohesive understanding as to how these processes occur. Thus, this information provided supported the claim of the discipline-based astronomy education research regarding students' prevailing alternative conception about eclipses and the need for an intervention. Finally, students were uncertain mainly about how this phenomenon occurs and further agreed that the occurrence of eclipse is difficult as students are required to formulate abstract understanding of the dynamic relations between the world and the 3-dimensional space it is part of (Barnett et al., 2013).

Table 6

Themes and Formulated Meanings about Students' Conceptions after the Intervention

Themes	Formulated Meanings	Groups	F	Sources
Alignment	Eclipses are about the alignment of sun, moon and earth	Experimental	5	P1,P2,P4, P6,P7
		Control	3	P9,P12,P15
	One celestial object (moon) covers another one (sun)	Control	2	P13,P14
	A solar eclipse is when the moon covers the sun and lunar eclipse is when the Earth covers the sun.	Experimental	3	P1,P3,P7
		Control	6	P9,P10,P12,P13,P15, P16
Distinguishable Characteristics	The full moons' colour is normal while in a lunar eclipse it becomes red.	Experimental	3	P1,P3,P7
		Control	5	P10,P11,P12,P13,P15
Occurrence of Eclipse	Lunar eclipse happens rarely while full moon happens regularly	Experimental	1	P4
		Control	1	P12
Accurate Celestial Distance	The sun is very far compared to the distance of the moon to the Earth that's why the moon can block the sun.	Experimental	5	P3,P4,P6,P7, P8
		Control	8	P9,P10,P11,P12 P13,P14,P15,P16
Accurate Effect of Eclipse	Solar eclipse might damage the eyesight	Experimental	5	P1,P2,P4, P6,P7
		Control	3	P9,P11,P12

Alignment

Based on the answers by the respondents from both the experimental and control groups, the students grasp a deeper understanding of the topic after the integration of the conceptual change framework of instruction. A greater number of students in the experimental group grasps the concept of the topic eclipses compared to the control group. Almost all of the respondents now know that an eclipse happens due to the alignment of the Sun, Moon, and Earth. They are aware of the difference in the alignment of these celestial bodies in the Solar and Lunar eclipse.

Distinguishable Characteristics

Before the intervention, the respondents did not know why the moon turns red when a lunar eclipse happens. After the intervention, few respondents stated that:

"The moon becomes red because the light waves stretch out and look red."
They can now distinguish the difference between a full moon and a lunar eclipse.

Occurrence of Eclipse

The respondents have a clear understanding of the occurrence of an eclipse and the difference between it from a full moon. They are aware that an eclipse rarely happens while a full moon happens regularly or once a month. The respondents also know that an eclipse is a phenomenon.

Accurate Celestial Distance

Many respondents stated that:

"The sun is much farther than the distance of the moon to the Earth, that is why the moon can block the sun."

This is the reason why the moon can block the sun even if it is small. The respondents understand this concept clearly. They are aware that due to the distance of the sun from earth and moon, the sun seems small and can be blocked by the moon and a solar eclipse can happen.

Accurate Effect of Eclipse

Many respondents did not have any idea what was/were the effect(s) of the eclipse before the integration of the respective instructions for both groups. After the integration, many students are now aware that looking directly at the sun during a solar eclipse can damage their eyesight. They know that they need to wear protective eyewear. This knowledge can help them someday if a solar eclipse will occur and they want to see it.

Students' Experiences after the Intervention

The table below shows the themes and formulated meanings of the students' experiences in teaching the lesson eclipses after the implementation of the intervention. The following data gathered were the responses of the selected student participants.

Table 8

Themes and Formulated Meanings of Students' Experiences

Themes	Formulated Meanings	Groups	f	Sources
Level of Engagement and Difficulty	The lesson was easy.	Experimental	4	P1, P2, P3, P4
		Control	6	P9,P10,P12,P13,P15, P16
	The lesson was hard but manageable.	Experimental	3	P5, P6, P7
		Control	1	P11
	The lesson was good and enjoyable	Experimental	7	P1, P2, P3, P4, P6, P7,P8
		Control	8	P9,10, P11,P12, P13,P14,P15,P16
Learning Gains	Learning how eclipses occur	Experimental	6	P1, P2, P5, P6, P7, P8
		Control	4	P10,P11, P12,P16
	Being able to correct stories about myths and misconceptions	Experimental	7	P3, P1, P2, P5, P6, P7, P8
		Control	2	P9, P15

Features of the instruction	Creating concept map	Experimental	5	P1, P2, P3, P4, P7
	Playing with online charade		2	P6, P8
	Formulating an eclipse diagram		1	P9
	Video presentation about the eclipses		1	P4
	Formulating an eclipse diagram	Control	3	P9,P11,P12
	Asking of process questions		1	P13
	Video presentation about the eclipses		1	P13

Level of Engagement and Difficulty

Majority of students reported to be comfortable with the lesson and with the kind of instruction provided to them. According to the student's response:

"I didn't find any difficulties in understanding the lesson, especially when we did some research to get information." P4

This statement describes that most of them did not experience conceptual difficulty in understanding the lesson after being exposed to the instruction. They were also guided to use different learning sources to confirm their doubts about the concept. The abstract nature of the topic on eclipses requires full and conceptual understanding (Taber, 2019) rather than a partial and shallow recognition. Owing to students' narratives, it is considered a positive experience that some students were able to mention that they did not find any difficulty in understanding the lesson. These students' narrative accounts supported students' gain in their level of understanding in the posttest. Both types of instructions were able to engage students' understanding in a pace that is easy to follow. Meanwhile, some of the students were having minimal difficulties in understanding the lesson at the beginning but they understood the lesson as the teacher got deeper with the teaching and learning process. One response included:

"At first, I was confused, and now it much clearer" P2

As Weerasinghe (2017) stated, the satisfaction of students can be correlated to the result of an evaluation of students' educational experience from a lesson presented. This means that students' satisfactory performance reflects how they were taught which can be attributed to the different aspects of the instructional models. Moreover, one student has said,

"I think it was simple at first, in the beginning of the discussion, however later on the discussion it became a little hard, just a little hard. But I got to understand what it means after the discussion." P8

Students' experiences in the control group are quite similar with the experiences of the experimental group as many of them shared the same answers with regards to the implementation of the lesson. All students in the control group were satisfied with lesson delivery and five out of eight students claimed that they find learning how eclipses occur enjoyable. Responses included:

"Understanding how eclipse occur, like when the moon is able to block the sun was the coolest part" P5

"I enjoyed learning more things about eclipse because I didn't really know much about it before, so it was enjoyable." P11

The experiences of students towards a particular lesson implementation is a significant factor in students' progress and improvement, particularly students' active participation (Picardal, 2019) in understanding conceptually challenging topics like eclipses. As mentioned in the study of Karslı and Patan (2016), exposing students to a more engaging, fun and interactive learning environment might help them to learn and develop a better understanding of the concepts behind eclipses. Basically, students find a particular topic easy to understand when they also enjoyed learning the topic as it was reflected in students' post exam scores featuring an improvement of their academic performance for enjoyment is regarded as a positive impression and stimuli in learning (Hernik & Jaworska, 2018).

Thus, from the participants' responses, students' conceptual understanding can be attributed directly to students' enjoyment and lesson satisfaction.

Learning Gains

Students nuanced that it was a great experience to be able to understand how an eclipse occurs as they could now correct alternative conceptions surrounding the occurrence of eclipses. As one student has mentioned,

> *"(…) for me, I think it's the part where other people believe what is wrong and that we could settle these misconceptions and spread the knowledge of how an eclipse scientifically works." P7*

Thus, students understand things more easily when what they learn has practical applications. Moreover, students' improvement may also be attributed to the inclusion of realistic and practical based activities (Broman et al., 2015; Demircioglu et al., 2013; Gilbert, et al. 2011; as cited in Karslı & Patan 2016) in the implementation of CCFI as students were able to emphasize that; after the discussion they were able to assimilate the importance of understanding the phenomenon as they were also able to correct existing alternative conceptions.

Varied Classroom Instructional Activities

The responses of the students regarding their experiences were also centered on the instructional activities implemented during the instruction. Most of the students found these activities enjoyable while learning. Such activities were concept mapping, diagram making and charades for the experimental group. They enjoyed the lesson because of the variety of instructional activities that werere conducive for learning. According to the student's response:

> *"I was able to illustrate the arrangement of the sun, moon and earth during the solar eclipse and lunar eclipse" P1*
>
> *The statement explains diagram making and concept mapping. P5*
>
> *"We can make concepts about the eclipses so that we can recall from our lessons." P12*

For charades, the student stated:

> *"It was fun trying to guess what it was." P4*

Meanwhile, in the control group, three out of eight students mentioned that creating an eclipse diagram helped them understand the lesson more as it was also enjoyable. The inclusion of the video presentation also helped to keep the students engaged during the class discussion. Meanwhile, one student mentioned,

> *"I found it enjoyable when we were called to answer the questions and when I got to answer the question about the alignment of the sun, moon and earth. I think it was fun because I got puzzled by it." P8*

Discussion

The study presented the effect of the emerging instructional model called CCFI in facilitating understanding and accurate conception of science concepts. There was a significant increase in students' level of understanding about eclipses in both the experimental and control group. However, surprisingly, it was in the experimental group exposed to CCFI that registered beyond the standard passing score in the posttest. This important observation favoring CCFI could be attributed to its appropriateness in the online learning modality when the instruction was implemented as well as on the different stages of the instructional model. Similar to Kural and Kocakülah (2016) who recommended a new teaching model called Teaching Model for Hot Conceptual Change (TMHCC) with eight phases of learning syntaxes to promote conceptual change, CCFI shared the same goal for students and for teachers to have another option in teaching lessons. Conceptual change has been seen as a potential teaching pedagogy that can facilitate the development of 21st century skills (Djudin, 2021). Anchoring on the major proponent of conceptual change theory, Posner et al. (1982) explained that there should be four conditions that need to be met in order for conceptual change to occur, namely; (1) there is dissatisfaction with the (initial) conception that is owned (dissatisfaction), (2) the new concept is easier to understand (intelligible), (3) the new concept is more plausible, and (4) the new concept is felt to be useful (fruitful). CCFI has addressed all these criteria for conceptual change as reflected in the various stages of instruction and as evidenced in students' increased understanding and change of conceptions. To be specific, CCFI emphasized the importance of diagnosing what students bring to the classroom. Recognizing students' prior knowledge is a crucial step towards promoting conceptual understanding (Dorsah & Okyer, 2020). In addition, it is significant to consider that, for students to fully understand the lesson, the activities must be effective in arousing students' interests and enjoyment to participate during the discussion instead of just passively listening to the teacher (Slater & Gelderman, 2017). Similar to what Kaçar and Balım (2021) observed that, students demonstrated conceptual change when they were presented with opportunities to explore information about the lesson. Students' interview responses on their experiences towards CCFI were altogether positive as they were able to perform varied activities that were inquiry based and designed for independent learning. These findings support observation of Yıldız-Feyzioğlu and Demirci (2021), that open inquiry appears to have effects deep enough to bring about changes in students' conceptions. They also expressed more satisfaction with the presence of differentiated instructional activities included in the CCFI stages. One of the most important highlights of the CCFI in promoting conceptual change could also be the reflection stage. The same argument was reported by Antonio and Prudente (2021) on the positive effect of metacognitive approach in teaching science concepts. The online-based activities that students performed could also be the contributing factors to the learning gains of students since most of these students were digital native. The CCFI was tailored to fit the new learning modality so that learning can still go on. Shatri (2020) cited several benefits of using information and communication technology that students can harness to leverage their learning experience. Moreover, students have found concept mapping, specifically, as an effective way to engage them in conceptual understanding as reflected in the findings of the study performed by Bakouli and Jimoyiannis (2014) concluding that concept mapping is an effective learning tool in concept integration. One important feature of the CCFI as implemented in the instruction is the use of varied instructional materials fit for online learning. As mentioned by Adkins (2020), the purpose of using instructional materials is for students to assimilate the information presented to them. CCFI, therefore, provided students the tool to comprehensively understand the concept behind eclipses while also having fun. This study does not however claim that conceptual change development happened linearly following the stages of the instructional model. Conceptual change occurs depending on individual students at any stage of their learning and it may be gradually or longer than what is expected given that the duration of instruction is limited only. The same caveat by Djudin (2021) on conceptual change development of learners in which they do not completely abandon their prior conceptions even when conceptual change has occurred. What is essential in this study is that it was able to confirm that CCFI can promote conceptual understanding and conceptual change among students.

Conclusion and Recommendations

This study investigated the effectiveness of CCFI as an instructional model in teaching eclipses in promoting conceptual understanding and positive learning experiences of students. From the analysis of data, the following findings were drawn: (1) Students' level of understanding significantly increased after CCFI instruction. (2) Students demonstrated conceptual change of their prior knowledge from alternative conceptions to scientifically correct ideas. (3) Students gained positive learning experience all throughout the exposure to the instructional model.

In consideration to the learning gains attributed to the CCFI, teachers may consider this as an addition to the repertoire of instructional models that they can adapt and implement in their lesson designs in teaching not just astronomy lessons but in Science in general.

While this study validated successfully the new instructional framework and generated positive effects to the learning outcome, there are a number of limitations in terms of its generalizability. The sample size is small due to the constraints in accessing students brought about by the pandemic. The implementation of instruction was done purely online, which may be new to students as to the learning platform. Although, students have been doing online classes for almost two years, which may have given them ease of use and access to online learning platforms. Finally, the means of data collection including the administration of test and interview were done virtually, which could produce different results if it was done in a face-to-face setting. Future studies may replicate this investigation by completely adopting the framework and implementing it in other science topics and other disciplines to validate the extent of effectiveness and other features of the CCFI.

Acknowledgments

The authors express their heartfelt gratitude to Sotero B. Cabahug FORUM for Literacy allowing them to conduct the study and to the anonymous reviewers for their insightful comments and suggestions that made a significant improvement to the manuscript. Moreover, the researchers also recognize the National Research Council of the Philippines of the Department of Science and Technology for the publication grant through their Research Dissemination in Local and International Platforms (RDLIP) program.

References

Acut, D.P. & Latonio, R.A.C. (2021). Utilization of stellarium-based activity: its effectiveness to the academic performance of Grade 11 STEM strand students. *Journal of Physics: Conference Series, 1835* (1), 012082. https://doi.org/10.1088/1742-6596/1835/1/012082

Adkins, S. (2020, June 28). What is the purpose of instructional materials? https://askinglot.com/what-is-the-purpose-of-instructional-materials

Alparslan C., Tekkaya, C., & Geban, O. (2010). Using the conceptual change instruction to improve learning. *Journal of Biological Education, 37*(3), 133-137. https://doi.org/10.1080/00219266.2003.9655868

Antonio, R. P., & Prudente, M. S. (2021). Metacognitive Argument-Driven Inquiry in Teaching Antimicrobial Resistance: Effects on Students' Conceptual Understanding and Argumentation Skills. *Journal of Turkish Science Education*, *18*(2), 192-217.

Bailey, J. M. (2011). *Astronomy education research: Developmental history of the field and summary of the literature*. Commissioned paper for the National Research Council Board on Science Education's Committee on the Status, Contributions, and Future Directions of Discipline Based Education Research.

Bakouli, V., & Jimoyiannis, A. (2016). *Concept mapping as cognitive tool in science education: An analysis of students' learning using SOLO taxonomy.* Recent Advances in Science and Technology Education, Ranging from Modern Pedagogies to Neuroeducation and Assessment, Cambridge Scholars Publishing. https://www.researchgate.net/publication/327252136_Concept_mapping_as_cognitive_tool_in_science_education_An_analysis_of_students'_learning_using_SOLO_taxonomy

Barnett, M., Keating, T., Barab, S. A., & Hay, K. E. (2013). Conceptual change through building three-dimensional virtual models. Proceedings of the Fourth International Conference of the Learning Sciences, pp. 134-141. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.379.3834&rep=rep1&type=pdf

Barnett, M., & Morran, J. (2002). Addressing children's alternative frameworks of the moon's phases and eclipses. *International Journal of Science Education, 24*(8), 859-879. https://doi.org/10.1080/09500690110095276

Bernstein, J. (2013). *Exploring Children's Conceptual Development: An Examination of How Children Learn Astronomy from Reported Access to Related Materials, Experiences, and Conversations to Initial Understandings*. https://digitalcommons.calpoly.edu/psycdsp/39

Bryce, T. G. K.; Blown, E. J. (2012). The Novice-Expert Continuum in Astronomy Knowledge. *International Journal of Science Education, 34*(4), 545–587. https://doi.org/10.1080/09500693.2011.642325

Byrne, J., & Humble, Á. M. (2007). An introduction to mixed method research. *Atlantic Research Centre For Family-Work Issues*, *1*, 1-4.

Comins, N. F. (2001). *Heavenly errors: Misconceptions about the real nature of the universe*. Columbia University Press. https://www.jstor.org/stable/10.7312/comi11644

Çil, E. (2014). Teaching nature of science through conceptual change approach: conceptual change texts and concept cartoons. *Journal of Baltic Science Education, 13*(3), 339. http://oaji.net/articles/2015/987-1437678975.pdf

DeHaan, R. L. (2005). The impending revolution in undergraduate science education. *Journal of Science Education and Technology, 14*(2), 253-269. https://doi.org/10.1007/s10956-005-4425-3

Dorsah, P., & Okyer, M. (2020). Cultural factors affecting the teaching and learning of some science concepts. *European Journal of Education Studies, 7*(7).

Djudin, T. (2021). Promoting students' conceptual change by integrating the 3-2-1 reading technique with refutation text in the physics learning of buoyancy. *Journal of Turkish Science Education*, *18*(2), 290-303.

Gafoor, K. A., & Akhilesh, P. T. (2010). Strategies for Facilitating Conceptual Change in School. *Physics. Online Submission, 3*(1), 34-42. http://dx.doi.org/10.46827/ejes.v7i7.3159

Hernik, J., & Jaworska, E. (2018). *The effect of enjoyment on learning*. Proceedings of INTED 2018 Conference, pp. 0508-0514. https://library.iated.org/view/HERNIK2018EFF

Kaçar, S., & Balım, A. G. (2021). Investigating the effects of argument-driven inquiry method in science course on students' levels of conceptual understanding. *Journal of Turkish Science Education*, *18*(4), 816-845.

Karslı, F., & Patan, K. K. (2016). Effects of the context-based approach on students' conceptual understanding: "the umbra, the solar eclipse and the lunar eclipse". *Journal of Baltic Science Education, 15*(2), 246. http://journals.indexcopernicus.com/abstract.php?icid=1202150

Kavanagh C., Agan L. &Sneider C. (2005). Learning about Phases of the Moon and Eclipses: A Guide for Teachers and Curriculum Developers. *The Astronomy Education Review, 1*(4),19-52. http://www.if.ufrgs.br/~fatima/trabalhos/fasesdalua/7-2-2.pdf

Kaya, E. & Geban, O. (2011). The effect of conceptual change based instruction on students' attitudes toward chemistry. *Procedia-Social and Behavioral Sciences, 15*(1), 515-519. https://doi.org/10.1016/j.sbspro.2011.03.133

Konicek-Moran, R., & Keeley, P. (2015). *Teaching for conceptual understanding in science*. Arlington: NSTA Press, National Science Teachers Association.

Layng, T. V. J. (2013). *Understanding concepts: Implications for science teaching*. Eschool News: Daily Tech News & Innovation, 1-12. https://www.researchgate.net/publication/311379149_Understanding_Concepts_Implications_for_Science_Teaching

Mills, S. (2016). Conceptual understanding: A concept analysis. *The Qualitative Report, 21*(3), 546. https://doi.org/10.46743/2160-3715/2016.2308

Moser, T. & Chen, V .(2016). *What is Conceptual Understanding?* Getting Smart. https://www.gettingsmart.com/2016/08/what-is-conceptual-understanding/

NASA. (2017). *Eclipse: Misconceptions*.https://eclipse2017.nasa.gov/eclipse-misconceptions

Pena, B. M., & Quilez, G. M. J., (2001) The importance of images in astronomy education. *International Journal of Science Education, 23*(11), 1125-1135. https://doi.org/10.1080/09500690110038611

Picardal, M. T. (2019). Does Conceptual Change Process of Instruction Promote Scientific Understanding of Biological Evolution? *Liceo Journal of Higher Education Research, 15*(2). http://asianscientificjournals.com/new/publication/index.php/ljher/article/view/1326

Prather, E. E., Slater, T. F., Adams, J. P., Bailey, J. M., Jones, L. V., & Dostal, J. A. (2004). Research on a lecture-tutorial approach to teaching introductory astronomy for non–science majors. *Astronomy Education Review, 3*(2). https://www.per-central.org/items/Load.cfm?ID=15084

Pundak, D. (2016). *Evaluation of conceptual frameworks in astronomy*. Problems of Education in the 21st Century, 69, 57. http://journals.indexcopernicus.com/abstract.php?icid=1199766

Richardson, J.C., & Swan K. (2013). An Examination of Social Presence in Online Courses in Relation to Students' Perceived Learning and Satisfaction. *Journal of Asynchronous Learning Network, 7*(1). http://dx.doi.org/10.24059/olj.v7i1.1864

Şeker, R., & Kartal, T. (2017). The effect of computer-assisted instruction on students' achievement in science education. *Turkish Journal of Education*, *6*(1), 17-29.

Shatri, Z. G. (2020). Advantages and disadvantages of using information technology in learning process of students. *Journal of Turkish Science Education*, *17*(3), 420-428.

Slater, E. V., Morris, J. E., & McKinnon, D. (2018). Astronomy alternative conceptions in pre-adolescent students in Western Australia. *International Journal of Science Education, 40*(17), 2158-2180. https://doi.org/10.1080/09500693.2018.1522014

Slater, T. F., & Gelderman, R. (2017). Addressing students' misconceptions about eclipses. *The Physics Teacher, 55*(5), 314-315. https://doi.org/10.1119/1.4981046

Supriatna, U., Samsudin, A., & Efendi, R. (2019). Teaching solar system topic through Predict Observe-Explain-Apply (POEA) strategy: A path to students' conceptual change. *TADRIS: Jurnal Keguruan dan Ilmu Tarbiyah, 4*(1), 1-15. https://doi.org/10.24042/tadris.v4i1.3658

Syuhendri, S. (2017). A learning process based on conceptual change approach to foster conceptual change. Newtonian mechanics. *Journal of Baltic Science Education, 16* (2), 228. http://oaji.net/articles/2017/987-1497156471.pdf

Taber, K. S. (2019). *The Nature of the Chemical Concept: Re-constructing Chemical Knowledge in Teaching and Learning* (Vol. 3). Royal Society of Chemistry. https://doi.org/10.1039/9781788013611

Vosniadou, S., & Mason, L. (2012). *Conceptual change induced by instruction: A complex interplay of multiple factors*. In APA educational psychology handbook, Vol 2: Individual differences and cultural and contextual factors. (pp. 221-246). American Psychological Association. https://psycnet.apa.org/doi/10.1037/13274-009

Weerasinghe, I.MS. & Fernando R.L.S. (2017). Student Satisfaction with Online Learning: Is it a Psychological Contract. *American Journal of Educational Research, 5*(5), 533–539.

Yalcin, F. A., Yalcin, M., & Isleyen, T. (2012). Pre-Service Primary Science Teachers' Understandings of the Moon's Phases and Lunar Eclipse. *Procedia Social and Behavioral Sciences, 55*, 825-834. https://doi.org/10.1016/j.sbspro.2012.09.569

Yıldız-Feyzioğlu, E., & Demirci, N. (2021). The effects of inquiry-based learning on students' learner autonomy and conceptions of learning. *Journal of Turkish Science Education*, *18*(3), 401-420.