Indonesian Society for Science Educators
Journal of Science Learning
journal homepage: ejournal.upi.edu/index.php/jslearning

Animated Concept Cartoons as a Starter for Cognitive Conflict in Online Science Learning: A Case of Circular Motion

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ABSTRACT Before taking formal science education, learners usually construct preconceptions based on their daily life experiences, many of which are scientifically unacceptable misconceptions. In formal science learning, new concepts often contradict these misconceptions. To correct a misconception, it is first needed to create dissatisfaction about it by initiating cognitive conflict. This study aims to create an animated concept cartoon about circular motion and evaluate its usability to start cognitive conflict about centrifugal force misconception in online learning. This is a one-group quasi-experimental study whose participants are 110 undergraduate students with non-science backgrounds. An animated concept cartoon about circular motion and an online data collection instrument were developed and implemented for the participants. Results showed that half of the participants might be considered to be in a status of cognitive conflict after reading the animated concept cartoon. In addition, participants' overall satisfaction with the animated concept cartoon was found to be relatively high. Participants' satisfaction with the animated concept cartoon was equal for students with and without cognitive conflict. In the context of these findings, the animated concept cartoon may be considered an enjoyable and useful learning activity to initiate cognitive conflict in online science learning.

Keywords Animated Concept Cartoon, Cognitive Conflict, Circular Motion, Online Learning

1. INTRODUCTION

Concerning cognitivist learning theory, learning a new concept, contradictory to learners' existing conceptual schema, needs a conceptual change in its structure (Barrouillet, 2015). This learning type, called accommodation, starts with dissatisfaction with existing concepts (Posner, Strike, Hewson, & Gertzog, 1982). Therefore, an instructional process aiming at accommodating a new concept should be designed to make learners dissatisfied with existing concepts to increase their readiness for learning new concepts. In science learning, new concepts often contradict the old ones because learners usually construct a unique schema of science concepts based on their personal daily life experiences before taking formal science education (Pine, Messer, & St. John, 2001). Some of these introductory concepts involved in learners' existing schema are regarded as misconceptions. Misconceptions are false or partially false concepts about nature that are highly resistant to change (Clement, 1982). All the false concepts about nature declared by an individual are not regarded as misconceptions. Individuals generally have their explanations about the reasons for the false concepts (Franklin, 1992). Besides, because of their robust nature, the false concepts, which the individual is sure about, may be regarded as misconceptions (Kaltakci Gurel, Eryilmaz, & McDermott, 2015). As mentioned above, correcting a misconception is first needed to create dissatisfaction about it. Therefore, to take learners to the phase of dissatisfaction with a misconception, using a starter for cognitive conflict is suggested at the beginning of the instruction (Kang, Scharmann, & Noh, 2004). In literature, concept cartoons are regarded as effective starters for cognitive conflict because they present correct concepts and misconceptions on the same page, all of which sound correct but contradict each other (Keogh, Naylor, & Wilson, 1998).

Concept cartoons, which are one-frame illustrations demonstrating conflicting ideas about a daily life situation, have been used as classroom activities in science courses for several purposes (Naylor & Keogh, 2013). In literature, concept cartoons were mostly used to diagnose misconceptions (Ekici, Ekici, & Aydin, 2007; Kandil Ingec, 2008; Chin & Teou, 2009; Kusumaningrum & Indriyanti,

Received: 8 December 2021
Revised: 16 March 2022
Published: 27 July 2022

2018; Atasoy, 2020; Serttas & Turkoglu, 2020) and to correct them (Stephenson & Warwick, 2002; Ekici et al., 2007; Taslidere, 2014; Kumi-Manu, 2021). As described above, concept cartoons are used to overcome misconceptions by creating cognitive conflict. A concept cartoon alone does not reveal which is the right idea; instead, it presents misconceptions and a scientifically acceptable concept together. To correct a misconception, the concept cartoon is usually integrated into a classroom discussion moderated and directed by the teacher (Keogh et al., 1998). During this guided discussion, students are expected to realize the correct concept. In addition, to detect and correct misconceptions, concept cartoons are also used to teach a specific science concept. In this context, Kabapinar (2005) used several concept cartoons as teaching/learning material for several science concepts such as mass, volume, phase changes, atoms, and molecules in primary science courses. Similarly, Sanliturk and Zeybek (2022) created and used a series of digital concept cartoons to teach the concepts of reproduction, growth, and development in plants and animals. They found that digital concept cartoons are effective teaching material.

Concept cartoons are commonly recommended learning material in science education. However, because of their static nature, traditional concept cartoons printed on paper are not generally accepted as a suitable medium for science concepts related to motion. In other words, as a static illustration, a cartoon is expectedly insufficient to describe a situation involving motion (Höffler & Leutner, 2007). Traditionally, motion is partially described by several supporting lines in cartoons that help imagine it. However, motion obviously can be better described by demonstrating it with an animation that is a dynamic medium rather than a still image. Therefore, an animated concept cartoon may be helpful to start a cognitive conflict in learning science concepts related to motion by presenting the correct concept and misconceptions together. In this regard, circular motion, which may be appropriate to be presented in an animated concept cartoon, is one of the science concepts that has a prevalent misconception, called centrifugal force. According to this misconception, rotation is caused by the balance between centrifugal force and an external force opposite to it (Volfson, Eshach, & Ben-Abu, 2020).

Regarding Newton's laws of motion, such a balance of forces yields an unaccelerated motion. It cannot create a circular motion, a kind of accelerated motion needing an unbalanced force. In this context, an animated concept cartoon presenting the centrifugal force misconception and the concept of centripetal force, which is the actual cause of circular motion, may be an effective instructional material to create cognitive conflict.

Traditionally, concept cartoons have been used in school science instruction to initiate cognitive conflict (Naylor & Keogh, 2013). On the other hand, concept cartoons, animated or not, may also be used in online science teaching for the same purpose (Basarmak & Mahiroglu, 2016). In the COVID-19 pandemic, science instruction is primarily performed online in many countries without sufficient preparation. This urgent transition from face-to-face to online teaching caused quality issues in online science instruction. Animated concept cartoons may help these issues by enriching the variety of e-learning activities in online science education. In addition, because of their animated structure, animated concept cartoons may be more suitable for science concepts, most of which have dynamic nature. In this context, the purpose of this study is to develop an animated concept cartoon about circular motion and evaluate whether it can create cognitive conflict or not in an online learning process.

2. METHOD

This study is a one-group post-test only quasi-experimental research study aiming to develop an animated concept cartoon about circular motion and to evaluate its capability to initiate cognitive conflict about centrifugal force misconception. In brief, to achieve this aim, an animated concept cartoon, which is integrated into an online questionnaire to measure cognitive conflict, was developed and implemented for a group of undergraduate students. Data collected in this implementation were analyzed to conclude about the capability of the concept cartoon to initiate cognitive conflict about centrifugal force misconception in online learning.

2.1 Participants

In this study, participants are 110 undergraduate students who study primary education and social science education at a state university in Turkey. In this sample, 78 (71%) female and 32 (29%) male students were selected through convenience sampling, representing the population of 408 students in these departments. Participants do not have extensive science backgrounds and are attendees of the introductory science course or science, technology, and society course, which are online conceptual science courses for students with non-science backgrounds. In this study, students who do not have extensive science backgrounds were chosen as participants because they possibly have more preconceptions about circular motion than those studying science majors. This may make animated concept cartoons more beneficial for non-science majors students.

2.2 Material and Instruments

In this study, an animated concept cartoon about circular motion was used as digital material to initiate cognitive conflict. An online questionnaire was used as a data collection instrument to measure cognitive conflict. The animated concept cartoon is a GIF animation created by the researcher using computer drawing and animation software. The GIF format is chosen for this animation because it is easy to create and integrate into online learning

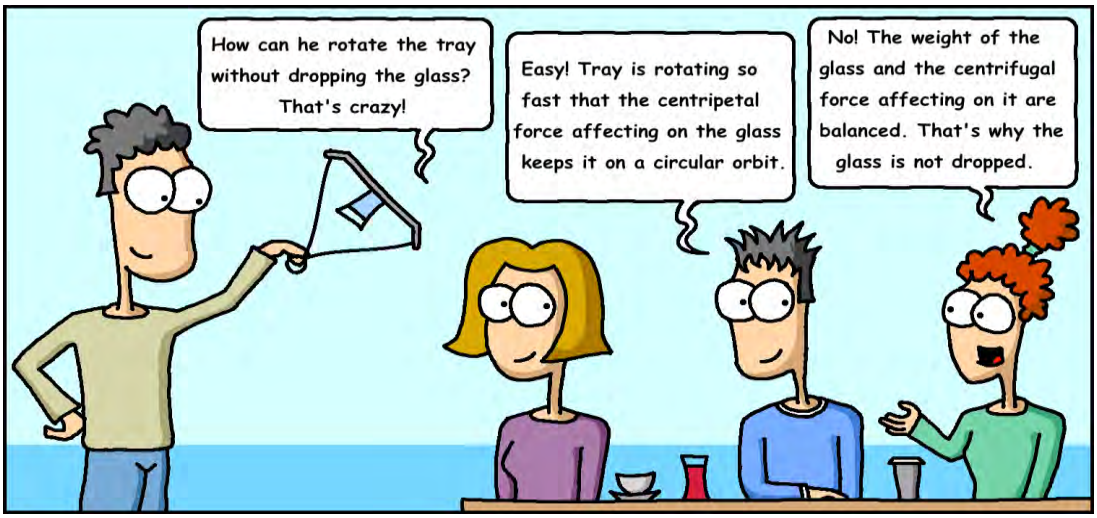

Figure 1 A screenshot from the animated concept cartoon

Table 1 Items in the data collection instrument

#	Question
P1	I like science.
P2	I am interested in science.
P3	I think science is important.
P4	I think I am successful in science.
M1	You read the concept cartoon above. In your opinion, who is correct?
M2	You picked one. Are you sure that the person you picked is correct?
M3	If you are sure about your answer, did you feel a conflict before your decision?
S1	I do not like the animated concept cartoon.
S2	I read the animated concept cartoon with enjoyment.
S3	I found the animated concept cartoon fun.
S4	The animated concept cartoon caught my attention.
S5	Reading the animated concept cartoon is boring.
S6	The animated concept cartoon is intriguing.
S7	The animated concept cartoon is remarkable.
S8	The animated concept cartoon may be used as an introductory activity in distance education.
S9	The animated concept cartoon is a suitable material for distance education.
S10	I found the animated concept cartoon useful.
S11	The animated concept cartoon is thought-provoking.
S12	The animated concept cartoon is clear.
S13	The animated concept cartoon is not suitable for my age.

environments. However, it is possible to convert it into other computer animation or video formats. The animated concept cartoon created in this study demonstrates a daily life situation in which a waiter rotates a tray with his hand, and three guests talk about why a glass of water on the rotating tray does not fall. Tray rotation is a well-known traditional behavior of waiters in Turkey. The first guest asks why the glass of water on the rotating tray does not fall. The second guest correctly answers this question regarding centripetal force, while the third guest answers it concerning the misconception of centrifugal force. Figure 1 shows a screenshot from the animated concept cartoon created in this study.

This animated GIF image is integrated into an online questionnaire to measure cognitive conflict. In addition to the preliminary Likert-type items about participants' opinions about science, this questionnaire mainly includes questions about who is correct in the concept cartoon and whether the participant is sure about who is correct. The participants, who are not sure, are assumed in a status of cognitive conflict. On the other hand, some of the sure participants may also feel a cognitive conflict before getting sure. Therefore, the questionnaire includes an additional question for the sure participants asking whether they feel a conflict before getting sure or not. These participants are assumed in a status of temporary cognitive conflict. In addition to the preliminary items and the main questions, the questionnaire includes several supplementary Likert-type items asking about satisfaction (enjoyment, interest, and usefulness) with the animated concept cartoon.

Supplementary satisfaction items were set to be ordered randomly for each participant. Table 1 demonstrates the preliminary opinion items (P), the main cognitive conflict questions (M), and the supplementary satisfaction items (S) in the data collection instrument.

Both the animated concept cartoon about circular motion and the questionnaire for cognitive conflict were designed and constructed with the supervision of experts' opinions. In other words, initial versions of both instruments were given to two science education experts and revised concerning their opinions before implementing by the participants.

2.3 Implementation

As mentioned above, participants of this study are a group of undergraduate students attending the introductory science course or science technology and society course, which are offered as online courses because of the COVID-19 pandemic. After revising the initial versions of instruments, an online form including the final versions of the animated concept cartoon and the questionnaire was constructed. After getting official permission from the research ethics committee, the link to the online form was shared with the participants before learning the concepts of circular motion in the introductory science course. The participants were also informed about the importance of their answers' independence. They responded to the online questionnaire in about two weeks using their computers or mobile devices. After completing the questionnaire, their responses data were downloaded and converted for statistical analyses.

2.4 Statistical Analysis

Before analyzing data from the main cognitive conflict items, participants' opinions about science measured by preliminary opinion items (P) were analyzed to describe the characteristics of the sample according to their opinions about science.

After this preliminary analysis, data from the main cognitive conflict items (M) were analyzed. In this context, frequencies and percentages of participants who responded correctly and incorrectly about the cause of circular motion were calculated. Then, the frequencies and percentages of participants who were sure and unsure about their responses to the first question were calculated. As mentioned in the previous sections, the students who are unsure about their responses to the first question are regarded as in the cognitive conflict status. In addition, frequencies and percentages of participants who were sure about their responses but felt a conflict before getting sure were also calculated. These participants are accepted as in the status of temporary cognitive conflict. In addition to these descriptive statistics, a statistical comparison of the frequencies of the participants in the status of the cognitive conflict who responded correctly and incorrectly about the cause of circular motion was performed by using the chi-square independence test to check whether the concept cartoon starts cognitive conflict equally for correct and incorrect responses or not.

In addition to statistical analyses on cognitive conflict described above, several supplementary descriptive statistics were also calculated based on data from supplementary items in the questionnaire. In addition to descriptives, the Pearson-r reliability of these supplementary items was also calculated. These supplementary statistics demonstrate participants' opinions about using the animated concept cartoon in an online learning environment in the dimensions of enjoyment, interest, and usefulness. Furthermore, the findings of this analysis were used to evaluate participants' overall satisfaction with the animated concept cartoon. Finally, participants' satisfaction with the animated concept cartoon was compared with regard to being in the status of cognitive conflict by using the Mann-Whitney U-test because of the non-normal distribution of students' satisfaction scores. The results of these analyses will be used as feedback to improve the animated concept cartoon.

3. RESULTS AND DISCUSSION

This study's results of statistical analyses were classified into three main categories. At first, the descriptive results of participants' opinions about science were reported. Then, the results of the statistical analysis of the items about the cognitive conflict were presented. Finally, the analysis results of participants' opinions about the animated concept cartoon were reported.

3.1 Participants' Opinions about Science

Participants' opinions about science were measured by four items representing four dimensions of attitude: the enjoyment of science, interest in science, importance (value) of science, and perception of self-success in science. These items are not an actual attitude scale to calculate the individual attitude scores of the participants. Instead, they are just descriptive items to describe the characteristics of the sample in the affective domain. Table 2 demonstrates participants' opinions about science.

As shown in Table 2, most participants have positive opinions about the enjoyment (P1) and importance (P3) of science. However, their responses to interest in science (P2) and self-perception of success in science (P4) seem to be more dispersed. In other words, for most participants, interest in science and self-perception of success in science does not seem to be high. These dispersed results are somehow expected for a sample with non-science majors.

3.2 Participants' Conceptions and Cognitive Conflict

As mentioned in the previous sections, participants were asked three questions about centrifugal force misconception and cognitive conflict. Before performing deeper analyses, descriptive statistics give some idea about participants' conceptions and their status of cognitive conflict. Table 3 shows the frequencies and percentages of participants' conceptions of circular motion.

Table 2 Participants' opinions about science

	Frequencies*				
Items	**SD**	**D**	**N**	**A**	**SA**
I like science (P1)	8	7	10	61	24
I am interested in science (P2)	7	21	29	34	19
I think science is important (P3)	8	2	3	37	60
I think I am successful in science (P4)	12	29	34	26	9

* SD: Strongly Disagree, D: Disagree, N: Neutral, A: Agree, SA: Strongly Agree

Table 3 Descriptive statistics of participants' conceptions on circular motion

Conception (M1)			
Centripetal force freq. (%)		**Centrifugal force freq. (%)**	
51 (46.4)		59 (53.6)	
Sure (%)	**Not Sure (%)**	**Sure (%)**	**Not Sure (%)**
24 (21.8)	27 (24.5)	32 (29.1)	27 (24.5)

Table 4 Participants' status of cognitive conflict

Cognitive Conflict (M2)			
Not Sure (%)	**Sure (%)**		
54 (49.1)	56 (50.9)		
	Temporary cognitive conflict (M3)		
	Feel conflict (%)	**Do not feel conflict (%)**	**Missing (%)**
	27 (24.5)	26 (23.6)	3 (2.7)

As shown in Table 3, more than half of the participants seem to choose centrifugal force as the cause of circular motion in the related question. However, it does not mean that these participants have the centrifugal force misconception. In this study, the criterion of having a misconception is to be sure about it. In this context, it may be safely stated that 29.1 percent of the participants, who are sure about their answers, have the centrifugal force misconception. On the other hand, 21.8 percent of the participants are sure about their correct answers to centripetal force. All of the other participants are not sure about their conceptions. Although the frequencies of the four groups shown in Table 2 seem to differ, these four frequencies are not statistically different (chi-squared = .564; p = .453).

After demonstrating the participants' conceptions of circular motion, descriptive statistics of their cognitive conflict status may be useful for evaluating the capability of the animated concept cartoon. Table 4 shows participants' status of cognitive conflict.

As demonstrated in Table 4, slightly less than half of the participants, who are unsure about their answers, may be regarded as being in the status of cognitive conflict after reading the animated concept cartoon. Therefore, the frequencies of the participants, who are in cognitive conflict and not in cognitive conflict, can be accepted as equal (chi-squared = .036; p = .849). On the other hand, 24.5 percent of the participants were sure about their answers and declared that they felt a conflict before getting sure. Therefore, these participants may be regarded as being in the status of temporary cognitive conflict after reading the animated concept cartoon. Therefore, the frequencies of the participants, who are in temporary cognitive conflict and not in temporary cognitive conflict, can also be accepted as equal (chi-squared = .019; p = .891).

3.3 Satisfaction with the Animated Concept Cartoon

At first, the frequencies of participants' responses to the satisfaction items were calculated. Next, the items with negative meaning were reversed for further analyses, then participants' individual and average scores, named the concept cartoon satisfaction score, were calculated. Finally, the frequencies of participants in each satisfaction item were demonstrated in Table 5.

As shown in Table 5, most participants have positive opinions about the animated concept cartoon. As mentioned above, participants' concept cartoon satisfaction scores were calculated based on their responses to 13 satisfaction items. Their average concept cartoon satisfaction score is 54.3 out of 65 with 0.945 reliability, which may be regarded that the participants have a high level of satisfaction with the animated concept cartoon. In addition to average satisfaction scores, the distribution of the individual scores is quite skewed that most participants are massed at high satisfaction scores. Figure 2 shows the histogram of participants' satisfaction scores.

In addition to the central tendency and distribution of satisfaction scores, a statistical comparison of satisfaction scores of the participants who are in the status of cognitive conflict and the others is useful to make deeper inferences about the capability of the animated concept cartoon. In

Table 5 Participants' responses to the satisfaction items

#	Item	SD	D	N	A	SA
S1	I do not like the animated concept cartoon.*	57	42	5	1	5
S2	I read the animated concept cartoon with enjoyment.	3	5	9	45	48
S3	I found the animated concept cartoon fun.	2	8	8	46	46
S4	The animated concept cartoon caught my attention.	4	5	5	45	51
S5	Reading the animated concept cartoon is boring.*	62	39	8	0	1
S6	The animated concept cartoon is intriguing.	4	6	10	41	49
S7	The animated concept cartoon is remarkable.	3	7	6	44	50
S8	The animated concept cartoon may be used as an introductory activity in distance education.	4	7	9	39	51
S9	The animated concept cartoon is a suitable material for distance education.	4	6	11	41	48
S10	I found the animated concept cartoon useful.	3	6	7	44	50
S11	The animated concept cartoon is thought-provoking.	4	9	6	49	42
S12	The animated concept cartoon is clear.	4	10	8	50	38
S13	The animated concept cartoon is not suitable for my age.*	50	38	14	6	2

* Items with an asterisk have a negative meaning and were reversed for analysis.

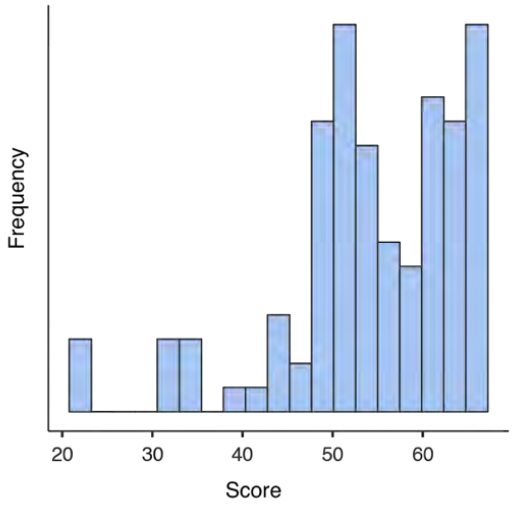

Figure 2 Histogram of participants' satisfaction scores

this regard, Mann-Whitney U-test was performed to make this comparison because of the non-normal distribution of satisfaction scores. It was found that there is no significant difference in satisfaction scores of the participants who are in the status of cognitive conflict and not in the status of cognitive conflict ($U = 1308$, $p = .221$). The descriptive and inferential findings of the animated concept cartoon are discussed in the next section.

3.4 Discussion

Concept cartoons are usually used to detect the existence of misconceptions and/or to start cognitive conflict at the beginning of the teaching/learning process. Instead of the traditional static version printed on paper, animated concept cartoons may be useful for the same purpose in an online learning environment, especially for the concepts related to motion. In this study, an animated concept cartoon about circular motion was developed and implemented for a group of undergraduate students in an online science course to evaluate the extent to which reading this cartoon creates a cognitive conflict. Results showed that about half of the participants chose the cartoon character justifying the centrifugal force misconception. However, it does not mean that all these participants have the centrifugal force misconception. In this study, the criterion of having a misconception is to be sure about it, as mentioned in the previous sections. In this regard, about 29 percent of all participants seem to be sure about centrifugal force misconception. This finding is similar to the ones in the literature related to the misconceptions about circular motion (Bani-Salameh, 2016; Volfson et al., 2020). As described above, this study does not focus on detecting this particular misconception. Instead, it investigates whether or not the animated concept cartoon starts the cognitive conflict. Students' cognitive conflict status is measured based on being unsure about their responses. Results showed that students who chose centripetal and centrifugal forces tend equally to be in cognitive conflict, and this finding may be interpreted that narrations of the cartoon characters are sound correct, which is one of the must-have features of a good concept cartoon (Keogh et al., 1998).

In this study, the students who are sure about their responses are simply accepted not to be in the status of cognitive conflict. However, some may feel a temporary conflict before getting sure about their responses. Therefore, an additional item measured the status of temporary cognitive conflict in the data collection instrument. Results indicated that half of the participants who are eventually sure about their responses are in the status of temporary cognitive conflict before getting sure.

This result may indicate that the animated concept cartoon starts a temporary cognitive conflict as well as the long-term cognitive conflict.

Regardless of choosing correct or incorrect concepts in the concept cartoon, approximately half of the students were observed to have long-term cognitive, and one-quarter of the students were observed to have temporary cognitive conflict after reading the animated concept cartoon. These findings indicate that the animated concept cartoon sufficiently achieved the aim of initiating cognitive conflict. As mentioned above, one of the reasons behind this result may be that the narrations in the speech balloons sound equally correct. As expected, the narration stating centrifugal force misconception sounds correct because it is a widespread, persistent misconception (Volfson et al., 2020). Another reason the concept cartoon successfully starts cognitive conflict may be its daily life context. Misconceptions often originate and are consolidated by individuals' daily life experiences (Kinik Topalsan & Bayram, 2019). Therefore, the concept cartoon demonstrating a daily life situation about circular motion may evoke or excite a dormant centrifugal force misconception and initiate a cognitive conflict.

As described above, this study also focuses on participants' overall satisfaction with the animated concept cartoon to get feedback for future revisions. Participants' overall satisfaction with the animated concept cartoon, including enjoyment, interest, and usefulness, is relatively high in these dimensions. In addition, no difference in the satisfaction scores of participants in the status of cognitive conflict and not in the status of cognitive conflict was found. This result indicates that animated concept cartoons may be regarded as enjoyable, remarkable, and useful learning activities in the online science teaching process regardless of being in cognitive conflict. Similarly, literature reports that concept cartoons are funny, exciting, and useful learning aids (Keogh & Naylor, 2000; Cinar, 2017; Norfarah, Mohd Ali, & Chong, 2019).

CONCLUSION

This study aims to evaluate the usability of an animated concept cartoon about circular motion; however, it mainly relies on participants' opinions. Therefore, a definite cause-and-effect relationship cannot be established as a result of this study, which is the study's main limitation. An experimental research setting can investigate a cause-and-effect relationship between two variables. Therefore, the other researchers are suggested to perform experimental research studies about the causality between the use of concept cartoons and cognitive conflict. This study may also suggest educational policymakers, instructional material developers, and science teachers. Due to their dynamic nature, animated concept cartoons are very suitable for teaching/learning science concepts, most of which are somehow related to motion. In addition, as digital material, animated concept cartoons are appropriate for computer and internet-based teaching/learning. In addition to online learning, animated concept cartoons may also be used in real classrooms equipped with computer technologies. Therefore, science curricula may be revised to offer some digital activities initiating cognitive conflict, such as animated concept cartoons. In addition, digital instructional material and activity developers may produce a series of animated concept cartoons covering all science concepts. After initiating cognitive conflict, to present scientifically correct concepts, developers may also design and develop supplementary digital learning activities that may be used after concept cartoons, such as simulations and virtual experiments. Besides, through in-service training, science teachers may be trained to use animated concept cartoons effectively in online and face-to-face classroom teaching.

The animated concept cartoon developed in this study was used as a standalone online activity to create cognitive conflict about students' preconceptions about circular motion in online science instruction. Results indicated that this animated concept cartoon might be a suitable digital activity for this specific purpose. In conclusion, concerning statistical findings of this study reported and discussed previously, animated concept cartoons have a serious potential to be remarkable, enjoyable, and useful digital activities that can be used to initiate cognitive conflict about students' preconceptions at the beginning of teaching/learning process in online science education.

ACKNOWLEDGMENT

The author would like to thank H. Pesman and K. E. Bagriyanik for contributing to developing the animated concept cartoon by giving invaluable feedback about its content, appearance, and implementation.

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