Journal of Turkish Science Education, 2022, *19*(3), 808-829.
DOI no: 10.36681/tused.2022.151

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

Exhaustive Studies before Covid-19 Pandemic Attack of Students' Conceptual Change in Science Education: A Literature Review

Ananda Hafizhah Putri[1], Achmad Samsudin[2], Andi Suhandi[3]

[1]*Universitas Pendidikan Indonesia, ananda.hafizhah@upi.edu, ORCID ID: 0000-0002-3160-5593*
[2]*Universitas Pendidikan Indonesia, ORCID ID: 0000-0003-3564-6031*
[3]*Universitas Pendidikan Indonesia, ORCID ID: 0000-0001-9912-7308*

ABSTRACT
This systematic review is aimed to explore the researches that established students' conceptual change process, both studies that facilitate conceptual change and studies that determined learner characters influencing conceptual change. Overall, 50 studies were examined in this review. The current study focused on the common characteristics of the literature, the conceptual change instructional interventions used and the methods used to assess them. This review generates four averments about the current study: (1) physics subjects have obtained more attention than other science domains; (2) the majority of studies were conducted on undergraduate students of various majors, not only science education students; (3) studies about conceptual change have developed from a cognitive-only perspective to metacognitive aspects; (4) design on conceptual change study has been dominated by quasi experiment with only pre- and post-intervention. Based on these averments, the authors invite the future empirical studies to consider affective variables in designing instructional approach, focus on examining pre-service science teachers' conceptual change through the implementation of an instructional intervention, and apply qualitative data collection methods regarding affective and metacognitive variables through the implementation of an instructional intervention.

RESEARCH ARTICLE

ARTICLE INFORMATION
Received:
09.02.2022
Accepted:
13.08.2022

KEYWORDS:
Conceptual change, misconception, cognitive, affective, literature review.

To cite this article: Hafizhah Putri, A. Samsudin , A. & Suhandi, A. (2022). Exhaustive studies before covid-19 pandemic attack of students' conceptual change in science education: a literature review. *Journal of Turkish Science Education, 19*(3), 808-829.

Introduction

Learning scientific concepts involves difficult and time-consuming process that frequently requires students to consider their existing conceptions (Loyens et al., 2015; Resbiantoro & Setiani, 2022). Science education researchers have obviously documented that the students enter the classrooms with pre-instructional alternative conceptions (Broughton, Sinatra, & Reynolds, 2010; Diakidoy et al., 2016; Vosniadou & Skopeliti, 2005;). These prior conceptions are often incomplete or incorrect and influence students' performance on assessments and their ability to explain about natural phenomena. Educational researchers develop instructional approaches that support students' efforts to restructure their prior knowledge, a process called conceptual change. The instruction is explicitly aimed to assist students to identify the discrepancy between their prior knowledge and the scientific concepts (Duit, Treagust, & Widodo, 2008).

In contrast to general learning, the process of conceptual change frequently involves fundamental changes in conceptual constructions and adoption of new learning techniques in response to material which explicitly opposes one's prior beliefs (Vosniadou, 2013). To reveal how the conceptual change occurs has been a prodigious challenge for science educators since the 1980's. The origin of the area is commonly pinpointed in the early 1980's, once journals utilizing "conceptual changes" in titles or as a keyword begin to arise. Nussbaum & Novick (1986) and Posner et al. (1982) were among the first peer-reviewed studies published on the subject. Coincidentally, these two articles are credited with igniting the entire field that followed (Lin J.-W.et al., 2016).

Numerous views on conceptual change process have developed, resulting in numerous conceptual change models exist. Misconceptions develop when pupils assign concepts to wrong ontological categories, according to one distinction in the classical conceptual change model (Chi, Slotta, & De Leeuw, 1994). Conceptual change, according to this viewpoint, occurs when students alter their perceptions of a concept's nature. Another version considers the influence of affective factors on conceptual change such as motivation, interest and self-efficacy (Pintrich et al., 1993). Lastly, several academics advocate for a multidimensional approach which considers epistemological (classical), ontological and affective aspects when considering conceptual change (Tyson et al., 1997).

The transition of conceptual change models from cognitive-only to an understanding of the role of student traits in learning, is possibly the utmost notable contemporary growth in the field of conceptual change research (Sinatra, 2005). Earlier researches that determined affective variables used qualitative research methods like interviews to look for signs of conceptual shift (Venville & Treagust, 1998). A quantitative study approach has successfully revealed the influence of affective factors on students' conceptual change (Cordova et al., 2014). According to the latest research, certain "learner characteristics" appear to have an impact on the existence of conceptual changes (Sinatra & Mason, 2013). These comprise mindfulness, emotional and attitude (Chancey et al., 2020), interest (both individual and situational interest) (Mason, Gava, & Boldrin, 2008; Murphy & Alexander, 2004; Venville & Treagust, 1998), and self-efficacy (Linnenbrink-Garcia et al., 2012).

In the scientific field, as a result of developing conceptual models of change, many conceptual change instructional interventions have been conducted to remediate student misconceptions. Current instructional interventions that have implemented in science education study comprise: conceptual change texts (Cil & Cepni, 2015; Ozkan & Selcuk, 2015; Yuruk & Erog, 2016); cognitive conflict (Dega, Kriek, & Mogese, 2013; Madu & Orji, 2015); inquiry learning (Claver et al., 2021; Jiang et al., 2018; Supasorn, 2015), and computer simulations (Dega, Kriek, & Mogese, 2013; Fan, Geelan, & Gillies, 2018). Despite the value of conceptual change instruction and its agreement with contemporary constructivist perspectives of scientific learning, science teachers continue to favour transmissive learning strategies that promote knowledge acquisition (Duit, Widodo, & Wodzinski, 2007).

Conceptual change study in the last decade has been loaded by many instructional interventions. The review will be beneficial to provide the overview of the implementation of those instructional interventions. Yet, there are still few literature review studies conducted in science education. The existed review discussed about inhibition and conceptual learning in science (Mason & Zaccoletti, 2021), models of conceptual change in science learning (Potvin et al., 2020), instructional strategies to promote conceptual change about force and motion (Tomara, Tselfes, & Guoscos, 2017), conceptual change instructional approaches in earth and space science (Mills, Thomas, & Lewthwaite, 2016), and conceptual methapor (Amin, 2015). In addition, as part of our upcoming research in the field, we conducted a literature review to wrap up the implementation of the instructional interventions existed in conceptual change study.

Since the outbreak of the COVID-19, there have been transformation and adjustments in many sectors. Educational institutions in the majority of the countries from at all levels of education have migrated from the traditional methods of learning to virtual learning using electronic devices and online applications. This adjustment takes some times to establish the nice environment of teaching and learning process. Some keywords relating to the specific current condition in science education research have increased specifically. As an important topic in science education research, the authors aim to review empirical studies relating conceptual change and make period of COVID-19 pandemic as a time point to investigate the progress of conceptual change studies in the few years back. A future literature review has potential to provide an overview of the field since COVID-19 pandemic.

Methods

Researchers adapted procedures from Randolph (2009) for reviewing the literature in this investigation as Mills, Thomas, & Lewthwaite (2016) did in their review. The tasks involved in conducting a systematic literature review are formulating the problem, collecting data, evaluating data, analyzing and interpreting (Randolph, 2009). These five main tasks were operationalized by the researchers as detailed below.

Problem Formation

The development of questions that will lead to a literature review is the first step in the problem formulation process. To aid the literature review in this study, the following questions were devised:
(1) What are some of the common features of the literature?
(2) What instructional approach for conceptual change have been implemented in science classroom?
(3) What methodologies were utilized to evaluate the efficacy of these approaches?
(4) Which variables for conceptual change have been examined in science education?
(5) Based on the current research, what are the recommendations for future studies?

Data Collection

The authors assemble the studies included in this review from two main resources. Firstly, the first author conducts a manual search of currently published article since 2011 onwards in science education, cognitive science, and educational psychology journals. We chose the publishers indexed by Web of Science and Scopus such as Taylor & Francis, Springer, Wiley, Elsevier, Sage, and the others. The keywords used were: "conceptual change", "misconception", "student's conception" or "conceptual change in science education". Secondly, the reference lists of studies identified applicable. Hundreds of documents were discovered. Yet, only 50 articles matched our criteria as will be explained in the following section.

Data Evaluation

The first author sifted through hundreds of search results to find potentially relevant studies by reading their titles and abstracts first. Following that, several studies were thoroughly scrutinized for their applicability. Our two primary criteria in selecting article to review are studies in the field of science education and to use the certain treatments to measure or improve student's conceptions. As a result, only 50 studies were used to compile the data. In results, the topic which was not from science education (see, for example, Sel & Sözer, 2019) and researches that merely identified students' alternative beliefs, not whether or not they were changed by a specific intervention (e.g Redhana et al., 2017) were excluded.

Information taken from related studies was organized into a computerized database to keep this review manageable. This included information about the author of each study, the date of publication, the name of the journal, the author's region, the research approach, the participants, conceptual change theoretical framework, the findings, the limitations and recommendations for further research. To find gaps within existing literature subjects, the authors examined for similarities among teaching approaches.

Findings and Interpretation

Studies on conceptual changes have been published in educational and educational psychological journals for a long time. Numerous the most influential current conceptual change researchers (diSessa, 2006; Duit & Treagust, 2003; Vosniadou, 2008) traced the conceptual change field's inception went back to the 1970's, with the appearance of progressively fruitful study areas systematically concerned in students' misconceptions about scientific concepts (Driver & Easley, 1978).

The review activity of this study conducted for 7 weeks from September 22nd to November 3rd, 2021. The first author presented the report of review activity of 10 articles in every Wednesday of the first five weeks to other researchers. We synthesized the reviewed literature in the last two weeks. The authors were still identifying some limited theoretical and methodological advancements over this time. They are represented in the following four averments, all of which are supported by the findings of this review:

1. Physics disciplines have received more attention than other science domains;
2. The majority of studies were conducted on undergraduate students of various majors, not only science education students.
3. Studies on conceptual change have progressed from a cognitive to a metacognitive perspective; and,
4. Design on conceptual change study has been dominated by quasi-experimental with only pre- and post-intervention.

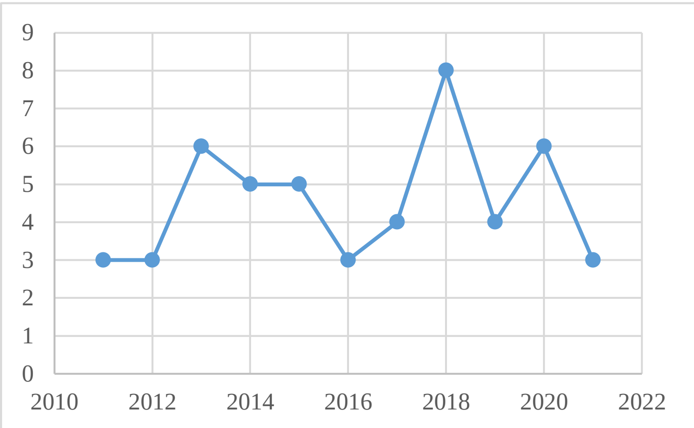
The findings presented below support the assertions made above.

Common Characteristics of the Literature

This section provides a resume of the common characteristics of the researches in this review.

Figure 1

Number of Publication per Year



Year, Publisher, and Region of Research

The researches chosen for review spanned from 2011 to 2021 (as shown in Figure 1). The majority of the researches were published in prominent scientific education journals like International Journal of Science Education (see Table 1). Educational psychology journals also published many studies relating conceptual change such as Learning and Instruction. The majority of the study was conducted in the United States, with Türkiye, Australia and Indonesia following closely after. Table 2 shows the entire data set. The number of publications has fluctuated throughout the last decade, as seen in Figure 1. The most number of publications emerged in 2018 and decreased gradually forwards. Although the authors set the publication time spanned until 2021, still no study conducted in COVID-19 pandemic era. As an effect of COVID-19 pandemic, academics and researchers have faced unpredicted and continuous disruptions in their teaching and research activities. Students and the teacher face several obstacles in learning process (Muthuprasad et al., 2021; Wisanti et al., 2021; Yesiloglu et al., 2021). Attention was dedicated in building attractive and pleasant learning environment though online distance learning or hybrid learning. Consequently, conceptual change study was not found in period 2020-2021. Therefore, this study contributes to the stand point for future studies of conceptual change in science education after COVID-19 pandemic.

Table 1

The Distribution of Research on Conceptual Changes in Science Education Based on Countries.

No	Country	f	E.g, (Only First Author Cited)
1	United States	10	Arthurs (2020), Chancey (2020), Thomas (2020), Zvoch (2019), Yazbec (2019), Heddy (2018), Taasoobshirazi (2016), Cordova (2014), Yin (2013), Gadgil (2012)
2	Türkiye	8	Taşlıdere (2021), Sarioglan (2017), Ozkan(2016), Yürük(2016), Çil(2015), Ozkan(2015), Çil (2014), Sevim (2013)
3	Australia	4	McLure (2020), Fan (2018), Liu (2018), Schleigh (2015)
4	Indonesia	3	Djudin (2021), Anggoro (2019), Syuhendri (2017)
5	Netherland	3	Loyens (2015), Lazonder (2014), Koops (2012)
6	Canada	3	Muis (2013), Ranellucci (2013), Franco (2012)
7	China	2	Gao (2018), Jiang (2018)
8	Italy	2	Mason (2018), Mason (2017)
9	Singapore	2	Fulmer (2013), Lee (2011)
10	United Kingdom	2	Flynn (2014), Howe (2013)
11	Switzerland	2	Leuchter (2020), Edelsbrunnera (2018)
12	Spain	1	Claver (2021)
13	Israel	1	Asterhan (2020)
14	Philippines	1	Morales (2017)
15	Ghana	1	Hanson (2018)
16	South Africa	1	Kapartzianis (2014)
17	Nigeria	1	Madu (2015)
18	Ethiopia	1	Dega (2013)
19	Cyprus	1	Hadjiachilleos (2013)
20	Finland	1	Ahopelto (2011)
21	Taiwan	1	Lin (2011)
	Total	50	

Table 2

The Journals That Have Been Selected for Review

No	Name of Journal	Indexed By	f
1	International Journal of Science Education	Scopus (Q1) & WoS (SSCI)	5
2	Journal of Baltic Science Education	Scopus (Q2) & WoS (SSCI)	5
3	Learning and Instruction	Scopus (Q1) & WoS (SSCI)	4
4	EURASIA Journal of Mathematics, Science and Technology Education	Scopus (Q2)	3
5	Journal of Turkish Science Education	Scopus (Q2)	3
6	Contemporary Educational Psychology	Scopus (Q1) & WoS (SSCI)	2

7	Instructional Science	Scopus (Q1) & WoS (SSCI)	2
8	Research in Science & Technological Education	Scopus (Q2) & WoS (SSCI)	2
9	International Journal of Education in Mathematics, Science and Technology	Scopus (Q2) & WoS (ESCI)	2
10	Other journals (22 journals, 22 documents)	Scopus and or WoS	1 per journal
	Total		50

Science Content

The majority of the studies in the review mentioned an instructional approach aimed at facilitating students' correct conceptions of physics materials, followed by biology, chemistry, earth-space science and integrated science, respectively. The accumulation of discussed topics was presented in Table 3. Based on Table 3, several studies examined some specific topics in either same or different science content. The most widely examined physics concept was Newtonian Mechanics. This topic was examined in every educational stage. There are two reasons why researchers are interested in examining Newtonian mechanics, especially concept relating with free-falling object, gravity and the action-reaction force. First, many studies showed that students and teachers have an alternative conception on the Newtonian Mechanics. Because of these abstract concepts, students frequently believe in their intuition and/or sensory perception (Galili & Bar, 2001; Vicovaro, 2014). Second, from an epistemological perspective, the fundamental building blocks of studying physics are the notions of force and motion (Carson & Rowlands, 2005; Tomara, Tselfes, & Guoscos; 2017; Young & Freedman, 2006;) and as one of the most important aspects of science literacy (Christensen et al., 2014).

Table 3

Discussed Topics in Examining Students' Conceptual Change

Science Content	Specific Topic	Reference(s)	f
Physics	Newtonian Mechanics	Mclure, Won & Treagust (2020)	16
		Anggoro et al. (2019)	
		Yazbec, Borovsky & Kaschak (2019)	
		Fan, Geelan & Gillies (2018)	
		Liu & Nesbit (2018)	
		Syuhendri (2017)	
		Morales (2017)	
		Taasoobshirazi et al. (2016)	
		Loyens et al. (2015)	
		Schleigh, Clark & Menekse (2015)	
		Lazonder & Ehrenhard (2014)	
		Flynn & Hardman (2014)	
		Koops & Hoevenaar (2013)	
		Howe, Devine & Tavares (2013)	
		Ranellucci et al. (2013)	
		Franco et al. (2012)	
	Pendulum	Ballesta-claver & Angustias (2021)	1
	Work and Energy	Lin, Liu & Chu (2011)	2
		Mason et al. (2018)	
	Pressure	Ozkan & Selcuk (2016)	2
		Ozkan & Selcuk (2015)	
	Density	Zvoch, Holveck & Porter (2019)	1
	Buoyancy	Djudin (2021)	8
		Leuchter et al. (2020)	
		Edelsbrunner et al. (2018)	
		Gao et al. (2018)	
		Ozkan & Selcuk (2016)	

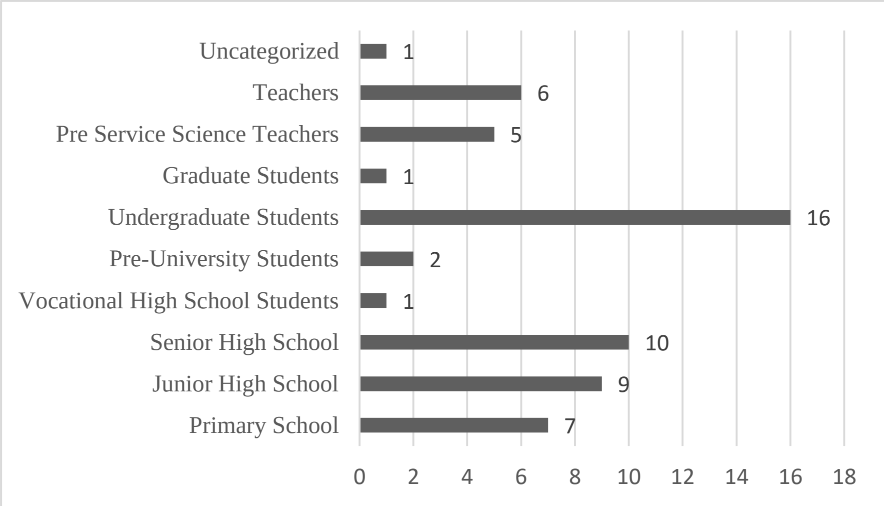
		Ozkan & Sezgin Selcuk (2015)	
		Hadjiachilleos, Valanides & Angeli (2013)	
		Yin, Tomita & Shavelson (2013)	
	Rotation	Lin, Liu & Chu (2011)	1
	Angular Momentum	Sarioglan & Kucukozer (2017)	1
	Mechanical Waves	Taşlıdere (2021)	1
	Temperature and Heat	Madu & Orji (2015)	2
		Yürük & Eroğlu (2016)	
	Thermal energy	Mclure, Won & Treagust (2020)	1
	Electricity	Dega, Kriek & Mogese (2013)	1
	Simple Electric Circuit	Kapartzianis & Kriek (2014)	1
	Electrical Resistance	Jiang et al. (2018)	1
	Magnetism	Dega, Kriek & Mogese (2013)	1
Biology	Genetics	Mclure et al. (2020)	2
		Yazbec, Borovsky & Kaschak (2019)	
	Evolution	Mclure, Won & Treagust (2020)	2
		Asterhan & Resnick (2020)	
	HIV / AIDS	Thomas & Kirby (2020)	1
	Circulatory System	Gadgil, Malach & Chi (2012)	1
	Water Cycle	Lee, Jonassen & Teo (2011)	1
	Groundwater Residence	Arthurs, Kowalski & Elwonger (2020)	1
	Photosynthesis	Ahopelto et al. (2011)	1
	Genetically modified foods	Chancey et al. (2020)	1
Earth & Space	Star Formation & Star Colors	Yazbec, Borovsky & Kaschak (2019)	1
	Seasonal Change	Mason et al. (2017)	3
		Cordova et al. (2014)	
		Fulmer (2013)	
	Climate Change	Chancey et al. (2020)	2
		Heddy et al. (2018)	
Chemistry	Acid-Base	Hanson (2018)	1
	Chemical Bonds	Sevim (2013)	1
	Intermolecular Forces	Sevim (2013)	1
Integrated Science	Nature of science	Çil & Çepni (2016)	2
		Cil (2014)	

Participants

The distribution of participants is shown in Figure 2. Most studies were conducted on undergraduate students with various majors, not only science education programme. Some studies were carried out with students from primary, junior and senior high school. Very few studies evaluated treatments targeting teachers' and pre service teachers' alternative conceptions. Only one study that targeted secondary school teachers and vocational high school students; no study evaluated senior high school teachers' scientific conceptions.

Figure 2

Distribution of Participant



The Approach of Study

The majority of the research was done on a small scale with a limited group of students, such as an intact primary school class. The majority of studies used a quasi-experimental study design aimed at comparing treatments between groups. A few studies were single case research designs that was primarily exploratory and interpretive in the natural setting. Several studies used mixed method approach in response to comprehensive analysis about conceptual change. Then, only three studies used qualitative approach in form of case study and described students' affective aspects on conflict cognitive through interview.

Table 4

The Approach of Studies

No	Research Approach	Number of Studies
1	Quantitative	33
2	Qualitative	4
3	Mixed Method	13
	Total	50

Conceptual Change Theoretical Framework

Almost all the studies conducted focused on conceptual change from a cognitive framework. Conceptual change model proposed by Posner et al. (1982) dominated the theoretical perspective in these studies. They were guided by theoretical frameworks that suggest that the experience of cognitive conflict that happens when confronted with information that explicitly opposes prior conceptions leads to conceptual change (Özdemir & Clark, 2007; Posner et al., 1982). Despite the fact that numerous researchers have identified cognitive conflict as a precondition for the process of substantial conceptual change, this perspective has faced noteworthy criticism (Caravita & Halden, 1994; Hatano & Iganaki, 2003; Pintrich et al. 1993; Sinatra & Pintrich; 2003; Smith et al. 1993). It is hypothesized that several emotional and motivational variables play an important part in learning about conceptual changes. However, the role of these variables is very complex (Cordova et al., 2014). Therefore, some studies have used Cognitive Reconstruction of Knowledge model (CRKM) by Dole and Sinatra (1998) as a wide-ranging analysis of numerous views, such as cognitive constructivist, social psychological and a product of science education (Potvin et al., 2020). Empirical researches have shown that considering cognitive conflict alone cannot adequately account for differences in the efficacy of instructional interventions aimed at correcting student misconceptions (Limon, 2001; Ramsburg & Ohlsson, 2016). As a result, present academics have extended on classic framework of conceptual change to recognize the significance of individual differences and motivational components in conceptual change.

Conceptual Change Instructional Approach, Variables Examined, and The Methods to Assess Itss Effectiveness

The reviewed researches conducted several instructional interventions for conceptual change to improve students' misconceptions of science materials or natural phenomena with accepted scientific concepts. These comprised: texts, graphic organizer, computer assisted instruction, learning strategy, learning models, method and assessment. Researchers in conceptual change field even integrated each intervention, so that was possible to find some interventions in one study. For example, Taşlıdere (2021) examined the relative effectiveness of conceptual change texts with concept cartoons (CCTCC) and 5E learning model with simulation activities (5ESA) on pre-service teachers' conceptual comprehension of waves. The complete conceptual change instructional interventions are presented in Table 5.

Table 5

List of the Conceptual Change Instructional Interventions and the Related Studies

Instructional Interventions	Specific Approach	Reference(s)	Number of Studies
Texts	Conceptual Change Text	Taşlıdere (2021) Syuhendri (2017) Yuruk & Erog (2016) Cil & Cepni (2015) Ozkan & Selcuk (2016) Ozkan & Selcuk (2015) Cil (2014) Sevim (2013)	8
	Refutation Text	Djudin (2021) Chancey et al. (2020) Asterhan & Resnick (2020) Thomas & Kirby (2020) Cordova et al. (2014) Heddy et al. (2018) Franco et al. (2012) Yazbec, Borovsky, & Kaschak (2019) Mason et al. (2018) Mason et al. (2017) Ranelluci et al. (2013)	11
	Expository Text	Yazbec, Borovsky & Kaschak (2019) Mason et al. (2018) Ahopelto et al. (2011)	3
	Fiction Book	Flynn & Hardman (2014)	1
Computer Assisted Instruction	Simulation	Fan, Geelan, Gillies (2018) Lazonder & Ehrenhard (2014) Dega, Kriek, & Mogese (2013) Howe, Devine & Tavares (2013)	4
	System Modelling	Lee, Jonassen & Teo (2011)	1
	Clicker-Assisted Conceptual Change Model	Lin, Liu & Chu (2011)	1
	Games	Koops & Hoevenaar (2012)	1
	Multimedia	Anggoro et al. (2019)	1

Graphic Organizer	Refutation Map	Liu & Nesbit (2018)	1
	Concept Map	Hanson & Seheri-Jele (2018)	1
	Diagram	Gadgil, Malach & Chi (2012)	1
Learning Strategy	Analogy	Hanson & Seheri-Jele (2018) Sevim (2013)	2
	Cognitive Conflict	Madu & Orji (2015) Dega, Kriek & Mogese (2013)	2
	Cognitive Perturbation	Dega, Kriek & Mogese (2013)	1
	Concept Cartoon	Taşlıdere (2021) Cil (2014)	2
	Concept Clipboard	Cil & Cepni (2015)	1
	CVS	Edelsbrunne et al. (2018)	1
	3-2-1 Reading	Djudin (2021)	1
	TFA	McLure, Won & Treagust (2020)	1
Learning Model	Contextual Based Learning	Morales (2017) Ozkan & Selcuk (2016) Ozkan & Selcuk (2015)	3
	Inquiry	Claver et al. (2021) Zvoch, Holveck & Porter (2019) Edelsbrunne et al. (2018) Jiang et al. (2018)	4
	Problem Based Learning	Loyens et al. (2015)	1
	Meaning-making based instruction	Sarioglan & Kucukozer (2017)	1
	Conceptual Change Model	Kapartzianis & Kriek (2014)	1
	5E	Taşlıdere (2021)	1
Method	Drawing	Arthurs, Kowalski & Elwonger (2020)	1
Assessment	Formative assessments	Yin, Tomita & Shavelson (2014)	1
	Clinical Interview	Hadjiachilleos, Valanides & Angeli (2013)	1

The field also explored many variables in establishing students' conceptual change process. It includes cognitive, affective, metacognitive and other aspects. The summary of variables examined in the field are presented in Table 6.

Table 6

Variables Examined in the Field and the Related Studies

Cognitive Aspects		
Variable	Reference(s)	f
Conceptual Change (Cognitive-only aspect examined)	Djudin (2021)	28
	Claver, Blanco & Pérez (2021)	
	Taşlıdere (2021)	
	Arthurs, Kowalski & Elwonger (2020)	
	McLure, Won & Treagust (2020)	
	Zvoch, Holveck & Porter (2019)	
	Anggoro et al. (2019)	
	Flynn & Hardman (2019)	
	Gao et al. (2018)	
	Liu & Liu (2018)	
	Jiang et al. (2018)	
	Syuhendri (2017)	
	Yuruk & Erog (2016)	
	Schleigh, Clark & Menekse (2015)	
	Hadjiachilleos, Valanides & Angeli (2013)	
	Howe (2013)	

	Loyens et al. (2015)	
	Sarioglan & Kucukozer (2017)	
	Yin, Tomita & Shavelson (2013)	
	Çil & Çepni (2015)	
	SEVİM (2013)	
	Ahopelto et al. (2011)	
	Çil (2014)	
	Ozkan & Selcuk (2015)	
	Madu & Orji (2015)	
	Dega, Kriek & Mogese (2013)	
	Koops & Hoevenaar (2012)	
	Gadgil, Malach & Chi (2011)	
Misconceptions	Ozkan & Selcuk (2016)	5
	Djudin (2021)	
	Hanson & Seheri-Jele (2018)	
	Mason et al. (2017)	
	Lazonder & Ehrenhard (2013)	
Problem Solving	Lee, Jonassen & Teo (2011)	2
	Asterhan (2020)	
Prior Knowledge	Mason et al. (2018)	2
	Cordova et al. (2014)	
Cognitive Engagement	Thomas & Kirby (2020)	2
	Taasoobshirazi et al. (2016)	
Knowledge Representation	Franco et al. (2012)	2
	Lin, Liu & Chu (2011)	
Cognitive Conflict	Thomas & Kirby (2020)	1
Cognitive processing	Franco et al. (2012)	1
The control-of-variables strategy	Edelsbrunne et al. (2018)	1
Reading comprehension	Mason et al. (2018)	1
	Affective	
Self-efficacy	Cordova et al. (2014)	1
Confidence in prior knowledge	Cordova et al. (2014)	1
Interest	Cordova et al. (2014)	1
Emotional	Chancey et al. (2020)	1
individual interest	Thomas & Kirby (2020)	1
situational interest	Thomas & Kirby (2020)	1
Attitude	Chancey et al. (2020)	1
Attitudes toward science	Fulmer (2013)	1
Confidence in learning	Fan, Geelan & Gillies (2018)	1
Boredom	Taasoobshirazi et al. (2016)	1
Enjoyment and anxiety	Taasoobshirazi et al. (2016)	1
	Metacognitive	
Epistemic beliefs	Morales (2018)	2
	Franco et al. (2012)	
Need for cognition	Thomas & Kirby (2020)	2
	Taasoobshirazi et al. (2016)	
Metacognitive awareness	Mason et al. (2017)	1
Motivation	Taasoobshirazi et al. (2016)	1
Achievement goals	Ranelluci (2013)	1
Personal relevance	Heddy et al. (2018)	1
Attention	Heddy et al. (2018)	1
Mental model	Gadgil, Malach, Chi (2011)	1
	Other Domains	
Teacher's PCK	Fulmer (2013)	2
	Leuchter et al. (2020)	
Culture	Heddy (2018)	1
Gender	Fan, Geelan & Gillies (2018)	1
Teacher's understanding of conceptual change	Fulmer (2013)	1
Inquiry process skills	Fan, Geelan & Gillies (2018)	1
Level of academic achievement	Fan, Geelan & Gillies (2018)	1
Text Type	Yazbec, Borovsky & Kaschak (2019)	1

Text Texture	Yazbec, Borovsky & Kaschak (2019)	1
Variability	Yazbec, Borovsky & Kaschak (2019)	1

Based on Table 6, it can be seen that more than half reviewed studies examined conceptual change itself as results of cognitive-only framework used in those studies. Affective, metacognitive and other domains started to emerge in the literature. Conceptual change as a cognitive variable was measured or described in many methods. The most used were using profile of conception/understanding, remediation of misconception and learning gains. Conceptual change was also modelled by the four-level learning progression (e.g. Gao et al., 2018), learning progression (e.g. Anggoro et al., 2019) and progress of concept sketch (e.g. Arthurs, Kowalski & Elwonger, 2020). The data of conceptual change was nearly generated by pre- and post-test. Some studies used pre- and post-questionnaire (e.g. Claver, Blanco & Pérez, 2021) and free recall test (e.g. Liu & Liu, 2018).

In terms of affective, metacognitive and other domains, they were examined through refutation texts, related questionnaire or interviews. Refutation text was most used to bring about affective and or metacognitive aspects, such as epistemic belief (e.g. Franco et al., 2012), achievement goals (e.g. Ranellucci et al., 2013), confidence in prior knowledge, self-efficacy, interest and prior knowledge (e.g. Cordova et al., 2014), mindfulness, emotional and attitude (e.g. Chancey et al., 2020), and situational interest (e.g. Thomas & Kirby, 2020).

Based on findings, the most noticeable trend in the current literature is that instructional studies in science education used theoretical and methodological frameworks that are now considered outdated. The most significant theoretical limitation was that nearly all of the studies observed conceptual change from a cognitive-only framework which led into examining of conceptual change itself quantitatively. Studies in establishing the factor influencing conceptual change process have explored some affective and metacognitive variables. Yet, those variables have not been considered in empirical study to foster conceptual change. Another obvious trend is that research method used in these studies was dominated with pre- and post-test with small group and data collection was obtained and analysed quantitatively.

Recommendations for Upcoming Study Synthesized from the Literature

The authors have recognized the necessity for conceptual change study in the science education that:

1. Invites future empirical study to design instructional approach by considering affective variables. From the review, almost all empirical studies have used refutation text widely to determine various affective and metacognitive variables that influence student's conceptual change, such as mindfulness, emotional and attitude (e.g. Chancey et al., 2020), situational interest (e.g. Thomas & Kirby, 2020), epistemic beliefs (e.g. Yazbeck, Borovsky & Kaschak, 2019), inhibition (e.g. Mason et al., 2018), confidence in previous conception, interest, and self-efficacy (e.g. Cordova et al., 2014), etc. These variables have not been explicitly considered in designing instructional interventions. Only few studies inserting affective or metacognitive aspects explicitly in the learning stages. For example, Loyens et al. (2015) considered deep engagement in problem-based learning's stage as a metacognitive cause of student's conceptual change in their result and discussion. Thus, future novel instructions considering the affective and metacognition aspects explicitly will be useful to strengthen empirically the previous studies that have explored those aspects.
2. Applies qualitative data collection methods regarding affective and metacognitive variables through the implementation of an instructional intervention. Following the first recommendation, beside as a consideration of learning stages, affective and metacognitive aspects should be measured by qualitative data collection to strengthen empirically the previous studies more. From the review, there was no study that examined an instructional approach and measured the affective or metacognitive aspects. Only cognitive aspect was measure in the reviewed studies.

3. Focuses on examining pre-service science teachers' conceptual change through the implementation of an instructional intervention. From the review, only five studies that examined both pre-service teacher's and teacher's conceptual changes. Previous studies have found that teachers lacked a thorough comprehension of scientific notions (Adu-Gyamfi, 2019; Halim et al., 2014). Furthermore, some studies reported that both students and teachers have similar alternative ideas (Abd-El-Khalick et al., 1998; Burgoon et al. 2011; Dogan & Abd-El-Khalick, 2008). This discovery could be attributed to elementary teachers who are not well prepared to teach science in accordance with accepted scientific concepts (Halim et al., 2014). In response this finding, research that implement instructional approach based on conceptual change to pre-service science teacher will be useful. In accordance with Mahasneh and Al-Zou'bi (2021), at a closer look at the preparation of science teachers is essential to help students reach various learning goals.

Concluding Remarks

This study has investigated the recent body of study which explored instructional approaches aimed at enabling student's correct conceptions about science materials. In general, it seems that instructional approaches over the past one decade have been varying from textual and using several learning strategies to the use of computer-assisted instruction as technological advancement. Most of the researchers compared and combined some existing instructional approaches and established their effectiveness in fostering conceptual change. Another trend in conceptual change research was figuring out or establishing the factors building up conceptual change process that students have. These factors consist of affective and metacognitive variable determining individual characteristics, such as mindfulness, emotional and attitude, situational interest, epistemic beliefs, confidence in prior knowledge, self-efficacy, achievement goals, epistemic beliefs and knowledge representations.

References

Abd-El-Khalick, F., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: making the unnatural natural. *Science Education*, 82, 417–436. https://doi.org/10.1002/(SICI)1098-237X(199807)82:4<417::AID-SCE1>3.0.CO;2-E

Adu-Gyamfi, K. (2019). Pre-service teachers' conception of an effective science teacher: the case of initial teacher training. *Journal of Turkish Science Education*, 18(4), 605-621. https://doi.org/10.36681/tused.2020.12

Amin, T. G. (2015). Conceptual metaphor and the study of conceptual change: research synthesis and future directions. *International Journal of Science Education*, 37(5-6), 966-991. https://doi.org/10.1080/09500693.2015.1025313

Anggoro, S. (2019). Using a discrepant event to facilitate preservice elementary teachers' conceptual change about force and motion, *EURASIA Journal of Mathematics, Science and Technology Education* 15(8), 1-21. https://doi.org/10.29333/ejmste/105275

Arthurs, L. A., Kowalski, C. M., & Elwonger, J. M. (2020). Drawing as a method to facilitate conceptual change in earth sciences education, *Journal of Astronomy & Earth Sciences Education*, 7(1), 1-24.

Asterhan, C. S. C., & Resnick, M. S. (2020). Refutation texts and argumentation for conceptual change: a winning or a redundant combination?. *Learning and Instruction*, 65(September 2019), 101265. https://doi.org/10.1016/j.learninstruc.2019.101265

Ballesta-claver, J., & Angustias, I. (2021). A revisited conceptual change in mathematical-physics education from a neurodidactic approach: a pendulum inquiry. *Mathematic*, 9(15), 1755. https://doi.org/10.3390/math9151755

Broughton, S. H., Sinatra, G. M., & Reynolds, R. E. (2010). The nature of the refutation text effect: an investigation of attention allocation. *Journal of Educational Research*, 103(6), 407–423. https://doi.org/10.1080/00220670903383101

Campbell, J. & Mayer, R. E. (2009). Questioning as an instructional method: does it affect learning from lectures?. *Applied Cognitive Psychology*, 23(6), 747-759. https://doi.org/10.1002/acp.1513

Caravita, S., & Halldén, O. (1994). Re-framing the problem of conceptual change. *Learning and Instruction*, 4(1), 89–111. https://doi.org/10.1016/0959-4752(94)90020-5

Carson, R., & Rowlands, S. (2005). Mechanics as the logical point of entry for the enculturation into scientific thinking. *Science & Education*, 14, 473–493. https://doi.org/10.1007/s11191-004-1791-9

Chancey, J. B., Heddy, B. C., Lippmann, M., & Meek, D. (2020). Investigating the impact of mindfulness-based interventions on processes of conceptual, emotional, and attitude change, *Journal of Cognitive Enhancement*. 5(2), 204-217. https://doi.org/10.1007/s41465-020-00195-z

Chi, M., Slotta, J., & De Leeuw, N. (1994). From things to processes: a theory of conceptual change for learning science concepts. *Learning and Instruction*, 4(1), 27–43. https://doi.org/10.1016/0959-4752(94)90017-5

Çil, E. (2014). Teaching nature of science through conceptual change approach: conceptual change texts and concept cartoons, *Journal of Baltic Science Education*, 13(3), 339-350. https://doi.org/10.33225/jbse/14.13.339

Çil, E., & Çepni, S. (2015). The effectiveness of conceptual change texts and concept clipboards in learning the nature of science. *Research in Science and Technological Education*, 34(1), 43–68. https://doi.org/10.1080/02635143.2015.1066323

Christensen R, Knezek G, Tyler-Wood T, Gibson D. (2014). Longitudinal analysis of cognitive constructs fostered by stem activities in middle school students. *Knowledge Management & E-Learning*, 6(2), 103–122. https://doi.org/10.34105/j.kmel.2014.06.008

Cordova, J. R., Sinatra, G. M., Jones, S. H., Taasoobshirazi, G., & Lombardi, D. (2014). Confidence in prior knowledge, self-efficacy, interest and prior knowledge: influences on conceptual change. *Contemporary Educational Educational Psychology*, 39(2), 164–174. https://doi.org/10.1016/j.cedpsych.2014.03.006

Dega, B. G., Kriek, J., & Mogese, T. F. (2013). Students' conceptual change in electricity and magnetism using simulations: a comparison of cognitive perturbation and cognitive conflict, *Journal of Research in Science Teaching*, 50(6), 677-698. https://doi.org/10.1002/tea.21096

Dole, J. A., & Sinatra, G. M. (1998). Reconceptualizing change in the cognitive conception of knowledge. *Educational Psychologist*, 33(2–3), 109–128. https://doi.org/10.1080/00461520.1998.9653294

Diakidoy, I. N., Mouskounti, T., Fella, A., & Ioannides, C. (2016). Comprehension processes and outcomes with refutation and expository texts and their contribution to learning. *Learning and Instruction*, 41, 60–69. https://doi.org/10.1016/j.learninstruc.2015.10.002

diSessa, A. A. (2006). *A history of conceptual change research: Threads and fault lines*. In R. K. Sawyer (Ed.), The Cambridge handbook of the learning sciences (pp. 265–281). Cambridge University press.

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. https://doi.org/10.36681/tused.2021.66

Dogan, N., & Abd-El-Khalick, F. (2008) Turkish grade 10 students' and science teachers' conceptions of nature of science: a national study. *Journal of Research in Science Teaching*, 45(10), 1083–1112. https://doi.org/10.1002/tea.20243

Driver, R., & Easley, J. (1978). Pupils and paradigms: a review of literature related to concept development in adolescent science students. *Studies in Science Education*, 5(1), 61–84. https://doi.org/10.1080/03057267808559857

Duit, R., & Treagust, D. (2003). Conceptual change : a powerful framework for improving science teaching and learning. *International Journal of Science Education*, 25(6), 671–688. https://doi.org/10.1080/09500690305016

Duit, R., Treagust, D., & Widodo, A. (2008*). Teaching for conceptual change - theory and practice*. In S. Vosniadou (Ed.), International handbook of research on conceptual change. New York: Routledge

Duit, R., Widodo, A., & Wodzinski, C. (2007). *Conceptual change ideas – teachers' views and their instructional practice.* In S. Vosnaidou, A. Baltas, & X. Vamvokoussi (Eds.), Re-framing the problem of conceptual change learning and instruction (pp. 197–217). Amsterdam: Elsevier

Edelsbrunner, P. A., Schalk, L., Schumacher, R., & Stern, E. (2018). Learning and individual differences variable control and conceptual change: a large-scale quantitative study in elementary school. *Learning and Individual Differences*, 66, 38-53. https://doi.org/10.1016/j.lindif.2018.02.003

Fan, X., Geelan, D., & Gillies, R. (2018). Evaluating a novel instructional sequence for conceptual change in physics using interactive simulations, *Education Science*, 8(1), 29. https://doi.org/10.3390/educsci8010029

Flynn, S., & Hardman, M. (2019). The use of interactive fiction to promote conceptual change in science. *Science & Education*, 28(1), 127-152. https://doi.org/10.1007/s11191-019-00032-6

Franco, G. M., Muis, K. R., Kendeou, P., Ranellucci, J., Sampasivam, L., & Wang, X. (2012). Examining the influences of epistemic beliefs and knowledge representations on cognitive processing and conceptual change when learning physics. *Learning and Instruction*, 22(1), 62–77. https://doi.org/10.1016/j.learninstruc.2011.06.003

Fulmer, G. W. (2013). Constraints on conceptual change: how elementary teachers' attitudes and understanding of conceptual change relate to changes in students' conceptions. *Journal of Science Teacher Education*, 24(7), 1219–1236. https://doi.org/10.1007/s10972-013-9334-3

Gadgil, S., Nokes-Malach, T. J., & Chi, M. T. H. (2012). Effectiveness of holistic mental model confrontation in driving conceptual change. *Learning and Instruction*, 22(1), 47–61. https://doi.org/10.1016/j.learninstruc.2011.06.002

Galili, I. (2001). Weight versus gravitational force: Historical and educational perspectives, *International Journal of Science Education*, 23(10), 1073-1093. https://doi.org/10.1080/09500690110038585

Gao, Y., Zhai, X., & Andersson, B. (2018). Developing a learning progression of buoyancy to model conceptual change: a latent class and rule space model analysis, *Research in Science Education*, 50(4). https://doi.org/10.1007/s11165-018-9736-5

Halim, L., Yong, T. K., & Meerah, T. S. M. (2014). Overcoming students' misconceptions on forces in equilibrium: an action research study. *Creative Education*, 5, 1032-1042. https://doi.org/10.4236/ce.2014.511117

Hadjiachilleos, S., Valanides, N., & Angeli, C. (2013). The impact of cognitive and affective aspects of cognitive conflict on learners' conceptual change about floating and sinking. *Research in Science and Technological Education*, 31(2), 133–152. https://doi.org/10.1080/02635143.2013.811074

Hanson, R., & SEHERI-JELE, N. (2018). Assessing conceptual change instruction accompanied with concept maps and analogies: a case of acid-base strengths. *Journal of Turkish Science Education*, 15(4), 55–64. doi: 10.12973/tused.10245a

Hatano, G., & Iganaki, K. (2003). *When is conceptual change intended? A cognitive-sociocultural view*. In G. M. Sinatra & P. R. Pintrich (Eds.), Intentional conceptual change (pp. 407–427). Mahwah, NJ: Lawrence Erlbaum Associates.

Heddy, B. C., Taasoobshirazi, G., Chancey, J. B., & Danielson, R. W. (2018). Developing and validating a conceptual change cognitive engagement instrument. *Frontiers in Education*, 3, 1–9. https://doi.org/10.3389/feduc.2018.00043

Howe, C., Devine, A., & Taylor Tavares, J. (2013). Supporting conceptual change in school science: a possible role for tacit understanding. *International Journal of Science Education*, 35(5), 864–883. https://doi.org/10.1080/09500693.2011.585353

Jiang, T., Wang, S., Wang, J., Ma, Y. (2018). Effect of different instructional methods on students' conceptual change regarding electrical resistance as viewed from a synthesized theoretical framework, *EURASIA Journal of Matematics, Science, and Technology Education*, 14(7), 2771-2786. https://doi.org/10.29333/ejmste/90592

Kapartzianis, A., & Kriek, J. (2014). Conceptual change activities alleviating misconceptions about electric circuits, *Journal of Baltic Science Education*, 13(3), 2014, 298-315. https://doi.org/10.33225/jbse/14.13.298

Koops, M., & Hoevenaar, M. (2013). Conceptual change during a serious game: using a lemniscate model to compare strategies in a physics game. *Simulation & Gaming*, 44(4), 544-561. https://doi.org/10.1177/1046878112459261

Lazonder, A. W., & Ehrenhard, S. (2014). Relative effectiveness of physical and virtual manipulatives for conceptual change in science: How falling objects fall. *Journal of Computer Assisted Learning*, 30(2), 110–120. https://doi.org/10.1111/jcal.12024

Lee, C. B., Jonassen, D., & Teo, T. (2011). The role of model building in problem solving and conceptual change. *Interactive Learning Environments*, 19(3), 247–265. https://doi.org/10.1080/10494820902850158

Leuchter, M., Saalbach, H., Studhalter, U., Tettenborn, A., Leuchter, M., Saalbach, H., Studhalter, U., & Tettenborn, A. (2020). Teaching for conceptual change in preschool science: relations among teachers' professional beliefs, knowledge, and instructional practice. *International Journal of Science Education*, 42(12), 1941-1967. https://doi.org/10.1080/09500693.2020.1805137

Lin, Y. C., Liu, T. C., & Chu, C. C. (2011). Implementing clickers to assist learning in science lectures: The clicker-assisted conceptual change model. *Australasian Journal of Educational Technology*, 27(6), 979–996. https://doi.org/10.14742/ajet.924

Limon, M. (2001). On the cognitive conflict as an instructional strategy for conceptual changes: a critical appraisal. *Learning and Instruction*, 36(4-5), 357–380. https://doi.org/10.1016/S0959-4752(00)00037-2

Lin, J.-W., Yen, M.-H., Liang, J.-C., Chiu, M.-H., & Guo, C.-J. (2016). Examining the factors that influence students' science learning processes and their learning outcomes: 30 years of conceptual change research. *Eurasia Journal of Mathematics, Science & Technology Education*, 12(9), 2617–2646. https://doi.org/10.12973/eurasia.2016.000600a

Linnenbrink-Garcia, L., Pugh, K., Koskey, K., & Stewart, V. (2012). Developing conceptual understanding of natural selection: the role of interest, efficacy, and basic prior knowledge. *The Journal of Experimental Education*, 80(1), 45–68. https://doi.org/10.1080/00220973.2011.559491

Liu, Q., & Nesbit, J. C. (2018). Conceptual change with refutational maps. *International Journal of Science Education*, 40(16), 1980-1998. https://doi.org/10.1080/09500693.2018.1515513

Loyens, S. M. M., Jones, S. H., Mikkers, J., & van Gog, T. (2015). Problem-based learning as a facilitator of conceptual change. *Learning and Instruction*, 38, 34–42. https://doi.org/10.1016/j.learninstruc.2015.03.002

Madu, B. C., & Orji, E. (2015). Effects of cognitive conflict instructional strategy on students' conceptual change in temperature and heat. *SAGE Open*, 5(3), 1-9. https://doi.org/10.1177/2158244015594662

Mahasneh, A., & Al-Zou'bi, Z. (2021). Conceptions of assessment: perceptions of science teachers in jordan. *Journal of Turkish Science Education*, 18(3), 389-400. https://doi.org/10.36681/tused.2021.80

Mason, L., Baldi, R., Di, S., Scrimin, S., Danielson, R. W., & Sinatra, G. M. (2017). Textual and graphical refutations: Effects on conceptual change learning. *Contemporary Educational Psychology*, 49, 275–288. https://doi.org/10.1016/j.cedpsych.2017.03.007

Mclure, F., Won, M., Treagust, D. F. (2020). A sustained multidimensional conceptual change intervention in grade 9 and 10 science classes in grade 9 and 10 science classes. *International Journal of Science Education*, 42(5), 703-721. https://doi.org/10.1080/09500693.2020.1725174

Morales, M. P. E. (2017). Exploring indigenous game-based physics activities in pre-service physics teachers' conceptual change and transformation of epistemic beliefs. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(5), 1377–1409. https://doi.org/10.12973/eurasia.2017.00676a

Mason, L., Zaccoletti, S., Carretti, B., Scrimin, S., Diakidoy, I. N., & Mason, L. (2018). The role of inhibition in conceptual learning from refutation and standard expository texts. *International*

Journal of Science and Mathematics Education, 17(3), 483-501. https://doi.org/10.1007/s10763-017-9874-7

Mason, L., & Zaccoletti, S. (2021). Inhibition and conceptual learning in science: a review of studies. *Educational Psychology Review*, 33(1), 181-212. https://doi.org/10.1007/s10648-020-09529-x

Mills, R., Tomas, L., & Lewthwaite, B. (2016). Learning in Earth and space science: a review of conceptual change instructional approaches. *International Journal of Science Education*, 38(5), 767-790. https://doi.org/10.1080/09500693.2016.1154227

Murphy, P., & Alexander, P. (2004). Persuasion as a dynamic, multidimensional process: An investigation of individual and intraindividual differences. *American Educational Research Journal*, 41 (2), 337–363. https://doi.org/10.3102/00028312041002337

Muthuprasad, T., Aiswarya, S., Aditya, K. S., & Jha, G. K. (2021). Students' perception and preference for online education in India during COVID -19 pandemic. *Social Sciences & Humanities Open*, 3(1), 100101.

Nussbaum, J., & Novick, S. (1982). Alternative frameworks, conceptual conflict and accommodation: Toward a principled teaching strategy. *Instructional Science*, 11(3), 183–200.

Özdemir, G., & Clark, D. B. (2007). An overview of conceptual change theories. *Eurasia Journal of Mathematics, Science & Technology Education*, 3(4), 351–361. https://doi.org/10.12973/ejmste/75414

Ozkan, G., & Selcuk, G. S. (2016). Facilitating conceptual change in students' understanding of concepts related to pressure. *European Journal of Physics*, 37(5), 1–20. https://doi.org/10.1088/0143-0807/37/5/055702

Ozkan, G., & Sezgin Selcuk, G. (2015). The effectiveness of conceptual change texts and context-based learning on students' conceptual achievement. *Journal of Baltic Science Education*, 14(6), 753–763. https://doi.org/10.33225/jbse/15.14.753

Pintrich, P., Marx, R., & Boyle, R. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research*, 63(2), 167–199. https://doi.org/10.3102/00346543063002167

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Towards a theory of conceptual change. *Science Education*, 66(2), 211–227. https://doi.org/10.1002/sce.3730660207

Potvin, P., Nenciovici, L., Malenfant-Robichaud, G., Thibault, F., Sy, O., Mahhou, M. A., Bernard, A., Allaire-Duquette, G., Blanchette Sarrasin, J., Brault Foisy, L. M., Brouillette, N., St-Aubin, A. A., Charland, P., Masson, S., Riopel, M., Tsai, C. C., Bélanger, M., & Chastenay, P. (2020). Models of conceptual change in science learning: establishing an exhaustive inventory based on support given by articles published in major journals. *Science Education*, 56(2), 157–211. https://doi.org/10.1080/03057267.2020.1744796

Ramsburg, J. T., & Ohlsson, S. (2016). Category change in the absence of cognitive confict. *Journal of Educational Psychology*, 108(1), 98–113. https://doi.org/10.1037/edu0000050

Randolph, J. (2009). A guide to writing the dissertation literature review. *Practical Assessment, Research, and Evaluation*, 14(13), 1-13. https://doi.org/10.7275/b0az-8t74

Ranellucci, J., Muis, K. R., Duffy, M., Wang, X., Sampasivam, L., & Franco, G. M. (2013). To master or perform? Exploring relations between achievement goals and conceptual change learning. *British Journal of Educational Psychology*, 83(3), 431–451. https://doi.org/10.1111/j.2044-8279.2012.02072.x

Redhana, I. W., Sudria, I. B. N., Hidayat, I., & Merta, L. M. (2017). Identification of chemistry learning problems viewed from conceptual change model, *Jurnal Pendidikan IPA Indonesia*, 6(2), 356-364. https://doi.org/10.15294/jpii.v6i2.8741

Resbiantoro, G., & Setiani, R. (2022). A review of misconception in physics: the diagnosis, causes, and remediation. *Journal of Turkish Science Education*, 19(2). 403-427. https://doi.org/10.36681/tused.2022.128

Sarioglan, A. B., & Kucukozer, H. (2017). Effect of meaning making approach on students' conceptual understanding: an examination of angular momentum conservation, *International Journal of*

Education in Mathematics, Science and Technology, 5(3), 203-220. https://doi.org/10.18404/ijemst.296035

SEVİM, S. (2013). Promoting conceptual change in science, which is more effective: conceptual change text or analogy?, *Journal of Turkish Science Education*, 10(3), 24-36.

Schleigh, S. P., Clark, D. B., & Menekse, M. (2015). Constructed-response as an alternative to interviews in conceptual change studies: students' explanations of force, *International Journal of Education in Mathematics, Science and Technology*, 3(1), 14–36.

Syuhendri. (2017). A learning process based on conceptual change approach to foster conceptual change in newtonian mechanics. *Journal of Baltic Science Education*, 16(2), 228-240. https://doi.org/10.33225/jbse/17.16.228

Sel, B., & Sözer, M, A. (2019). The effect of conceptual change texts on the level of conceptual understanding of students. *International Electronic Journal of Elementary Education*, 11(4), 383-391. https://doi.org/10.26822/iejee.2019450796

Sinatra, G., & Mason, L. (2013). *Beyond knowledge: Learner characteristics influencing conceptual change*. In S. Vosniadou (Ed.), International handbook of research on conceptual change (2nd ed., pp. 377–394). New York, NY: Routledge

Sinatra, G. (2005). The warming trend in conceptual change research: The legacy of Paul R. Pintrich. *Educational psychologist*, 40(2), 107–115. https://doi.org/10.1207/s15326985ep4002_5

Smith, J. P., diSessa, A. A., & Roschelle, J. (1993). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *Journal of the Learning Sciences*, 3, 115–163. https://doi.org/10.1207/S15327809JLS0302_1

Supasorn, S. (2015). Grade 12 students' conceptual understanding and mental models of galvanic cells before and after learning by using small-scale experiments in conjunction with a model kit. *Chemistry Education Research and Practice*, 16, 393–407.

Taasoobshirazi, G., Heddy, B., & Bailey, M. (2016). A multivariate model of conceptual change. *Instructional Science*. https://doi.org/10.1007/s11251-016-9372-2

Taşlıdere, E. (2021). Relative effectiveness of conceptual change texts with concept cartoons and 5e learning model with simulation activities on pre-service teachers' conceptual understanding of waves, *Participatory Educational Research*, 8(4), 215–238. https://doi.org/10.17275/per.21.87.8.4

Thomas, C. L., & Kirby, L. A. J. (2020). Situational interest helps correct misconceptions: An investigation of conceptual change in university students. *Instructional Science*, 48(3), 223–241. https://doi.org/10.1007/s11251-020-09509-2

Tomara, M., Tselfes, V., & Guoscos, D. (2017). Instructional strategies to promote conceptual change about force and motion: A review of the literature, *Themes in Science & Technology Education*, 10(1), 1-16

Tyson, L., Venville, G., Harrison, A., & Treagust, D. (1997). A multidimensional framework for interpreting conceptual change events in the classroom. *Science Education*, 81(4), 387–404. https://doi.org/10.1002/(SICI)1098-237X(199707)81:4<387::AID-SCE2>3.0.CO;2-8

Venville, G. J., & Treagust, D. F. (1998). Exploring conceptual change in genetics using a multidimensional interpretive framework. *Journal of Research in Science Teaching*, 35(9), 1031–1055. https://doi.org/10.1002/(SICI)1098-2736(199811)35:9<1031::AID-TEA5>3.0.CO;2-E

Vicovaro, M. (2014). Intuitive physics of free fall: an information integration approach to the mass-speed belief. *Psicológica*, 35, 463-477

Vosniadou, S. (2008). *Conceptual change research: An introduction*. In S. Vosniadou (Ed.), International handbook of research on conceptual change (pp. xiii–xxviii). Routledge.

Vousniadou, S. (2013). Conceptual change in learning and instruction: The framework theory approach, International handbook of research on conceptual change, 2nd Edn, ed S. Vosniadou (pp 11-30). Routledge

Vosniadou, S., & Skopeliti, I. (2005). Conceptual change from the framework theory side of the fence. *Science Education*, 23, 1427–1445. https://doi.org/10.1007/s11191-013-9640-3

Wisanti., Ambawati, R., Putri, E K., Rahayu, D A., & Khaleyla, F. Science online learning during the covid-19 pandemic: difficulties and challenges, *Journal of Physics: Conference Series*, 1747. https://doi.org/10.1088/1742-6596/1747/1/012007

Yazbec, A.., Borovsky, A., & Kaschak, M. P. (2019). Examining the impact of text style and epistemic beliefs on conceptual change. *PLoS ONE*, 1–16. https://doi.org/10.1371/journal.pone.0220766

Yesiloglu, S. N., Gençer, S., Ekici, F., & Isik, B. (2021). Examining pre-service teachers' views about online chemistry laboratory learning experiences amid the covid-19 pandemic. *Journal of Turkish Science Education*, 18, 108-124.

Yin, Y., Tomita, M. K., & Shavelson, R. J. (2013). Using formal embedded formative assessments aligned with a short term learning progression to promote conceptual change and achievement in science, *International Journal of Science Education*, 36(4), 531-552. https://doi.org/10.1080/09500693.2013.787556

Young, H. D., & Freedman, R. A. (2006). *University Physics* 12 edn. Reading, MA: Addison Wesley

Yürük, N., & Eroğlu, P. (2016). The effect of conceptual change texts enriched with metaconceptual processes on pre-service science teachers' conceptual understanding of heat and temperature. *Journal of Baltic Science Education*, 15(6), 693–705. https://doi.org/10.33225/jbse/16.15.693

Zvoch, K., Holveck, S., & Porter, L. (2019). Teaching for conceptual change in a density unit provided to seventh graders: a comparison of teacher- and student-centered approaches, *Research in Science Education*. 51(5), 1395-1421. https://doi.org/10.1007/s11165-019-09907-8

Appendix. The Reviewed Articles

Ahopelto, I., Mikkilä-Erdmann, M., Anto, E., & Penttinen, M. (2011). Future elementary school teachers' conceptual change concerning photosynthesis. *Scandinavian Journal of Educational Research*, 55(5), 503–515. https://doi.org/10.1080/00313831.2010.550060

Anggoro, S. (2019). Using a discrepant event to facilitate preservice elementary teachers' conceptual change about force and motion, *EURASIA Journal of Mathematics, Science and Technology Education* 15(8), 1-21. https://doi.org/10.29333/ejmste/105275

Arthurs, L. A., Kowalski, C. M., & Elwonger, J. M. (2020). Drawing as a method to facilitate conceptual change in earth sciences education, *Journal of Astronomy & Earth Sciences Education*, 7(1), 1-24

Asterhan, C. S. C., & Resnick, M. S. (2020). Refutation texts and argumentation for conceptual change: a winning or a redundant combination?. *Learning and Instruction*, 65(September 2019), 101265. https://doi.org/10.1016/j.learninstruc.2019.101265

Ballesta-claver, J., & Angustias, I. (2021). A revisited conceptual change in mathematical-physics education from a neurodidactic approach: a pendulum inquiry. *Mathematic*, 9(15), 1755. https://doi.org/10.3390/math9151755

Chancey, J. B., Heddy, B. C., Lippmann, M., & Meek, D. (2020). Investigating the impact of mindfulness-based interventions on processes of conceptual, emotional, and attitude change, *Journal of Cognitive Enhancement*. 5(2), 204-217. https://doi.org/10.1007/s41465-020-00195-z

Çil, E. (2014). Teaching nature of science through conceptual change approach: conceptual change texts and concept cartoons, *Journal of Baltic Science Education*, 13(3), 339-350. https://doi.org/10.33225/jbse/14.13.339

Çil, E., & Çepni, S. (2015). The effectiveness of conceptual change texts and concept clipboards in learning the nature of science. *Research in Science and Technological Education*, 34(1), 43–68. https://doi.org/10.1080/02635143.2015.1066323

Cordova, J. R., Sinatra, G. M., Jones, S. H., Taasoobshirazi, G., & Lombardi, D. (2014). Confidence in prior knowledge, self-efficacy, interest and prior knowledge: influences on conceptual change. *Contemporary Educational Educational Psychology*, 39(2), 164–174. https://doi.org/10.1016/j.cedpsych.2014.03.006

Dega, B. G., Kriek, J., & Mogese, T. F. (2013). Students' conceptual change in electricity and magnetism using simulations: a comparison of cognitive perturbation and cognitive conflict, *Journal of Research in Science Teaching*, 50(6), 677-698. https://doi.org/10.1002/tea.21096

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. https://doi.org/10.36681/tused.2021.66

Edelsbrunner, P. A., Schalk, L., Schumacher, R., & Stern, E. (2018). Learning and individual differences variable control and conceptual change: a large-scale quantitative study in elementary school. *Learning and Individual Differences*, 66, 38-53. https://doi.org/10.1016/j.lindif.2018.02.003

Fan, X., Geelan, D., & Gillies, R. (2018). Evaluating a novel instructional sequence for conceptual change in physics using interactive simulations, *Education Science*, 8(1), 29. https://doi.org/10.3390/educsci8010029

Flynn, S., & Hardman, M. (2019). The use of interactive fiction to promote conceptual change in science. *Science & Education*, 28(1), 127-152. https://doi.org/10.1007/s11191-019-00032-6

Franco, G. M., Muis, K. R., Kendeou, P., Ranellucci, J., Sampasivam, L., & Wang, X. (2012). Examining the influences of epistemic beliefs and knowledge representations on cognitive processing and conceptual change when learning physics. *Learning and Instruction*, 22(1), 62–77. https://doi.org/10.1016/j.learninstruc.2011.06.003

Fulmer, G. W. (2013). Constraints on conceptual change: how elementary teachers' attitudes and understanding of conceptual change relate to changes in students' conceptions. *Journal of Science Teacher Education*, 24(7), 1219–1236. https://doi.org/10.1007/s10972-013-9334-3

Gadgil, S., Nokes-Malach, T. J., & Chi, M. T. H. (2012). Effectiveness of holistic mental model confrontation in driving conceptual change. *Learning and Instruction*, 22(1), 47–61. https://doi.org/10.1016/j.learninstruc.2011.06.002

Gao, Y., Zhai, X., & Andersson, B. (2018). Developing a learning progression of buoyancy to model conceptual change: a latent class and rule space model analysis, *Research in Science Education*, 50(4). https://doi.org/10.1007/s11165-018-9736-5

Hadjiachilleos, S., Valanides, N., & Angeli, C. (2013). The impact of cognitive and affective aspects of cognitive conflict on learners' conceptual change about floating and sinking. *Research in Science and Technological Education*, 31(2), 133–152. https://doi.org/10.1080/02635143.2013.811074

Hanson, R., & SEHERI-JELE, N. (2018). Assessing conceptual change instruction accompanied with concept maps and analogies: a case of acid-base strengths. *Journal of Turkish Science Education*, 15(4), 55–64.

Heddy, B. C., Taasoobshirazi, G., Chancey, J. B., & Danielson, R. W. (2018). Developing and validating a conceptual change cognitive engagement instrument. *Frontiers in Education*, 3, 1–9. https://doi.org/10.3389/feduc.2018.00043

Howe, C., Devine, A., & Taylor Tavares, J. (2013). Supporting conceptual change in school science: a possible role for tacit understanding. *International Journal of Science Education*, 35(5), 864–883. https://doi.org/10.1080/09500693.2011.585353

Jiang, T., Wang, S., Wang, J., Ma, Y. (2018). Effect of different instructional methods on students' conceptual change regarding electrical resistance as viewed from a synthesized theoretical framework, *EURASIA Journal of Matematics, Science, and Technology Education*, 14(7), 2771-2786. https://doi.org/10.29333/ejmste/90592

Kapartzianis, A., & Kriek, J. (2014). Conceptual change activities alleviating misconceptions about electric circuits, *Journal of Baltic Science Education*, 13(3), 2014, 298-315. https://doi.org/10.33225/jbse/14.13.298

Koops, M., & Hoevenaar, M. (2013). Conceptual change during a serious game: using a lemniscate model to compare strategies in a physics game. *Simulation & Gaming*, 44(4), 544-561. https://doi.org/10.1177/1046878112459261

Lazonder, A. W., & Ehrenhard, S. (2014). Relative effectiveness of physical and virtual manipulatives for conceptual change in science: How falling objects fall. *Journal of Computer Assisted Learning*, 30(2), 110–120. https://doi.org/10.1111/jcal.12024

Lee, C. B., Jonassen, D., & Teo, T. (2011). The role of model building in problem solving and conceptual change. *Interactive Learning Environments*, 19(3), 247–265. https://doi.org/10.1080/10494820902850158

Leuchter, M., Saalbach, H., Studhalter, U., Tettenborn, A., Leuchter, M., Saalbach, H., Studhalter, U., & Tettenborn, A. (2020). Teaching for conceptual change in preschool science: relations among teachers' professional beliefs, knowledge, and instructional practice. *International Journal of Science Education*, 42(12), 1941-1967. https://doi.org/10.1080/09500693.2020.1805137

Lin, Y. C., Liu, T. C., & Chu, C. C. (2011). Implementing clickers to assist learning in science lectures: The clicker-assisted conceptual change model. *Australasian Journal of Educational Technology*, 27(6), 979–996. https://doi.org/10.14742/ajet.924

Liu, Q., & Nesbit, J. C. (2018). Conceptual change with refutational maps. *International Journal of Science Education*, 40(16), 1980-1998. https://doi.org/10.1080/09500693.2018.1515513

Loyens, S. M. M., Jones, S. H., Mikkers, J., & van Gog, T. (2015). Problem-based learning as a facilitator of conceptual change. *Learning and Instruction*, 38, 34–42. https://doi.org/10.1016/j.learninstruc.2015.03.002

Madu, B. C., & Orji, E. (2015). Effects of cognitive conflict instructional strategy on students' conceptual change in temperature and heat. *SAGE Open*, 5(3), 1-9. https://doi.org/10.1177/2158244015594662

Mason, L., Baldi, R., Di, S., Scrimin, S., Danielson, R. W., & Sinatra, G. M. (2017). Textual and graphical refutations: Effects on conceptual change learning. *Contemporary Educational Psychology*, 49, 275–288. https://doi.org/10.1016/j.cedpsych.2017.03.007

Mason, L., Zaccoletti, S., Carretti, B., Scrimin, S., Diakidoy, I. N., & Mason, L. (2018). The role of inhibition in conceptual learning from refutation and standard expository texts. *International Journal of Science and Mathematics Education*, 17(3), 483-501. https://doi.org/10.1007/s10763-017-9874-7

Mclure, F., Won, M., Treagust, D. F. (2020). A sustained multidimensional conceptual change intervention in grade 9 and 10 science classes in grade 9 and 10 science classes. *International Journal of Science Education*, 42(5), 703-721. https://doi.org/10.1080/09500693.2020.1725174

Morales, M. P. E. (2017). Exploring indigenous game-based physics activities in pre-service physics teachers' conceptual change and transformation of epistemic beliefs. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(5), 1377–1409. https://doi.org/10.12973/eurasia.2017.00676a

Ozkan, G., & Selcuk, G. S. (2016). Facilitating conceptual change in students' understanding of concepts related to pressure. *European Journal of Physics*, 37(5), 1–20. https://doi.org/10.1088/0143-0807/37/5/055702

Ozkan, G., & Sezgin Selcuk, G. (2015). The effectiveness of conceptual change texts and context-based learning on students' conceptual achievement. *Journal of Baltic Science Education*, 14(6), 753–763. https://doi.org/10.33225/jbse/15.14.753

Ranellucci, J., Muis, K. R., Duffy, M., Wang, X., Sampasivam, L., & Franco, G. M. (2013). To master or perform? Exploring relations between achievement goals and conceptual change learning. *British Journal of Educational Psychology*, 83(3), 431–451. https://doi.org/10.1111/j.2044-8279.2012.02072.x

Sarioglan, A. B., & Kucukozer, H. (2017). Effect of meaning making approach on students' conceptual understanding: an examination of angular momentum conservation, *International Journal of Education in Mathematics, Science and Technology*, 5(3), 203-220. https://doi.org/10.18404/ijemst.296035

Sevim, S. (2013). Promoting conceptual change in science, which is more effective: conceptual change text or analogy?, *Journal of Turkish Science Education*, 10(3), 24-36.

Schleigh, S. P., Clark, D. B., & Menekse, M. (2015). Constructed-response as an alternative to interviews in conceptual change studies: students' explanations of force, *International Journal of Education in Mathematics, Science and Technology*, 3(1), 14–36.

Syuhendri. (2017). A learning process based on conceptual change approach to foster conceptual change in newtonian mechanics. *Journal of Baltic Science Education*, 16(2), 228-240. https://doi.org/10.33225/jbse/17.16.228

Taasoobshirazi, G., Heddy, B., & Bailey, M. (2016). A multivariate model of conceptual change. *Instructional Science*. https://doi.org/10.1007/s11251-016-9372-2

Taşlıdere, E. (2021). Relative effectiveness of conceptual change texts with concept cartoons and 5e learning model with simulation activities on pre-service teachers' conceptual understanding of waves, *Participatory Educational Research*, 8(4), 215–238. https://doi.org/10.17275/per.21.87.8.4

Thomas, C. L., & Kirby, L. A. J. (2020). Situational interest helps correct misconceptions: An investigation of conceptual change in university students. *Instructional Science*, 48(3), 223–241. https://doi.org/10.1007/s11251-020-09509-2

Yazbec, A.., Borovsky, A., & Kaschak, M. P. (2019). Examining the impact of text style and epistemic beliefs on conceptual change. *PLoS ONE*, 1–16. https://doi.org/10.1371/journal.pone.0220766

Yin, Y., Tomita, M. K., & Shavelson, R. J. (2013). Using formal embedded formative assessments aligned with a short term learning progression to promote conceptual change and achievement in science, *International Journal of Science Education*, 36(4), 531-552. https://doi.org/10.1080/09500693.2013.787556

Yürük, N., & Eroğlu, P. (2016). The effect of conceptual change texts enriched with metaconceptual processes on pre-service science teachers' conceptual understanding of heat and temperature. *Journal of Baltic Science Education*, 15(6), 693–705. https://doi.org/10.33225/jbse/16.15.693

Zvoch, K., Holveck, S., & Porter, L. (2019). Teaching for conceptual change in a density unit provided to seventh graders: a comparison of teacher- and student-centered approaches, *Research in Science Education*. 51(5), 1395-1421. https://doi.org/10.1007/s11165-019-09907-8