Education and Science

Original Article

Vol 50 (2025) No 221 121-142

Examining Prediction Observation Explanation Method based Interactive e-books in terms of High School Students' Misconceptions, Self-Regulated Learning, Cognitive Engagement *

Nazmiye Çırakoğlu [1], İlknur Reisoğlu [2], Seyhan Eryılmaz Toksoy [3]

Abstract

This study aims to explain how high school students' misconceptions, cognitive engagement, and self-regulated learning levels change when using interactive e-books based on the prediction, observation, and explanation method for heat and temperature topics. It also aims to examine how the features of interactive e-books support eliminating misconceptions, cognitive engagement, and self-regulated learning. An explanatory mixed method was conducted with 31 high school students in this direction. The misconception detection test, self-regulated learning scale, cognitive engagement scale, and focus group interviews were used as data collection tools. The study found a significant difference between high school students' misconceptions, cognitive engagement, and self-regulated learning levels before and after using interactive e-books based on the prediction, observation, and explanation processes. It was revealed that the interactive e-book is grounded on a specific learning method, covering different multimedia materials, providing critical applications related to the concepts discussed, providing students with a sense of managing their learning process, and allowing observations on examples from everyday life. The study concluded that these characteristics make it easier for the students to understand the differences between different concepts and support cognitive engagement and self-regulated learning.

Keywords

Interactive e-book
Self-regulated learning
Cognitive engagement
Eliminating misconceptions
E-book

Article Info

Received: 07.11.2023
Accepted: 08.08.2024
Published Online: 01.29.2025

DOI: 10.15390/EB.2025.13048

* This article is derived from Nazmiye Çırakoğlu's Master's thesis entitled "Investigation of how an interactive electronic book developed based on the prediction observation explanation method supports the development of high school students' misconception, selfregulation and cognitive engagement", conducted under the supervision of İlknur Reisoğlu and Seyhan Eryılmaz Toksoy.

[1] Ministry of National Education, Türkiye, nazmiye_cirakoglu19@erdogan.edu.tr
[2] Recep Tayyip Erdoğan University, Faculty of Education, Department of Computer Education and Instructional Technology Education, Türkiye, ilknur.reisoglu@erdogan.edu.tr
[3] Recep Tayyip Erdoğan University, Faculty of Education, Department of Mathematics and Science Education, Türkiye, seyhan.eryilmaz@erdogan.edu.tr

Introduction

The fact that e-books offer their users many opportunities, such as low cost (Swanson, Austin, Stewart, & Scammacca, 2020), access (Hwang & Lai, 2017), portability (Li et al., 2020), navigation (Casselden & Pears, 2020), has been instrumental in replacing printed books in recent years (Boticki, Akçapınar, & Ogata, 2019). With the development of technology, interactive e-books have come to the fore with features such as audio, video, image gallery, interaction, slide shows (Almekhlafi, 2021; Swanson et al., 2020), animations (Lim, Liu, & Hou, 2020), simulations (Hadaya & Hanif, 2019), log recordings (Boticki et al., 2019; Umarji et al., 2020; Yang, Zargar, Adams, Day, & Connor, 2020; Zarzour, Bendjaballah, & Harirche, 2020). Thanks to these features, interactive e-books improve students' learning outcomes, such as academic achievement, motivation, and critical thinking (Casselden & Pears, 2020; Yorganci, 2022).

Researchers state that careful thinking and planning are essential in interactive e-book designs (Eitel, Bender, & Renkl, 2019; Schneider, Wirzberger, & Rey, 2019). It states that when the instructional process is not sufficiently developed, an extraneous cognitive load may occupy students' limited working memory, preventing them from understanding the subject (Mayer, 2014; Paas & Sweller, 2014). Rockinson-Szapkiw, Courduff, Carter, and Bennett (2013) state that it is essential to use appropriate learning methods when developing interactive e-books to create any difference in cognitive processes and learning achievements between interactive e-books and traditional textbooks. Pabrua Batoon, Victoria, Glasserman Morales, and Yanez Figueroa (2018) declare that an interactive e-book based on a learning method can help guide students' learning process and lead to better results. Liu, Chou, and Lee (2020) assert that using a teaching method as a basis helps the interactive e-book better structure its content and interactive features. For this reason, researchers note that interactive e-books developed without integrating with appropriate learning methods cannot meet learning expectations (Peng et al., 2009) and may be insufficient to support students' cognitive processes (Pabrua Batoon et al., 2018; Sung, Hwang, & Chen, 2019). It is also emphasized that well-designed interactive e-books can support students' cognitive processes (Bozkurt & Bozkaya, 2015).

It is asserted that student-centered interactive e-books should include appropriate learning methods to guide learning (Sung et al., 2019). Saripudin, Fauzi, and Nugraha (2022) recommend that interactive e-books be based on learning methods so teachers and students can interact effectively. Mana, Mich, De Angeli, and Druin (2013) also explained that interactive e-books present learning content in various exciting forms and play the role of a learning facilitator by embedding the teaching strategies within the learning content. In addition, using effective learning methods and digital technologies has become essential for students to achieve determined learning outcomes in online learning environments, especially after the pandemic (Lieung, Rahayu, & Yampap, 2021). Teachers are expected to use technology-supported, more practical, student-centered, flexible learning environments. Interactive e-books can meet the demands (Arifah, 2017; Pramana, Jampel, & Pudjawan, 2020).

Thanks to the flexibility offered by the interaction feature, interactive e-books have started to be developed based on different learning methods and strategies. (Hwang & Lai, 2017; Hwang, Tu, & Wang, 2018; Kao, Chiang, & Foulsham, 2019; Li et al., 2020; Sung et al., 2019; Tsuei, Huang, & Cheng, 2020). Besides, such interactive e-books effectively lower the students' surface strategy in learning, reduce the recitation of answers, and prevent them from only thinking about tests (Sung et al., 2019). In the literature, there are interactive e-book studies developed based on pedagogical methods such as guided learning (Sung et al., 2019), inquiry learning (Ormancı & Çepni, 2020), individual learning, project-based learning, game-based learning, cooperative learning (Chen, Hwang, Majumdar, Toyokawa, & Ogata, 2021), cognitive conflict model (Mufit, Asrizal, & Puspitasari, 2022), situational learning (Li et al., 2020; Sung, Hwang, Chen, & Liu, 2022), gamified flipped learning (Zhao, Hwang, Chang, Yang, & Nokkaew, 2021), flipped learning (Hwang & Lai, 2017). However, interactive e-book studies based on Prediction, Observation, Explanation (POE) method are limited.

Prediction, Observation, Explanation (POE) Method

POE is known as a three-phase teaching method. During the prediction phase, students must make predictions about an experiment, demonstration, or event presented for the learning outcomes (Pujiwati & Susilaningsih, 2020). At the observation phase, students are required to make observations for their predictions. At the end of the observation phase, the discrepancy between the predictions in the prediction phase and the observations should be determined (Sumilah & Sulistyaningrum, 2021; Yulianti, Suhandi, & Sopandi, 2020). The critical thing in this step is for the students to observe the event or situation comfortably and to create a contradiction in their minds (Tomara, Tselfes, & Gouscos, 2017). Students are expected to reach an explanation by comparing their predictions and observations during the explanation phase. At the end of the explanation phase, the teacher summarizes the explanations about the learning outcome. POE requires students to observe the presented situation and explain the situation by detecting the difference between their predictions and observations (Yuenyong & Yuenyong, 2021). This method, frequently used in science teaching, is effective in teaching concepts and identifying and eliminating misconceptions (Banawi, Sopandi, Kadarohman, & Solehuddin, 2019; Fuadi, Sopandi, Priscylio, Hamdu, & Mustikasari, 2020; Latifah et al., 2019; Nalkıran & Karamustafaoğlu, 2020; Pujiwati & Susilaningsih, 2020; Zakiyah, Widodo, & Tukiran, 2019). However, the method has been used in case studies, usually in the environments where experiments were conducted, and students have been asked to specify their prediction observations and explanations on paper (Cengiz, 2018; Pujiwati & Susilaningsih, 2020).

Limited studies have used the POE method in a technology-supported way. Hong, Hwang, Tai, and Tsai (2017) used, through an app called "WhyWhy," a multiple-choice question at the prediction phase, an animated presentation at the observation phase, and a multiple-choice question at the explanation phase. Akpınar (2014) investigated the effect of interactive animation throughout POE on students' understanding of concepts about static electricity. Alfiyanti and Jatmiko (2020) studied students' critical thinking skills using PhET simulations throughout POE. It is thought that the POE method can be applied more effectively when students interact with various multimedia elements in interactive e-books. With the animations, pictures, videos, and concept cartoons in interactive e-books, students' prior knowledge can be revealed, they can be encouraged to make observations regarding the predictions they have made based on their prior knowledge, and their evaluation of the results they have obtained can be supported. In this way, students' misconceptions can be identified and eliminated. With the multimedia materials included in interactive e-books based on the POE method, students can engage cognitively by reflecting on their prior knowledge, comparing it with new knowledge, and observing evaluation results. With this method, self-regulated learning can be indirectly supported as students evaluate, organize, and renew their existing knowledge. In addition, if the student realizes that he or she has a misconception, re-examining the multimedia materials in the interactive book, checking the explanations, repeating the observations, or referring to new sources can also support self-regulated learning. In this regard, this study aims to examine how an interactive e-book based on POE supports high school students' eliminating misconceptions, cognitive engagement, and self-regulated learning.

There is a lack of interactive science teaching materials in our country (Ormancı & Çepni, 2020). Researchers also emphasize that interactive e-books should be spread at all levels of learning, especially in science and mathematics (Almekhlafi, 2021). In this sense, the interactive e-book developed will meet this need. Suppose how the POE-based interactive e-book supports cognitive engagement, self-regulated learning, and eliminating misconceptions is determined. In that case, recommendations can be made on better design adjustments to support these variables in interactive e-books. Suggestions can be made about what activities should be included to engage students more cognitively or what arrangements should be made in multimedia elements. Accordingly, this study seeks to answer the following research questions;

1. Is there a significant difference between high school students' misconceptions, cognitive engagement, and self-regulated learning levels before and after using POE-based interactive e-books on heat and temperature?
2. According to high school students, how do the features of the POE-based interactive e-book on heat and temperature support eliminating misconceptions, cognitive engagement, and self-regulated learning?

Literature Review

Interactive e-books in education

E-books are digital books that can be read easily through electronic devices. They consist of papers containing text or images similar to printed books regarding function and content (Firdausy & Prasetyo, 2020; Swanson et al., 2020). E-books also contain search abilities, text highlighting, and the ability to make notations and bookmark pages (Lim et al., 2020). Interactive e-books provide an interface that combines multimedia features such as videos, games, animated texts, and simulations to enhance learning and achieve learning outcomes such as academic achievement, motivation, critical thinking, and reading comprehension (Firdausy & Prasetyo, 2020; Yorganci, 2022). Interactive e-books are materials created by providing interaction features to multimedia elements in e-books to give students learning tasks, guidance, and feedback (Sung et al., 2019; Sung et al., 2022).

Studies on interactive e-books have often focused on reading comprehension as a topic (Boticki et al., 2019; Lee, 2017; Sung & Wu, 2017; Umarji et al., 2020; Wu, 2016; Zarzour et al., 2020). Also, the researchers investigated the effects of interactive e-books on reading behaviors (Hsieh & Huang, 2020; Lee, 2017; Yang et al., 2020), reading comprehension (Lim, Whitehead, & Choi, 2021; Tsuei et al., 2020; Umarji et al., 2020; Yohannes, Chen, & Chang, 2023), learning behaviors (Wu, 2016; Yin et al., 2019; Zarzour et al., 2020), academic achievement (Almekhlafi, 2021; Hadaya & Hanif, 2019; Hwang, & Lai, 2017; Hwang et al., 2018; Saripudin et al., 2022; Wang, Shimada, Oi, Ogata, & Tabata, 2020), motivation (Kao et al., 2019; Lin, Huang, & Chen, 2018; Sung & Wu, 2017), learning performance (Huang & Hwang, 2019; Wang et al., 2020), listening comprehension (Hsieh & Huang, 2020), spatial ability (Yorganci, 2022), attitude (Asi, Retnoningsih, & Irsadi, 2021) and language development (Korat & Falk, 2019). Cognitive engagement, self-regulated learning, and eliminating misconceptions were examined in limited studies.

Various technologies such as log records (Boticki et al., 2019; Umarji et al., 2020; Yang et al., 2020; Zarzour et al., 2020) kept in interactive e-books, interaction features of e-books (Lee, 2017, 2020; Yang et al., 2020; Yin et al., 2019; Zarzour et al., 2020), augmented reality (Lin et al., 2018), digital games (Wang et al., 2020), content-related multimedia applications (Hsieh & Huang, 2020) integrated into interactive e-books were used to examine these variables in detail and from different views. As a sample, generally, university students (Almekhlafi, 2021; Kao et al., 2019; Lim et al., 2020; Wang et al., 2020), preschool (Li et al., 2020; Mouri, Uosaki, & Ogata, 2018; Sung & Wu, 2017; Wu, 2016; Yin et al., 2019), primary school students (Hwang & Lai, 2017; Hwang et al., 2018; Lee, 2017; Sung et al., 2019; Tsuei et al., 2020; Umarji et al., 2020; Yang et al., 2020), middle school students (Hadaya & Hanif, 2019; Lim et al., 2021; Ormancı & Çepni, 2020; Yohannes et al., 2023) high school students (Saripudin et al., 2022), teachers (Ormancı & Çepni, 2020) were studied. Studies on physics with high school students are limited (Adam & Suprapto, 2019; Adawiyah, Harjono, Gunawan, & Hermansyah, 2019; Afriwardani, Jumadi, & Pribadi, 2023; Hasan, Suyatna, & Suana, 2018; Harjono, Gunawan, Adawiyah, & Herayanti, 2020; Mufit et al., 2022; Perwita & Fauzi, 2021; Septikasari, Maison, & Nazarudin, 2021).

Interactive e-books and misconceptions

Students' explanations of concepts in different ways from their scientific definitions are known as misconceptions (Sa'adah & Haryadi, 2020). The fact that many concepts in physics are abstract causes students to have many misconceptions about this field (Bozzi et al., 2019; Fenditasari & Istiyono, 2020; Oktavianty, Haratua, & Anuru, 2018; Soeharto, Csapó, Sarimanah, Dewi, & Sabri, 2019). Concepts are the building blocks of knowledge, and if the misconception is determined and corrected as soon as possible, incorrect associations and incorrect learning can occur (Fenditasari & Istiyono, 2020).

The literature suggests that POE effectively eliminates misconceptions (Pujiwati & Susilaningsih, 2020). POE has steps to ensure conceptual change as it allows students to doubt their previous knowledge, strive to eliminate this doubt, and redefine the concept by comparing their old knowledge and reviewing their knowledge of understanding. In the prediction phase, a situation or an event that may involve a misconception is presented, ensuring that students focus on comprehension, while cognitive contradiction is also created. During the observation phase, students are offered opportunities to test their predictions and to have experience in structuring concepts. In the explanation phase, students are provided with explanations for the correct configuration of the concepts.

It is indicated in some previous studies that the images, videos, animations, and sounds contained in interactive e-books make it easier for students to understand (Kao et al., 2019; Sung et al., 2022) and embody concepts (Hasan et al., 2018; Harjono et al., 2020). The features of interactive e-books can help students visualize abstract concepts or processes more efficiently than other forms of textual presentation (Lee & Osman, 2012; Liu et al., 2020). It is stated in the literature that concepts that are abstract by their nature should be embodied as much as possible by using visual materials (Bozan & Savaş, 2019). E-books support comprehension by exposing diverse stimuli, such as carefully designed animations and sound effects (Shamir, Korat, & Shlafer, 2011). It is emphasized that using digital technologies in organizing learning activities attracts more attention from students in concept teaching (Fenditasari & Istiyono, 2020). Septikasari et al. (2021) and Afriwardani et al. (2023) determined that interactive e-books effectively teach concepts and eliminate misconceptions.

Interactive e-books and self-regulated learning

Self-regulated learning is the student's upper cognitive, motivational, and behavioral active participation in the learning process (Zimmerman, 1989). In the self-regulated learning process, students follow their learning strategies and make changes in the strategies when necessary (Cheng, 2011). In the self-regulated learning process, students must set learning goals, make learning plans, choose learning strategies, monitor learning processes, and evaluate learning outcomes (Cheng, 2011; Zimmerman, 1989). This means that students must be aware of their abilities and weaknesses (Chen & Su, 2019). Students with high self-regulated learning skills can self-direct themselves to acquire knowledge and skills without needing guidance from family, teachers, or others (Winne, 2017). Dabbagh and Kitsantas (2005) posited that web-based pedagogical tools like interactive e-books were most effective in supporting student engagement in different self-regulated learning processes while completing course assignments. Chen and Su (2019) declared that there is a need to utilize interactive e-books to help students better understand, manage, or adjust their learning. They indicated that the self-regulated learning scores of the students who used the interactive e-book system integrated with Moodle were better able to internalize their self-regulated learning strategies than those who used only Moodle. Researchers found that interactive e-books can potentially support students' self-regulation in digital learning (Ainulluluah, Boeriswati, Rahmawati, & Setiawan, 2022; Churiyah et al., 2023; Hidajat, 2023; Lestari, Suwarma, & Suhendi, 2024; Rahmawati & Muchtarom, 2023; Susantini, Puspitawati, Raharjo, & Suaidah, 2021). Yang and Ogata (2023) state that the note-taking strategies in interactive e-books allow students to monitor their learning processes and receive personalized feedback on improving their cognitive and metacognitive strategies for self-regulation abilities.

Interactive e-books and cognitive engagement

According to Boekaerts (2016), engagement refers to "the basic processing operations that describe how students react to and interact with the learning materials and environments" (p. 81). Cognitive engagement involves willingness and mental concentration while striving to learn and solve problems (Li et al., 2020). Cognitive engagement is the desire and effort of students to meet learning requirements and overcome challenges (Connell & Wellborn, 1991). For this reason, it is noted that cognitive engagement includes abilities such as focus, concentration, and effort (Skinner & Pitzer, 2012). In addition, Merkle, Ferrell, Ferrell, and Hair (2022) state that cognitive engagement also includes students' efforts to understand a learning material.

Interactive e-books have good potential to provide information transmission through visual and verbal channels and increase student engagement with interactive features that allow the student to make decisions or choices (Hwang & Lai, 2017; Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2014). With interactive multimedia elements (sound, animation, simulation, video) included in interactive e-books, students' engagement can be supported by interacting with the learning content instead of just reading it (Bikowski & Casal, 2018; Yohannes et al., 2023). Xu, Yau, and Reich (2021) suggest that the interaction elements in interactive books can affect engagement. It is argued that learning activities and tests in interactive e-books also encourage students to engage (Almekhlafi, 2021). Weng, Otanga, Weng, and Cox (2018) found that interactive e-books can improve students' cognitive learning outcomes. Lim et al. (2021) stated that interactive e-books with interactive multimedia features allow readers to engage in various ways with electronic text. It is claimed that e-books based on a learning approach or model can support students' engagement more easily (Huang & Hwang, 2019). Richter and Courage (2017) found that children were more engaged in interactive e-books than paper books. Reich et al. (2019) found that preschool students showed equivalent emotional and behavioral engagement during the story when read by an e-book or a person. Merkle et al. (2022) found that the effectiveness of interactive e-books is highly correlated with student cognitive engagement.

Method

In this study, the explanatory mixed method was used to find answers to the research questions. The explanatory mixed method consists of two stages. In the first stage, the researcher collects quantitative data, followed by qualitative data with data collection tools such as observation or interview (Kettles, Creswell, & Zhang, 2011). Qualitative data are used to explain, improve, and analyze quantitative results (Ivankova & Creswell, 2009). The results obtained from the two stages are interpreted together and mixed (Clark & Ivankova, 2015). In this study, while the role of the POE-based interactive e-book in the changes before and after the application was determined with the quantitative data collected through scales and tests, it was tried to explain which features of the interactive e-book affected this change with the qualitative data collected through focus group interviews. Thus, comprehensive data was collected on which features of the POE-based interactive e-book supported students' misconceptions, self-regulated learning, and cognitive engagement.

Sample

The research sample consists of 31 students (10 girls and 21 boys) studying in the 9th grade of high school. Twenty students have 4-6 years of experience using the web, while 6 have experience of more than seven years and 4 have 1-3 years of experience. The ages of the students range from 13 to 16 (Mean=14.70, SD=0.643). Focus group interviews were conducted with 12 of these students. Four students, each with high, medium, and low scores from the scales applied in the posttest, were allowed to participate in the interviews.

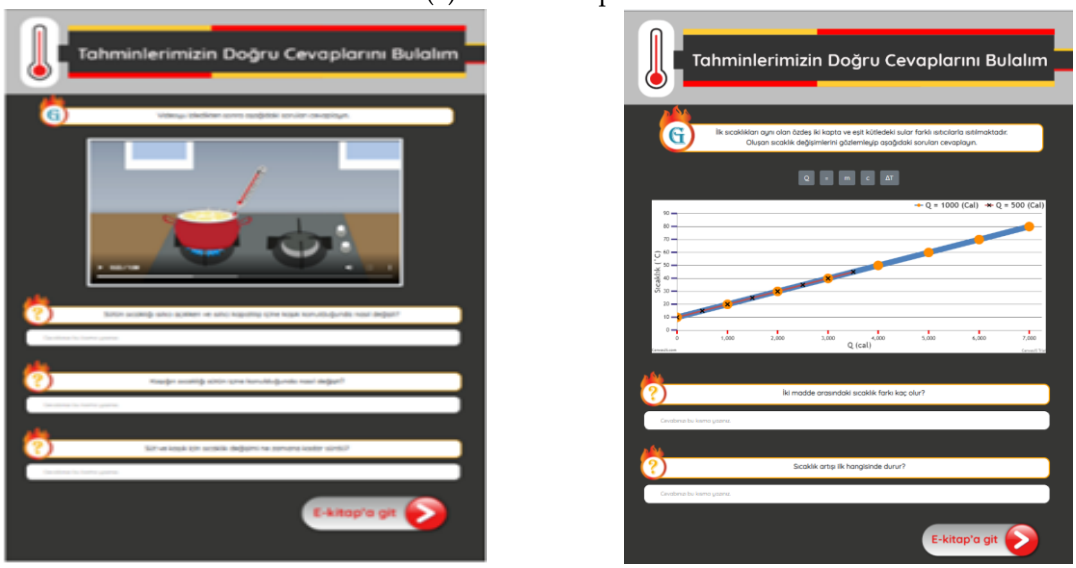
Interactive Heat and Temperature E-Book Based on the POE Method

One of the physics topics students often have misconceptions about is heat and temperature (Bozan & Savaş, 2019; Fenditasari & Istiyono, 2020). For this reason, before the e-book was developed, the "Heat and Temperature" unit in the 9th-grade physics course curriculum implemented in Turkey (Ministry of National Education, 2018) was examined. Activities that can be performed at the POE phases were prepared based on the topics and learning outcomes contained in the unit: heat and temperature, specific heat and heat capacity, thermal balance, change of state, energy transmission ways, energy transmission ways of solids, global warming, and expansion. While preparing the activities, 9th-grade textbooks and field experts' views were benefited.

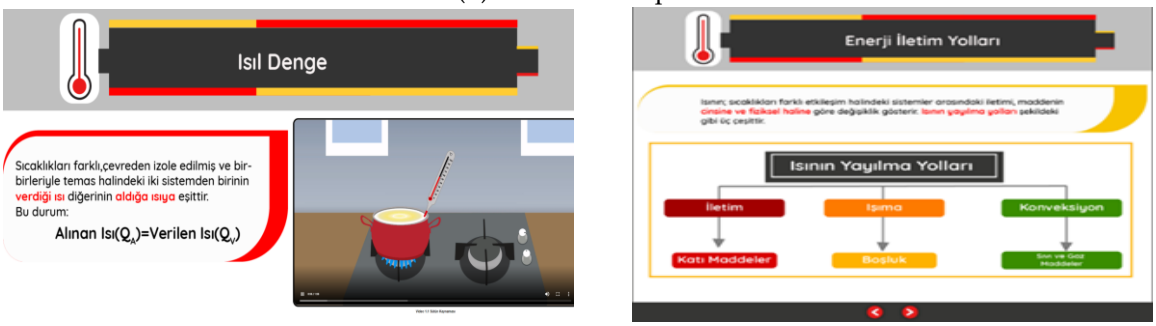
During the prediction phase, students' misconceptions were determined using concept cartoons involving dialogues of people expressing their views on a contradictory situation and comparing questions (Figure 1 (a)). During the observation phase, animations in which the predicted situation is narrated, concept cartoons, and simultaneously drawn graphics in learning outcomes related to the laws of physics were included (Figure 1(b)). At this phase, students were asked to watch the presented

animation or the drawn graphic carefully, as much as they wanted, and to answer the questions about the observations. During the explanation phase, a brief and concise explanation of the learning outcomes in the curriculum was visualized and tried to be presented to the students (Figure 1(c)). After the explanation phase, multiple-choice evaluation questions were included. Thus, it was ensured that the differences between the students' predictions and observations, if any, were eliminated, and the scientific knowledge was transferred.

(a). Prediction phase



(b). Observation phase



(c). Explanation phase

Figure 1. The interface of the POE based interactive e-book for heat and temperature

Opinions were received from 3 physics and 3 instructional technology design experts about the visuals, dialogues, animations, and concept cartoons created for each prepared event regarding scientific accuracy, student-level compliance, intelligibility, and message design. Researchers developed an interactive e-book in line with their opinions. The opinions of the same experts have consulted over again the developed e-book. After the arrangements were made, 20 students were allowed to use the book, and it was determined that there were no problems with using the book.

Data Collection Tools

Misconception detection test

One of the reliable methods that can be used to determine students' misconceptions is a two-stage test (Soeharto et al., 2019). In a two-stage test, students only mark the correct option in the first stage and explain the reason for the answer in the second stage (Soeharto & Csapo, 2021). In this study, researchers developed a misconception detection test with 26 two-stage questions for the learning outcomes of the "heat and temperature" unit in the 9th-grade physics curriculum. In each question in the test, students are presented with situations that include examples from daily life on the subject of heat and temperature, as well as dialogues with different perspectives on these situations. In the first stage, students must indicate which of the views they agree with in the form of dialogue, and in the second stage, they must express why they agree with that view.

Before the test was developed, students' misconceptions about heat and temperature were determined by examining the literature. Dialogues that deal with events or situations from daily life that may cause misconceptions determined by two physicist experts were created. Misconceptions that students could have were presented in the form of ideas in those dialogues. Dialogues were supported with appropriate concept cartoons to make the questions more understandable. The 26 questions created were submitted to three physics experts for their opinions. The questions were corrected based on expert views and administered to 20 students in 9th grade, and opinions were received from the students about the clarity of the questions. Options that can create clues have been arranged. A more understandable language was used in the question stems. The time of the test application was determined to be 35 minutes.

Self-Regulated learning scale

The study used the self-regulation scale developed by Haşlaman (2011), consisting of 59 items and four factors, to measure students' self-regulation skills. The scale items are in a 10-point Likert format. The scale includes 17 items under the prediction phase factor, 21 under the control/regulation factor, 11 under the monitoring factor, and 10 under the evaluation phase factor. The Cronbach's alpha coefficients of the factors vary between 0.90 and 0.91. The Cronbach's alpha coefficient for the entire scale of 59 items is 0.97.

Cognitive engagement scale

The study used the cognitive engagement scale, initially developed by Agarwal and Karahanna (2000) and adapted to Turkish by Usluel Koçak and Vural (2009), to measure the students' cognitive engagement. The scale consists of four factors and 17 items, all in a 10-point Likert format. The scale factors are time, curiosity, the focus of interest, and pleasure. Five items are under the time factor, and four are under the other factors.

Usluel Koçak and Vural (2009) developed the scale based on university students. In the present study, explanatory factor analysis (EFA) was applied to data collected from 125 high school students to determine the scale's suitability for the high school student level. As a result of the analysis, four factors were found to explain 79.817% of the total variance. After performing the rotation, it was understood that the factor load values were higher than .616. Across the scale, the Cronbach's alpha reliability coefficient was found to be .952. After AFA analysis, confirmatory factor analysis (CFA) was applied to data from 702 high school students to assess the structural validity of the resulting model (Kline, 2005). The good fit indices for the model were found as follows: X2/df=4.280 (p=.000); RMSEA=.068; GFI=.929; AGFI=.901; CFI=.956; NFI=.944; TLI=.945; SRMR=.0456.

Focus group interviews

After completing the activities, semi-structured focus group interviews were conducted with 12 students, forming groups of four. Focus group interviews were preferred because they effectively revealed an interactive and holistic perspective (Gibbs, 2012). Questions about which features of the POE-based interactive e-book affected eliminating misconceptions, self-regulated learning, and cognitive engagement were used in the interviews. During the interviews, students were asked: "Is there any information about heat and temperature that you misunderstood in your daily life but realized after using an interactive e-book? "Can you explain by giving an example?" "How effective was the interactive e-book in learning the subject?" "Which features do you find more effective at this point?" "Were there any features in the environment that attracted you?" "Animations, videos, images, etc., included in the interactive e-book. What do you think about it?" "How do you evaluate the interactive electronic book providing information about heat and temperature?" "Which features do you find more effective at this point?" "How did you use the interactive e-book during the application?" "While using the interactive e-book, did you think about how you could benefit from it to achieve your learning goals more effectively? If so, what kind of ways did you try?". Before the focus group interviews, a pilot study was conducted with a student to review and edit the interview questions. Each interview lasted about 1 hour.

Data Collection Process

In order to carry out the study, permission numbered 2021/51 was obtained from the Social and Human Sciences Ethics Committee of Recep Tayyip Erdoğan University on 02.03.2021. Then, the necessary permissions were obtained to research in schools affiliated with the Ministry of National Education. Parents of the students were also informed about the study, and a parental consent form was filled out for each student. All participants were informed about the research process and voluntarily participated. Before starting the practice with the interactive e-book, the misconception detection test, self-regulated learning scale, and cognitive engagement scale were administered to the students. Then, 2 hours of lessons were taught by the teacher each week so that the entire application was completed in 4 weeks. Activities with e-books were limited to the lesson hours. After the content coverage in all parts was completed, the misconception detection test, self-regulated learning scale, and cognitive engagement scale were administered to the students. Finally, focus group interviews were conducted with 12 students. The entire process was completed in a total of 6 weeks.

Data Analysis

To analyze the misconception test data, the answers given to the first stage of the test were classified as true and false, and the answers given to the second stage were classified as true, partially true, or false. Students' scores on the test were determined using the scoring recommended by Karataş, Köse, and Coştu (2003). In the first stage, those who stated the correct opinion were 1, and those who stated the wrong opinion were 0; in the second stage, those who explained the opinion as scientifically correct were digitized as 2, and those who partially explained the correct opinion were digitized as 1 point. Those who presented their opinion with incorrect explanations received a score of 0. Accordingly, those who express the correct opinion and explain the reason correctly receive 3 points, those who partially explain the right receive 2 points, and those who explain the wrong end up with 1 point. Those who stated the wrong opinion and explained the reason correctly received 2 points, those who explained partially correct got 1 point, and those who explained the wrong got 0 points. Since the data obtained from the misconception detection test scores, self-regulated learning, and cognitive engagement scales did not show normal distribution, the Wilcoxon signed-rank test was applied to the scores obtained by the high school students from these tests and scales before and after practice.

Data from focus group interviews were subjected to descriptive analysis. Accordingly, focus group interviews were transcribed first. After that, the data were read repeatedly, and the participants' ideas and thoughts on how interactive e-books develop for eliminating misconceptions, self-regulated learning, and cognitive engagement were coded. Code names were used in descriptions, and direct quotes from the students were included in this study.

Findings

The findings obtained from the data analysis are presented below in parallel with the research questions.

The Interactive E-Book Based on the POE Method and Misconceptions

To determine how the interactive e-book based on the POE method changed students' misconceptions before and after the application, the scores obtained from the misconception detection test were analyzed with the Wilcoxon signed-rank test (Table 1).

Table 1. The difference between students' misconceptions before and after the application

	Pre-tests Post-tests	**N**	**Mean Rank**	**Sum of Ranks**	**z**	**p**	**r**
Misconceptions	Negative Ranks	6	6.33	38	-4.118	.000***	.740
	Positive Ranks	25	18.32	458			
	Equal	0					
	Total	31					

***p<.001

As a result of the Wilcoxon signed-rank test, a significant difference was found in the students' misconception test scores after the practice (*Mean=27.77, SD=8.88*) compared to (*Mean=16.81, SD=4.12*) the pre-practice results (*z=-4.118, p<.001, r=-0.740*). Students' misconceptions in the post-test were less than in the pre-test. The effect size of the analysis is also high.

Focus group interviews were conducted to determine which features of the interactive e-book were effective in reducing misconceptions. In the focus group interviews, students mentioned that the video, animation, and concept cartoons contained in the interactive e-book were prepared based on everyday life examples, allowing them to understand the concepts and the differences between them easily. In particular, it was determined that the contradictory situations used at the prediction phase of the POE were helpful for the students to evaluate their previous knowledge of concepts. In contrast, the observation phase helped students see the results of the predicted situation related to concepts and understand the differences between concepts through concrete examples. The simplicity of the interactive e-book content and the use of natural language make it easier to learn the concepts. The high number of interactions, such as drag-and-drop, animations, and commenting on the events observed in the videos in the POE stages, also supported the students' learning of the concepts. The opportunity to watch videos and animations over and over again, to stop and replay parts that are not understood, also had a positive effect on concept learning. Some of the student views on this are as follows:

> *"The concept cartoons were beautiful. From the concept cartoons, the difference in specific heat was obvious. One burns less; one burns more. It highlights even the small difference. It shows every difference very well. I also observed them very well in the videos."*

> *"I was having fun going through the activities in the material. I was intrigued, and I understood the concepts. Having examples from daily life attracted my attention more. When I compared it to daily life, some things made me wonder if they were like that."*

> *"We always studied with a school book. I needed to understand more about the topics covered by the school book. In this book, it was like a colorful life. Moreover, I understood the issues better. For example, after watching the videos, we solved sample questions, and I understood better by solving them. It was better because it was visually weighted*."

The Interactive E-Book Based on the POE Method and Self-Regulated Learning

The scores obtained from the self-regulated learning scale were analyzed to determine how the interactive e-book based on the POE method affected the students' self-regulated learning before and after the application. The scores obtained from the self-regulated learning scale were analyzed with the Wilcoxon signed-rank test (Table 2).

Table 2. The difference between students' self regulated learning before and after the application

	Pre-tests Post-tests	**N**	**Mean Rank**	**Sum of Ranks**	**z**	**p**	**r**
Prediction	Negative Ranks	4	12.,63	50.50			
	Positive Ranks	27	16.50	445.50	-3.872	.000***	.695
	Equal	0					
	Total	31					
Control/ Regulation	Negative Ranks	5	7.60	38.00			
	Positive Ranks	25	17.08	427.00	-4.001	.000***	.719
	Equal	1					
	Total	31					
Monitoring	Negative Ranks	4	8.63	34.50			
	Positive Ranks	27	17.09	461.50	-4.185	.000***	.752
	Equal	0					
	Total	31					
Evaluation	Negative Ranks	6	7.67	46.00			
	Positive Ranks	25	18.00	450.00	-3.961	.000***	.711
	Equal	0					
	Total	31					
Self-regulated learning	Negative Ranks	3	11.67	35.00			
	Positive Ranks	28	16.46	461.00	-4.174	.000***	.750
	Equal	0					
	Total	31					

***p<.001

As a result of the Wilcoxon signed-rank test, a significant difference was found in the students' self-regulated learning scores after the practice (*Mean=392.096, SD=57.701*) compared to the pre-practice results (*Mean=313.774, SD=42.204*) (*z=-4.174, p<.001, r=-0.750*). In addition, it was determined that the scores of the prediction phase ($Mean_{before}$*=93.258,* SD_{before}*=17.191,* $Mean_{after}$*=114.258,* SD_{after}*=18.040, z=-3.872, p<.001, r=-0.695*), control/regulation ($Mean_{before}$*=109.161,* SD_{before}*=15.195,* $Mean_{after}$*=138.323* SD_{after}*=22.811, z=-4.001, p<.001, r=-0.719*), monitoring ($Mean_{before}$*=56.968,* SD_{before}*=8.317,* $Mean_{after}$*=72.355,* SD_{after}*=12.645, z=-4.185, p<.001, r=-0.752)*, and evaluation phase ($Mean_{before}$*=54.387,* SD_{before}*=9.715,* $Mean_{after}$*=67.161,* SD_{after} *=9.637, z=-3.961, p<.001, r=-0.711*), which were the sub-factors of the self-regulated learning post-test, differed significantly from the pre-test scores. The effect size of the analysis is also high.

In the focus group interviews, the students mentioned that through activities during the prediction and observation phases, they could notice their wrong information and correct that information with the texts, videos, and animations in the observation and explanation sections. In the interactive e-book based on the POE method, students could identify their missing and incorrect learning in the prediction and observation stages. Students stated that moving according to their learning speed, without being dependent on others, allowed them to manage the learning process. They suggested that the questions and activities contained in the interactive e-book were helpful in terms of allowing them to self-evaluate and see their progress. The ability to repeat the parts they did not understand during the prediction, observation, and explanation stages, watch them again, and navigate the e-book as they wished made them feel they were in control of the learning process. Dividing the heat temperature unit into subheadings facilitated access to the content and enabled step-by-step progress. Some of the student views on this are as follows:

"*First of all, topics are very complicated in the textbook. Here the sections are separated from each other. I understood better because the separation of subjects was very good. I managed the process better when I was learning on my own. Going step by step is clearer and not confusing.*"

"*By logging into the system on my own, seeing my mistakes and where I made mistakes, evaluating it, I learned the right thing, and I think it will add more to me. I gave my own answers in the system and found out easily from the e-book whether it was true or not.*"

"I watched and repeated it more and more, concentrating and watching it over and over again when I was studying for the exam. That was its biggest contribution when I was studying for the exam. I watched the parts again that I didn't understand, repeated the stuff that I didn't understand, and learned."

"While answering the questions in the interactive book, I identified what I had previously thought was wrong and learned the truth in the e-book."

The Interactive E-Book Based on the POE Method and Cognitive Engagement

The scores obtained from the cognitive engagement scale were analyzed to determine how the interactive e-book based on the POE method affected the students' cognitive engagement level before and after the application. The scores obtained from the self-regulated learning scale were analyzed with the Wilcoxon signed-rank test (Table 3).

Table 3. The difference between students' cognitive engagement before and after the application

	Pre-tests Post-tests	**N**	**Mean Rank**	**Sum of Ranks**	**z**	**p**	**r**
Time	Negative Ranks	4	14.88	59.50			
	Positive Ranks	26	15.60	405.50	-3.562	.000***	.640
	Equal	1					
	Total	31					
Focus of interest	Negative Ranks	10	10.70	107.00			
	Positive Ranks	20	17.90	358.00	-2.584	.000***	.464
	Equal	1					
	Total	31					
Pleasure	Negative Ranks	6	4.17	25.00			
	Positive Ranks	24	18.33	440.00	-4.275	.000***	.768
	Equal	1					
	Total	31					
Curiosity	Negative Ranks	5	6.20	31.00			
	Positive Ranks	25	17.36	434.00	-4.147	.000***	.745
	Equal	1					
	Total	31					
Cognitive engagement	Negative Ranks	4	5.00	20.00			
	Positive Ranks	25	16.50	415.00	-4.271	.000***	.767
	Equal	2					
	Total	31					

***p<.001

As a result of the Wilcoxon signed-rank test, a significant difference was found in the students' cognitive engagement scores after the practice (*Mean=127.451, SD=28.864*) compared to the pre-practice results (*Mean=99.419, SD=28.380*) (*z=-4.271, p<.001, r=-0.767*). In addition, it was determined that the scores obtained from the sub-factors of the cognitive engagement post-test including time ($Mean_{before}$=27.838, SD_{before}=8.714, $Mean_{after}$=33.613, SD_{after}=9.959, z=-3.562, p<.001, r=-0.640), focus of interest ($Mean_{before}$=22.290, SD_{before}=8.145, $Mean_{after}$=26.709, SD_{after}=6.739, z=-2.584, p<.001, r=-0.464), pleasure ($Mean_{before}$=24.419, SD_{before}=7.906, $Mean_{after}$=33.581, SD_{after}=6.999, z=-4.275, p<.001, r=-0.768), and curiosity ($Mean_{before}$=24.871, SD_{before}=7.907, $Mean_{after}$=33.548, SD_{after}=8.090, z=-4.147, p<.001, r=-0.745) differed significantly from the pre-test scores. The effect size of the analysis is also high.

In the focus group interviews, the students stated that animations, videos, cartoons, examples from daily life, and guessing and observing made the lessons more fun, allowing time to pass quickly in the lesson, enabling them to gather their attention and actively participate in the lesson, and making them feel happy when learning new information. It was determined that the contradictory situations presented, especially in interactive videos, concept cartoons, and animations, make students curious about the observation and evaluation stages of the interactive e-book. Some of these statements are as follows:

> *"The cartoons were nice. We had much fun discussing concept cartoons. We saw more clearly while watching the videos, which made it more memorable. We did not realize how time had passed."*
>
> *"Animations and cartoons were fun. The lesson was more fun. I paid more attention to the activities."*
>
> "*I was having fun. I was interested and felt that I was making sense of the concepts. I'm more interested in examples in everyday life. There were things in everyday life that I didn't know when I compared them.*"
>
> *"I was curious about the high temperature and low temperature phenomenon in the cartoons and tried it myself. I tried olive oil and water myself to see how it works."*

Conclusions and Discussions

As a result of the study, it was understood that the POE-based interactive e-book effectively eliminated students' misconceptions before and after the application. It was understood that the concept cartoons, animations, drag-and-drop activities, and educational videos in the POE-based interactive e-book are designed and prepared based on examples from daily life, helping students easily understand the concepts related to heat and temperature units and their differences. It was determined that the simple content of the developed e-book and the use of natural language make it easier to learn the concepts. It was revealed that including interactive activities with the content in the prediction and observation stages supports students' learning of concepts. It was identified that the contradictory situations used in the prediction stage of POE help reveal students' prior knowledge about concepts, and in the observation stage, seeing the results of prediction situations related to concepts and understanding the differences between concepts through concrete examples. It was understood that having the opportunity to watch videos and animations repeatedly, to stop and replay parts that need to be understood, positively affects concept learning. The opportunity for students to learn at their own pace enabled them to understand the concepts and their relationships better. Studies show that the applications and multimedia materials included in interactive e-books effectively help students understand concepts (Firdausy & Prasetyo, 2020; Harjono et al., 2020; Hikmaturrosyidah & Racmadiarti, 2022; Kao et al., 2019). It is argued that including activities that will create cognitive contradictions in interactive e-books and simply presenting the content make it easier for students to understand the concepts (Afriwardani et al., 2023; Mufit et al., 2022; Ormancı & Çepni, 2020). Animations, simulations, videos, and visuals in interactive e-books facilitate learning abstract concepts by visualizing physics-related concepts (Hasan et al., 2018) and effectively presenting details about physics concepts (Adawiyah et al., 2019). It is claimed that bridges should be built between interactive e-books and real-life learning to increase students' learning opportunities (Harjono et al., 2020; Mouri et al., 2018). In this regard, interactive e-books include activities that allow students to make predictions about contradictory situations related to concepts and observe the results of their predictions, include videos, animations, and concept cartoons developed based on examples related to daily life, and allow students to progress at their pace, will help students understand the concepts. It is effective in eliminating misconceptions. In this study, the student's answers to questions about the content of the videos and animations in the interactive e-book provided interactions with the content. In future studies, more interaction with the content can be achieved, especially by adding simulations to e-books. Interactive videos can be developed by adding open-ended, multiple-choice questions to the videos.

It was understood that when using POE-based interactive e-books, students' ability to work individually and identify their mislearning during the prediction and observation stages is beneficial for self-regulated learning. The POE-based interactive e-book was determined to keep students active throughout the learning process. Providing access to the e-book's contents at any time and place supports students' ability to work on their goals actively. Since students could access the videos, animations, visuals, and texts in the interactive e-book repeatedly throughout the process, they had additional study opportunities suitable for them. They eliminated their subject deficiencies through the e-book. The questions and activities in the POE-based interactive e-book were helpful for students to self-evaluate and see their development. In the literature, Chen and Su (2019) noted that increasing the bounds of the self-regulation environment to a certain extent can give students more autonomy to regulate their learning by themselves, such as monitoring and managing their thinking, learning, and assessment by themselves in order to achieve an academic goal. It is argued that including activities that will create cognitive contradictions in interactive e-books and simply presenting the content make it easier for students to understand their wrongs (Afriwardani et al., 2023; Mufit et al., 2022; Ormancı & Çepni, 2020). Susantini et al. (2021) suggest that providing students with opportunities to monitor, evaluate, and reflect on themselves in interactive e-books is necessary for self-regulated learning. Ainulluluah et al. (2022) argue that interactive e-books are essential in ensuring students' learning independence (the opportunity to start studying the subjects they want, navigation) and creating their own rules and principles regarding the learning processes. Accordingly, it can be stated that interactive e-books involving activities containing different multimedia elements that will allow students to notice and correct their misinformation, monitor their learning processes, and evaluate themselves can support self-regulated learning. Yang and Ogata (2023) argue that providing students with note-taking tools on the topics they study in interactive e-books and providing feedback on the notes taken will support self-regulation. Lestari et al. (2024) found that providing tips to students in interactive e-books to help them complete the tasks and giving feedback on their performance supports self-regulation. In this regard, adding tools for feedback, study strategies, and note-taking strategies to interactive e-books in future studies can support self-regulated learning.

The study detected that the animations, videos, and concept cartoons contained in the interactive e-book are associated with daily life and that prediction and observation activities support cognitive engagement by making lessons more fun, making the time pass quickly in the lesson, and enabling students to gather their attention and actively participate in the lesson. It was determined that the contradictory situations presented, especially in interactive videos, concept cartoons, and animations, make students curious about the content of the interactive e-book. Previous studies also report that the interaction elements and dynamic elements contained in interactive e-books are effective in ensuring student engagement (Chen, Yohannes, & Chang, 2023; Chesser, 2011). Roskos, Brueck, and Lenhart (2017) found that interactive e-books can attract students' attention, motivate them, and enable them to pay attention significantly when enriched with multimedia (animation, music, sound, spotlight). Huang and Hwang (2019) argue that videos in interactive e-books, activities that encourage deep thinking associated with everyday life, and reflections ensure student engagement. Lim et al. (2020) found that animations are practical and helpful in attracting and directing students' attention. Yohannes et al. (2023) stated that the interactive features of e-books increased curiosity and created an opportunity for a better understanding of the content. Accordingly, interactive e-books, including activities such as POE, inquiry, and problem-based learning that support students' cognitive engagement and applications associated with daily life, and exciting animations, videos, and concept cartoons related to content, can support students' cognitive engagement. Chen, Jamiat, and Mao (2023) determined that gamification components in interactive e-books increased students' engagement. In this sense, gamification elements can be added to activities in future studies.

Limitations and Suggestions for Future Researches

This study was conducted with 31 high school students based on explanatory mixed-method research. Scales and focus group interviews were used as data collection tools. However, the study has some limitations. These are based on heat and temperature, which is the subject of high school as content in the interactive e-book, and POE as the method. Future studies on interactive e-books can address different topics and learning methods. Another limitation is that the number of samples is 31. However, since it is based on the mixed research method, the reasons for the results obtained from quantitative data were tried to be explained by qualitative data. In order to generalize in future studies, experimental studies with larger samples will be more beneficial in order to see the effect of the method and interactive e-book features on students' learning outcomes more clearly. The third limitation is the use of scales and focus group interviews as a means of data collection. In future studies, including log records that hold students ' behavior in the e-book can provide more detailed information about the variables discussed.

References

Adam, A. S., & Suprapto, N. (2019). One-stop physics e-book package development for senior high school learning media. *IJET*, *14*(19), 150-158.

Adawiyah, R., Harjono, A., Gunawan, G., & Hermansyah, H. (2019). Interactive e-book of physics to increase students' creative thinking skills on rotational dynamics concept. In *Journal of Physics: Conference Series* (Vol. 1153, No. 1, p. 012117). Bristol: IOP Publishing.

Afriwardani, P., Jumadi, J., & Pribadi, F. O. (2023). Development of interactive physics e-book to reduce student misconception. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 2018-2024. doi:10.29303/jppipa.v9i4.1854

Agarwal, R., & Karahanna, E. (2000). Time flies when you're having fun: Cognitive absorption and beliefs about information technology usage. *MIS Quarterly, 24*(4), 665-694.

Ainulluluah, A., Boeriswati, E., Rahmawati, Y., & Setiawan, B. (2022). Systematic literature review: Improving self regulated learning through the flipped classroom model based on interactive e-books. *Jurnal Basicedu*, *6*(3), 4679-4685. doi:10.31004/basicedu.v6i3.2853

Akpınar, E. (2014). The use of interactive computer animations based on POE as a presentation tool in primary science teaching. *Journal of Science Education and Technology*, *23*(4), 527-537. doi:10.1007/s10956-013-9482-4

Alfiyanti, I. F., & Jatmiko, B. (2020). The effectiveness of Predict Observe Explain (POE) model with PhET to improve critical thinking skills of senior high school students. *Studies in Learning and Teaching, 1*(2), 76-85. doi:10.46627/silet.v1i2.34

Almekhlafi, A. G. (2021). The effect of e-books on preservice student teachers' achievement and perceptions in the United Arab Emirates. *Education and Information Technologies*, *26,* 1001-1021. doi:10.1007/s10639-020-10298-x

Arifah, B. (2017). Pengaruh model discovery learning dengan pendekatan scientific berbasis e-book pada materi rangkaian ınduktor terhadap hasil belajar siswa. *JUPITER (Jurnal Pendidikan Teknik Elektro), 2*(2), 21-28. doi:10.25273/jupiter.v2i2.1795

Asi, M., Retnoningsih, A., & Irsadi, A. (2021). Effectiveness of interactive e-book global warming and climate change integrated socio scientific issues peat ecosystem [Special issue]. *Jurnal Penelitian Pendidikan IPA, 7*, 240-244. doi:10.29303/jppipa.v7iSpecialIssue.1039

Banawi, A., Sopandi, W., Kadarohman, A., & Solehuddin, M. (2019). Prospective primary school teachers' conception change on states of matter and their changes through predict-observe-explain strategy. *International Journal of Instruction*, *12*(3), 359-374. doi:10.29333/iji.2019.12322a

Bikowski, D., & Casal, J. E., (2018). Interactive digital textbooks and engagement: A learning strategies framework. *Language Learning and Technology, 22*(1), 119-136. doi:10125/44584

Boekaerts, M. (2016). Engagement as an inherent aspect of the learning process. *Learning and Instruction*, *43*, 76-83. doi:10.1016/j.learninstruc.2016.02.001

Boticki, I., Akçapınar, G., & Ogata, H. (2019). E-book user modelling through learning analytics: The case of learner engagement and reading styles. *Interactive Learning Environments*, *27*(5-6), 754-765. doi:10.1080/10494820.2019.1610459

Bozan, İ., & Savaş, B. (2019). Üstün yetenekli öğrencilerde sık görülen kavram yanılgılarının öğretmen görüşlerine göre incelenmesi. *Disiplinlerarası Eğitim Araştırmaları Dergisi*, *3*(6), 87-98.

Bozkurt, A., & Bozkaya, M. (2015). Evaluation criteria for interactive e-books for open and distance learning. *International Review of Research in Open and Distributed Learning*, *16*(5), 58-82. doi:10.19173/irrodl.v16i5.2218

Bozzi, M., Ghislandi, P., Kazuhiko, T., Mami, M., Motoi, W., Naoto, N., ... Zani, M. (2019). *Highlight misconceptions in Physics: A TIME project*. Proceedings of INTED2019 Conference, Valencia, Spain.

Casselden, B., & Pears, R. (2020). Higher education student pathways to ebook usage and engagement, and understanding: Highways and cul de sacs. *Journal of Librarianship and Information Science*, *52*(2), 601-619. doi:10.1177/0961000619841429

Cengiz, E. (2018). An activity based on prediction-observation-explanation strategy used for teaching the particulate nature of matter. *Journal of Inquiry Based Activities*, *8*(1), 51-69.

Chen, C. H., & Su, C. Y. (2019). Using the BookRoll e-book system to promote self-regulated learning, self-efficacy and academic achievement for university students. *Journal of Educational Technology & Society*, *22*(4), 33-46.

Chen, M. R. A., Hwang, G. J., Majumdar, R., Toyokawa, Y., & Ogata, H. (2021). Research trends in the use of E-books in English as a foreign language (EFL) education from 2011 to 2020: A bibliometric and content analysis. *Interactive Learning Environments*, 1-17. doi:10.1080/10494820.2021.1888755

Chen, C., Jamiat, N., & Mao, Y. (2023). The study on the effects of gamified interactive e-books on students' learning achievements and motivation in a Chinese character learning flipped classroom. *Frontiers in Psychology*, *14*, 1-14. doi:10.3389/fpsyg.2023.1236297

Chen, H. L., Yohannes, A., & Chang, C. C. (2023). Designing an interactive e-book of three views for enhancing students' spatial ability. In *2023 14th IIAI International Congress on Advanced Applied Informatics (IIAI-AAI)* (pp. 717-718). IEEE. doi:10.1109/IIAI-AAI59060.2023.00148

Cheng, E. C. K. (2011). The role of self-regulated learning in enhancing learning performance. *The International Journal of Research and Review, 6*(1), 1-16.

Chesser, W. D. (2011). The e-textbook revolution. *Library Technology Reports*, *47*(8), 28-40.

Churiyah, M., Putri, O. M., Arief, M., Dharma, B. A., Sukmawati, E., & Zainuddin, Z. (2023). Project based learning interactive e-book: A solution to self regulated learning and student learning outcomes. In *BISTIC Business Innovation Sustainability and Technology International Conference (BISTIC 2023)* (pp. 132-142). Amsterdam: Atlantis Press.

Clark, V. L. P., & Ivankova, N. V. (2015). *Mixed methods research: A guide to the field* (Vol. 3). Thousand Oaks, CA: Sage.

Connell, J. P., & Wellborn, J. G. (1991). Competence, autonomy, and relatedness: A motivational analysis of self-system processes. In M. R. Gunnar & L. A. Sroufe (Eds.), *Self-processes and development* (pp. 43-77). New Jersey: Lawrence Erlbaum Associates, Inc.

Dabbagh, N., & Kitsantas, A. (2005). Using web-based pedagogical tools as scaffolds for self-regulated learning. *Instructional Science*, *33*(5-6), 513-540. doi:10.1007/s11251-005-1278-3

Eitel, A., Bender, L., & Renkl, A. (2019). Are seductive details seductive only when you think they are relevant? An experimental test of the moderating role of perceived relevance. *Applied Cognitive Psychology, 33*(1), 20-30. doi:10.1002/acp.3479

Fenditasari, K., & Istiyono, E. (2020). Identification of misconceptions on heat and temperature among physics education students using four-tier diagnostic test. *Journal of Physics: Conference Series, 1470*(2020), 1-12. doi:10.1088/1742-6596/1470/1/012055

Firdausy, B. A., & Prasetyo, Z. K. (2020). Improving scientific literacy through an interactive e-book: A literature review. In *Journal of Physics: Conference Series* (Vol. 1440, No. 1, p. 012080). Bristol: IOP Publishing.

Fuadi, F., Sopandi, W., Priscylio, G., Hamdu, G., & Mustikasari, L. (2020). Students' conceptual changes on the air pressure learning using predict-observe-explain strategy. *Mimbar Sekolah Dasar, 7*(1), 70-85. doi:10.17509/mimbar-sd.v7i1.22457

Gibbs, A. (2012). Focus groups and group interviews. In J. Arthur, M. Waring, R. Coe, & L. V. Hedges (Eds.), *Research methods and methodologies in education* (pp. 186-192). Thousand Oaks, CA: Sage.

Hadaya, A., & Hanif, M. (2019). The impact of using the interactive e-book on students' learning outcomes. *International Journal of Instruction*, *12*(2), 709-722. doi:10.29333/iji.2019.12245a

Harjono, A., Gunawan, G., Adawiyah, R., & Herayanti, L. (2020). An interactive e-book for physics to improve students' conceptual mastery. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(5), 40-49.

Hasan, M. F., Suyatna, A., & Suana, W. (2018). Development of interactive e-book on energy resources to enhance student's critical thinking ability. *Tadris: Jurnal Keguruan dan Ilmu Tarbiyah*, *3*(2), 109-121. doi:10.24042/tadris.v3i2.3114

Haşlaman, T. (2011). *Çevrimiçi öğrenme ortamının öğretmen ve öğrencilerin özdüzenleyici öğrenme becerileri üzerindeki etkisi* (Unpublished doctoral dissertation). Hacettepe University, Ankara.

Hidajat, F. A. (2023). The development of digital e-books to improve students' creativity skills: A self-regulation strategies approach. *International Journal of Instruction*, *16*(4), 367-384. doi:10.29333/iji.2023.16422a

Hikmaturrosyidah, N., & Racmadiarti, F. (2022). The development of interactive e-book based on multiple intelligences ecosystem topic to train creative thinking skills. *Journal of Biology Education*, *11*(1), 89-101.

Hong, J. C., Hwang, M. Y., Tai, K. H., & Tsai, C. R. (2017). An exploration of students' science learning interest related to their cognitive anxiety, cognitive load, self-confidence and learning progress using inquiry-based learning with an iPad. *Research in Science Education*, *47*(6), 1193-1212. doi:10.1007/s11165-016-9541-y

Hsieh, Y., & Huang, S. (2020). Using an e-book in the secondary English classroom: Effects on EFL reading and listening. *Education and Information Technologies*, *25*(2), 1285-1301. doi:10.1007/s10639-019-10036-y

Huang, H., & Hwang, G.-J. (2019). Facilitating inpatients' family members to learn: A learning engagement-promoting model to develop interactive e-book systems for patient education. *Educational Technology & Society, 22*(3), 74-87.

Hwang, G. J., & Lai, C. L. (2017). Facilitating and bridging out-of-class and in-class learning: An interactive e-book-based flipped learning approach for math courses. *Journal of Educational Technology & Society, 20*(1), 184-197.

Hwang, G.-J., Tu, N.-T., & Wang, X.-M. (2018). Creating interactive e-books through learning by design: The impacts of guided peer-feedback on students' learning achievements and project outcomes in science courses. *Educational Technology & Society, 21*(1), 25-36.

Ivankova, N. V., & Creswell, J. W. (2009). Mixed methods. In J. Heigham & R. A. Croker (Eds.), *Qualitative research in applied linguistics: A practical introduction* (pp. 135-161). London: Palgrave Macmillan.

Kao, G. Y. M., Chiang, X. Z., & Foulsham, T. (2019). Reading behavior and the effect of embedded selfies in role-playing picture e-books: An eye-tracking investigation. *Computers & Education*, *136*, 99-112. doi:10.1016/j.compedu.2019.03.010

Karataş, F. Ö., Köse, S., & Coştu, B. (2003). Öğrenci yanılgılarını ve anlama düzeylerini belirlemede kullanılan iki aşamalı testler. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, *13*(13), 54-69.

Kettles, A. M., Creswell, J. W., & Zhang, W. (2011). Mixed methods research in mental health nursing. *Journal of Psychiatric and Mental Health Nursing*, *18*(6), 535-542. doi:10.1111/j.1365-2850.2011.017

Korat, O., & Falk, Y. (2019). Ten years after: Revisiting the question of e-book quality as early language and literacy support. *Journal of Early Childhood Literacy*, *19*(2), 206-223. doi:10.1177/1468798417712105

Latifah, S., Irwandani, I., Saregar, A., Diani, R., Fiani, O., Widayanti, W., & Deta, U. A. (2019). How the Predict-Observe-Explain (POE) learning strategy remediates students' misconception on Temperature and Heat materials?. In *Journal of Physics: Conference Series* (Vol. 1171, No. 1, p. 012051). Bristol: IOP Publishing.

Lee, S. H. (2017). Learning vocabulary through e-book reading of young children with various reading abilities. *Reading and Writing, 30*(7), 1595-1616. doi:10.1007/s11145-017-9740-6

Lee, S. H. (2020). Learning vocabulary from e-book reading and recorded word explanation for low-income elementary students with and without reading difficulties. *Reading and Writing*, *33*(3), 691-717. doi:10.1007/s11145-019-09983-2

Lee, T. T., & Osman, K., (2012). Interactive multimedia module with pedagogical agents: Formative evaluation. *International Education Studies, 5*(6), 50-64. doi:10.5539/ies.v5n6p50

Lestari, D. A., Suwarma, I. R., & Suhendi, E. (2024). Feasibility analysis of the development of STEM-based physics e-book with self-regulated learning on global warming topics. *Indonesian Journal of Teaching in Science*, *4*(1), 1-10. doi:10.17509/ijotis.v4i1.60110

Li, J., Ma, F., Wang, Y., Lan, R., Zhang, Y., & Dai, X. (2020). Pre-school children's behavioral patterns and performances in learning numerical operations with a situation-based interactive e-book. *Interactive Learning Environments*, *28*(2), 148-165. doi:10.1080/10494820.2019.1636085

Liu, Y., Chou, P. L., & Lee, B. O. (2020). Effect of an interactive e-book on nursing students' electrocardiogram-related learning achievement: A quasi-experimental design. *Nurse Education Today*, *90*, 104427. doi:10.1016/j.nedt.2020.104427

Lieung, K. W., Rahayu, D. P., & Yampap, U. (2021). Development of an interactive e-book to improve student's problem solving. *Jurnal Ilmiah Sekolah Dasar*, *5*(1), 8-15.

Lim, J., Whitehead, G. E., & Choi, Y. (2021). Interactive e-book reading vs. paper-based reading: Comparing the effects of different mediums on middle school students' reading comprehension. *System*, *97*, 102434. doi:10.1016/j.system.2020.102434

Lim, B. C. Y., Liu, L. W. L., & Hou, C. C. (2020). Investigating the effects of interactive e-book towards academic achievement. *Asian Journal of University Education*, *16*(3), 78-88.

Lin, P. H., Huang, Y. M., & Chen, C. C. (2018). Exploring imaginative capability and learning motivation difference through picture E-book. *IEEE Access, 6*, 63416-63425. doi:10.1109/ACCESS.2018.2875675

Mana, N., Mich, O., De Angeli, A., & Druin, A. (2013). Interactive e-books for children. In *Proceedings of the 12th International Conference on Interaction Design and Children* (pp. 593-595). doi:10.1145/2485760.2485886

Mayer, R. E. (2014). Cognitive theory of multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 43-71). Cambridge: Cambridge University Press.

Merkle, A. C., Ferrell, L. K., Ferrell, O. C., & Hair Jr, J. F. (2022). Evaluating e-book effectiveness and the impact on student engagement. *Journal of Marketing Education*, *44*(1), 54-71. doi:10.1177/02734753211035162

Ministry of National Education. (2018). *Ortaöğretim 9. sınıf fizik öğretim programı.* Ankara: Milli Eğitim Bakanlığı Yayınları.

Mouri, K., Uosaki, N., & Ogata, H. (2018). Learning analytics for supporting seamless language learning using e-book with ubiquitous learning system. *Journal of Educational Technology & Society*, *21*(2), 150-163.

Mufit, F., Asrizal, A., & Puspitasari, R. (2022). Cognitive conflict-based e-book with real experiment video analysis integration to enhance conceptual understanding of motion kinematics. *Jurnal Pendidikan IPA Indonesia*, *11*(4), 626-639.

Nalkıran, T., & Karamustafaoğlu, S. (2020). Prediction-Observation-Explanation (POE) method and its efficiency in teaching "work, energy, power" concepts. *International Journal of Assessment Tools in Education*, *7*(3), 497-521. doi:10.21449/ijate.727399

Oktavianty, E., Haratua, T. M. S., & Anuru, M. (2018). The effect of remediation on reducing misconception: A meta-analysis of student thesis on physics education. *Journal of Physics: Conference Series, 1013*(2018), 1-5. doi:10.1088/1742-6596/1013/1/012039

Ormancı, Ü., & Çepni, S. (2020). Views on interactive e-book use in science education of teachers and students who perform e-book applications. *Turkish Online Journal of Qualitative Inquiry*, *11*(2), 247-279. doi:10.17569/tojqi.569211

Pabrua Batoon, M. V., Victoria, M., Glasserman Morales, L. D., & Yanez Figueroa, J. A. (2018). Instructional design to measure the efficacy of interactive e-books in a high school setting. *Turkish Online Journal of Distance Education*, *19*(2), 47-60. doi:10.17718/tojde.415641

Paas, F., & Sweller, J. (2014). Implications of cognitive load theory for multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 27-42). Cambridge: Cambridge University Press.

Peng, H. Y., Chuang, P. Y., Hwang, G. J., Chu, H. C., Wu, T. T., & Huang, S. X. (2009). Ubiquitous performance-support system as mindtool: A case study of instructional decision making and learning assistant. *Educational Technology & Society*, *12*(1), 107-120.

Perwita, D. P., & Fauzi, A. (2021). The analysis of depth high school physics material in terms of standards for the development of earthquake theme physics e-books. In *Journal of Physics: Conference Series* (Vol. 1876, No. 1, p. 1-8). Bristol: IOP Publishing.

Pujiwati, R., & Susilaningsih, E. (2020). The influence of POE Learning (Predict Observe Explain) Model on the understanding of science concept of students of smp negeri 32 semarang. *Jurnal Pembelajaran Sains*, *4*(1), 37-41. doi:10.17977/um033v4i1p37-41

Pramana, M. W. A., Jampel, I. N., & Pudjawan, K. (2020). Meningkatkan hasil belajar biologi melalui e-modul berbasis problem based learning. *Jurnal Edutech Undiksha*, *8*(2), 17-32. doi:10.23887/jeu.v8i2.28921

Rahmawati, A. J., & Muchtarom, M. (2023). Development of e-book based on self regulated learning enhancing self efficacy. In *International Conference on Education 2022 (ICE 2022)* (pp. 63-72). Amsterdam: Atlantis Press. doi:10.2991/978-2-38476-020-6_7

Reich, S. M., Yau, J. C., Xu, Y., Muskat, T., Uvalle, J., & Cannata, D. (2019). Digital or print? A comparison of preschoolers' comprehension, vocabulary, and engagement from a print book and an e-book. *AERA Open*, *5*(3), 1-16. doi:10.1177/2332858419878389

Richter, A., & Courage, M. L. (2017). Comparing electronic and paper storybooks for preschoolers: Attention, engagement, and recall. *Journal of Applied Developmental Psychology*, *48*, 92-102. doi:10.1016/j.appdev.2017.01.002

Rockinson-Szapkiw, A. J., Courduff, J., Carter, K., & Bennett, D. (2013). Electronic versus traditional print textbooks: A comparison study on the influence of university students' learning. *Computers & Education, 63,* 259-266. doi:10.1016/j.compedu.2012.11.022

Roskos, K., Brueck, J., & Lenhart, L. (2017). An analysis of e-book learning platforms: Affordances, architecture, functionality and analytics. *International Journal of Child-Computer Interaction*, *12*, 37-45. doi:10.1016/j.ijcci.2017.01.003

Sa'adah, S. A., & Haryadi, R. (2020). Literature review: Cognitive conflict approach in physics learning to overcome the misconception of physics. *ScienceEdu: Jurnal Pendidikan IPA*, *3*(2), 101-103.

Saripudin, D., Fauzi, W. I., & Nugraha, E. (2022). The development of interactive e-book of local history for senior high school in improving local wisdom and digital literacy. *European Journal of Educational Research, 11*(1), 17-31. doi:10.12973/eu-jer.11.1.17

Schneider, S., Wirzberger, M., & Rey, G. D. (2019). The moderating role of arousal on the seductive detail effect in a multimedia learning setting. *Applied Cognitive Psychology, 33*(1), 71-84. doi:10.1002/acp.3473

Septikasari, A. N., Maison, M., & Nazarudin, N. (2021). Interactive e-book for physics learning: Analysis of students' characters and conceptual understanding. *Indonesian Journal of Science and Mathematics Education*, *4*(1), 25-36.

Shamir, A., Korat, O., & Shlafer, I. (2011). The effect of activity with e-book on vocabulary and story comprehension: A comparison between kindergarteners at risk of learning disabilities and typically developing kindergarteners. *European Journal of Special Needs Education*, *26*(3), 311-322. doi:10.1080/08856257.2011.593824

Shernoff, D. J., Csikszentmihalyi, M., Schneider, B., & Shernoff, E. S. (2014). Student engagement in high school classrooms from the perspective of flow theory. In *Applications of Flow in Human Development and Education* (pp. 475-494). Dordrecht: Springer.

Skinner, E. A., & Pitzer, J. R. (2012). Developmental dynamics of student engagement, coping, and everyday resilience. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 21-44). New York, NY: Springer. doi:10.1007/978-1-4614-2018-7_2

Soeharto, S., Csapó, B., Sarimanah, E., Dewi, F. I., & Sabri, T. (2019). A review of students' common misconceptions in science and their diagnostic assessment tools. *Jurnal Pendidikan IPA Indonesia*, *8*(2), 247-266.

Soeharto, S., & Csapó, B. (2021). Evaluating item difficulty patterns for assessing student misconceptions in science across physics, chemistry, and biology concepts. *Heliyon, 7*(11), 1-10. doi:10.1016/j.heliyon.2021.e08352

Swanson, E., Austin, C. R., Stewart, A. A., & Scammacca, N. (2020). A meta-analysis examining the effect of e-book use on literacy outcomes for students in grades K-12. *Reading & Writing Quarterly*, *36*(5), 480-496. doi:10.1080/10573569.2019.16967

Sumilah, & Sulistyaningrum, H. (2021). POE learning improves primary school students' science learning achievement. In *Proceeding of International Conference in Education, Science and Technology* (pp. 469-473). Retrieved from http://prosiding.unirow.ac.id/index.php/iconest/article/view/1159/665

Sung, T. W., & Wu, T. T. (2017). Dynamic e-book guidance system for English reading with learning portfolio analysis. *The Electronic Library*, *35*(2), 358-373. doi:10.1108/EL-11-2015-0221

Sung, H. Y., Hwang, G. J., & Chen, S. F. (2019). Effects of embedding a problem-posing-based learning guiding strategy into interactive e-books on students' learning performance and higher order thinking tendency. *Interactive Learning Environments*, *27*(3), 389-401. doi:10.1080/10494820.2018.14742

Sung, H. Y., Hwang, G. J., Chen, C. Y., & Liu, W. X. (2022). A contextual learning model for developing interactive e-books to improve students' performances of learning the Analects of Confucius. *Interactive Learning Environments*, *30*(3), 470-483. doi:10.1080/10494820.2019.1664595

Susantini, E., Puspitawati, R. P., Raharjo, & Suaidah, H. L. (2021). E-book of metacognitive learning strategies: Design and implementation to activate student's self-regulation. *Research and Practice in Technology Enhanced Learning*, *16*(13), 1-17. doi:10.1186/s41039-021-00161-z

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

Tsuei, M., Huang, H. W., & Cheng, S. F. (2020). The effects of a peer-tutoring strategy on children's e-book reading comprehension. *South African Journal of Education*, *40*(2), 1-12.

Xu, Y., Yau, J. C., & Reich, S. M. (2021). Press, swipe and read: Do interactive features facilitate engagement and learning with e-books?. *Journal of Computer Assisted Learning*, *37*(1), 212-225. doi:10.1111/jcal.12480

Umarji, O., Day, S., Xu, Y., Zargar, E., Yu, R., & Connor, C. (2020). Opening the black box: User-log analyses of children's e-book reading and associations with word knowledge. *Reading and Writing, 34*, 627-658. doi:10.1007/s11145-020-10081-x

Usluel Koçak, Y., & Vural Kurt, F. (2009). Bilişsel kapılma ölçeği'nin Türkçeye uyarlama çalışması. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Dergisi*, *42*(2), 77-92.

Wang, J., Shimada, A., Oi, M., Ogata, H., & Tabata, Y. (2020). Development and evaluation of a visualization system to support meaningful e-book learning. *Interactive Learning Environments, 31*(2), 836-853. doi:10.1080/10494820.2020.18131

Weng, C., Otanga, S., Weng, A., & Cox, J. (2018). Effects of interactivity in e-textbooks on 7th graders science learning and cognitive load. *Computers & Education, 120*, 172-184. doi:10.1016/j.compedu.2018.02.00

Winne, P. H. (2017). Cognition and metacognition within self-regulated learning. In *Handbook of self-regulation of learning and performance* (pp. 52-64). London: Routledge.

Wu, T. T. (2016). A learning log analysis of an English-reading e-book system combined with a guidance mechanism. *Interactive Learning Environments, 24*(8), 1938-1956. doi:10.1080/10494820.2015.10702

Yang, C. C., & Ogata, H. (2023). Lag seqential anaiysis for identifying blended learners' sequential patterns of e-book note-taking for self-regulated learning. *Educational Technology & Society*, *26*(2), 63-75. doi:10.30191/ETS.202304_26(2).0005

Yang, D., Zargar, E., Adams, A. M., Day, S. L., & Connor, C. M. (2020). Using interactive e-book user log variables to track reading processes and predict digital learning outcomes. *Assessment for Effective Intervention, 46*(4). doi:10.1177/153450842094193

Yin, C., Yamada, M., Oi, M., Shimada, A., Okubo, F., Kojima, K., & Ogata, H. (2019). Exploring the relationships between reading behavior patterns and learning outcomes based on log data from e-books: A human factor approach. *International Journal of Human-Computer Interaction*, *35*(4-5), 313-322. doi:10.1080/10447318.2018.15430

Yohannes, A., Chen, H. L., & Chang, C. C. (2023). Effect of an interactive e-book on middle school students' mathematics reading and spatial ability. *Educational Technology Research and Development*, *71*(4), 1869-1886. doi:10.1007/s11423-023-10225-0

Yorganci, S. (2022). The interactive e-book and video feedback in a multimedia learning environment: Influence on performance, cognitive, and motivational outcomes. *Journal of Computer Assisted Learning*, *38*(4), 1005-1017. doi:10.1111/jcal.12658

Yuenyong, J., & Yuenyong, C. (2021). Examining grade 5 students' capability of analytical thinking in learning about heat conduction through Predict-Observe-Explain (POE) strategy. *Journal of Physics: Conference Series*, *1835*. doi:10.1088/1742-6596/1835/1/012024

Yulianti, R., Suhandi, A., & Sopandi, W. (2020). The effect of poe strategy on students'conceptual change regarding water density. *JPSD (Jurnal Pendidikan Sekolah Dasar)*, *6*(1), 15-29. doi:10.30870/jpsd.v6i1.7220

Zakiyah, I., Widodo, W., & Tukiran, T. (2019). The effectiveness of predict-observe-explain strategy to reduce misconception in thermochemistry. In *Mathematics, Informatics, Science, and Education International Conference (MISEIC 2019)* (pp. 112-115). Amsterdam: Atlantis Press.

Zarzour, H., Bendjaballah, S., & Harirche, H. (2020). Exploring the behavioral patterns of students learning with a Facebook-based e-book approach. *Computers & Education*, *156*, 103957. doi:10.1016/j.compedu.2020.103957

Zhao, J., Hwang, G. J., Chang, S. C., Yang, Q. F., & Nokkaew, A. (2021). Effects of gamified interactive e-books on students' flipped learning performance, motivation, and meta-cognition tendency in a mathematics course. *Educational Technology Research and Development*, *69*(6), 3255-3280. doi:10.1007/s11423-021-10053-0

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology, 81*(3), 329-339.