

Digital Comics in Online Learning During COVID-19: Its Effect on Student Cognitive Learning Outcomes

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Abstract—Comics have been used as an alternative tool to improve student learning outcomes during the pandemic, but not yet for junior high school science learning. The study aims to explore the impact of digital comics in online learning during the COVID-19 pandemic on students' cognitive learning outcomes (CLO). A quasi-experimental research design was used in the study. A total of 42 eighth-grade students participated in the current study. They were randomly assigned to two conditions. The first condition was online learning assisted by digital comic media. The second condition was non-comic online learning. A multiple-choice test developed by the researchers was used to measure students' CLO. Although the number of participants is limited, an independent samples t-test was used to analyze the data because the data was normally distributed. The results show that students' CLO differs significantly between comic and non-comic assisted online learning in favor of comic assisted online learning conditions. The possible reasons behind the findings were discussed. As a conclusion, several suggestions for researchers and teachers were offered.

Keywords—digital comics, cognitive learning outcome, pandemic

1 Introduction

Since the last year to the present, the coronavirus disease (henceforth COVID-19) pandemic has been shackling the world. Education is not excluded from the impact of this pandemic. The shift in learning from face-to-face to online learning happened rapidly. Another problem caused by the COVID-19 pandemic is that the learning environment changed into distance learning such as online learning [1]. Teachers and students changed the way they teach and learn to online learning [2]. Teachers should use feasible learning strategies to enable their students to learn well. It is obvious that the learning method used must be in harmony with existing conditions. In the COVID-19 pandemic, teachers teach from home, while the students receive materials from their homes as well. The delivery of learning material is assisted by technology.

Many problems emerge during the pandemic. The COVID-19 pandemic has a devastating impact on student learning achievement [3]. During the pandemic era, students experienced a decline in learning in science [4]; students do not do homework [5],

and they have difficulty understanding science concepts [6]. Researchers highlight that using digital technology during learning can help students revive their interest in science and make them motivated and gain learning experiences.

Although it is possible to reach studies that have investigated the impacts of comics in online learning in the COVID-19 pandemic era, it is difficult to find such studies done especially for science education. For example, [7] designed digital science comics to overcome teacher difficulties during online learning. They found that the comics created valid and feasible supports for students' literacy skills. Other researchers used comics during a pandemic as a tool for health communication [8]. They found that comics can reduce misinformation about the coronavirus but that there is no accurate data that shows an increase in the knowledge of respondents who use comics.

The latest publication in 2021 by [9] tested comics with a scientific approach and received positive responses from students. Finally, a single class experiment was conducted by [10] using digital comics for social science learning in the pandemic era. They found that digital comics influenced student learning success positively. On the other hand, their qualitative data findings showed that students were unable to communicate well with their teachers.

The decline in student achievement in science education must be overcome. To overcome this decline, teachers are the main innovators. If the teachers do not deal with it immediately, then the quality of the students will decline. This condition should not occur. During the COVID-19 pandemic, online learning must be supported by innovations to facilitate students in online learning. Indeed, technology has been widely used, for example, in the digital comic to support online learning. However, its effectiveness in optimizing science learning in junior high schools during the pandemic has not been widely carried out. The learning resources accompany students during their online learning. With the internet, students can access various information. Even though many references are available online, teachers must provide knowledge for their students, especially in extreme conditions such as the COVID-19 pandemic [11].

This study aims to explore the impact of digital comic media during the COVID-19 pandemic on the students' CLO concerning the science-related domain. The CLO of students who learned through digital comics will be compared to the CLO of students who learned without digital comics.

2 Literature review

Online learning environments provide a breadth of educational possibilities not accessible by traditional face-to-face learning and teaching [12]. Due to the COVID-19, education is rapidly pushed to online learning, and schools are being closed (off-limit) [13]. Another researcher [14] implemented online learning platforms and digital media to replace conventional teaching with online teaching during the COVID-19 pandemic. Online learning improves teaching efficiency and offers a more diverse learning experience regardless of time, space, and location [15]. Teachers must switch their teaching to online teaching. This teaching requires the teachers to use various digital resources for resolving problems and implementing online learning.

Several researchers have presented their studies on the impact of the shift from face-to-face learning to online learning [16]–[18]. Some of the things they found about this

shift in education were that teachers tried to provide effective teaching even though teaching moved to online schools. Digital media has poorly contributed to student activities during the lockdown [19]. The students' pleasure and familiarity with technology also affect their learning process in online education environments [20]. Students lose the opportunity to learn, such as reading. The progress of children learning online has decreased even more by more than 50% [21]. Learning resources provided by the teacher can be in the form of reading materials when they use digital comics. The reading materials must contain accurate and correct information—for example, comic learning media. In 2020 when the pandemic began, a review of the change from printed comics to digital comics was carried out [22]. Researchers found that digital comics have potential because the source material is taken from books, in a simple form, learning is more interactive and improves student memory.

In an online learning environment, teachers teach less than when they teach face-to-face, students receive fewer lessons, the quality of teaching is low, and student participation in online schools decreases drastically [23]. Several accessible learning resources are available online, but only children from well-off families can access them. Here we need learning resources that all levels of students can access. Digital learning resources that can be accessed at no cost. Education provides access according to the needs of students because the impact of the pandemic causes student achievement to fall. Parents of students look for online learning resources to keep their children learning.

Online learning during the lockdown due to the pandemic has indeed caused quite a stir for students. It is reported to negatively impact students because student learning time is reduced by 3.8 hours (reduced by more than half of the learning time per day, which is 7.4 hours) every day during the pandemic [24]. Online learning is an alternative during the COVID-19 pandemic. Interested or not, online learning must be carried out. Of course, this learning must be supported by appropriate learning sources, for example, digital learning sources.

Many digital learning sources are available, but not all teachers and students can access the resources. Teachers also find their access to school-provided offline learning materials limited during the lockdown. Digital learning sources are the alternative. Digital learning resources can be accessed online as long as students are at home [25]. Of course, digital devices such as mobile devices are needed [26]. Digital comic media is the comic media in the future [27]. Digital comics are very similar to printed comics but are distributed exclusively through digital platforms [28]. Digital comics can be a source of learning for students during a pandemic. Students can use it to gain scientific knowledge.

Research findings by [29] revealed that with the existence of comics where reference readings become crowded, students' reading skills are empowered, and they sincerely come to read. The findings of this study also indicate that comic books can serve as a motivational reading tool, especially useful in helping their students learn about history and science subjects. Although controversial, comics remain a popular source of reading material for students.

Reviewing comics from various aspects has been done by [30]. They reveal that comics have taken different forms over time, but some researchers use them in traditional ways (e.g., printed comics in face-to-face learning). Comics present a form of accuracy that links visual and textual, minimizing risk; even comics can be considered to carry negative and racist connotations if one is wrong in their creation. When reading

their reviews, one thing that caught our attention was that comics were created to communicate a process, be it mechanical, scientific, or otherwise. The reason that comics are used as a communication tool is sequential narrative. It is displayed in a bubble panel in which events combine various events into a story panel. Regarding science learning, many scientific processes must be told to students, such as food digestion. The pandemic situation caused this scientific story not to be delivered directly to students. This scientific story can be packaged in the form of a narrative that presents a cartoon to attract students' attention to read it. Comics are made in a digital form to improve student access.

Comics have been widely used in science education. The comic is an exciting medium for communicating scientific information. A concept could develop through a series of panels that combine images and text to create a graphic narrative [8]. Comics come in various forms, for example, the digital form [31]. A comic is an exciting tool for increasing interaction with science [32]. Presenting science in the comic form helps reach new and broader audiences and a new way to transfer scientific topics [33]. Teachers can consider the use of comics to explore their students' knowledge.

Comics help teachers to explain abstract concepts in science. Abstract concepts are not easy to teach. If the teacher only tells stories without showing them in real terms, students will have some misconceptions. Comics are powerful tools for educators to teach challenging science topics quickly, relevant, and efficiently to clarify abstract science concepts to students [34] and prevent students' misconceptions [35]. Indeed, there is a lot of scientific information obtained from the internet, but the teacher's control is needed. Taking information freely online without teacher guidance leads to the inaccuracy of the information received by students. Comics are a great learning resource. The teacher has checked the material content validity of the comic to use it.

[36] stated that students have various abilities in reading and understanding the information they get. The researcher used comics from a website to find out how students can remember and understand the text in a reading. This researcher found that students who read comics had a higher comprehension ability than students who had never read comics. Students who are experienced with comics are able to decipher the information contained in comics. Based on this researcher's findings, it is vital to provide students with the experience of reading comics. Students will become learners who are able to understand the contents of the reading. For school students, understanding the content of reading well prevents them from making mistakes. Science teaches facts in the form of phenomena that students must find solutions for. They get it from reading activities. Misreading causes errors in the solutions offered. This condition causes student learning achievement to decline because they are not able to provide the right solution. These student problems can be minimized by providing experiences to students through reading science information through comics.

The group of junior high school students experienced an increase in information understanding when researchers used comics [37]. The evaluation results show that students are able to know the risks that will occur, are able to get more information, and are able to make decisions when a document is transformed into a comic form compared to its original form. Here an idea can be taken, namely changing scientific information contained in ordinary books (textbooks) into comics. Students who have difficulty understanding scientific information can be overcome by using comics.

Students are encouraged to learn about science through comics created to convey a topic in science education. These comics may be used to convey scientific understanding [38]. Bringing technology to students by using it to make students like and enjoy the topic of learning [39]. Students can use comics in PDF files to study the anatomy of the human body because it contains content that is easy and easy for children [40]. Researchers use a homepage containing information on the anatomy of the human body that functions as a library. When accessed, it can increase the knowledge of the audience who reads it. In their research, cartoons that are included in the reading only fill part of the story. Thus, the use of comics is an appropriate strategy. Student performance can develop well, especially student CLO. The use of digital material can be done using a control class [41]. In this research, the use of comics in online learning is compared to the results of online classes without comics. A classroom without comics is a control in the effectiveness of comics to strengthen students' CLO.

3 Method

3.1 Research design

This research is an experimental research. This research used two classes: one experimental class (XG) and one control class (CG). XG is a class with the application of comics to online learning during the COVID-19 pandemic. CG is a class without the application of comics to online learning during the COVID-19 pandemic. A pre-test and post-test design were used. The pre-test of cognitive learning outcomes (henceforth Pre-CLO) was obtained before the learning process, while the post-test of cognitive learning outcomes (henceforth post-CLO) was obtained after the learning process.

3.2 Sample

The population in this study were students who attended one of the Private Junior High Schools (PHJS). They were eighth grade (VIII). They were randomly selected to be the XG and CG. There are 21 students in XG and 21 students in CG. All of them are then involved in the online learning process.

3.3 Design of comics

The comic used was the comic for junior high school students. The comic was designed in the form of a digital comic version. The comic consisted of 25 pages, including the front and back covers. The comic used was the result of development [42]. However, the comic that had been developed by previous researchers was a printed version. In the current research, the comic was turned into a digital comic (henceforth d-comic). A change was made in the cover design that was made more attractive. In addition, there were changes made to several images related to biological content. The comic storyline was created first. The character in the comic was then determined. Comics are drawn by hand in advance. This process is where the sketch forms. After making the comic storyline matches the images created, then the comic was designed

by using CorelDraw and colored. Then story balloons were added as a space to place the dialogue. The d-comic design is presented in Figure 1. The comics were sent to the students in pdf format through the online messaging program (WhatsApp).

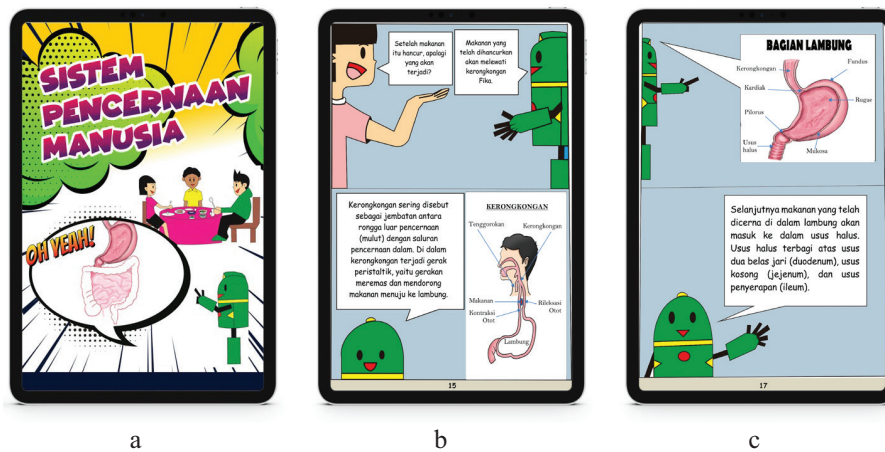


Fig. 1. (a) Front cover of d-comics; (b) and (c) content dialogue of d-comics

3.4 Instruments and procedure

The measuring instrument used was a multiple-choice test. The number of tests was ten items. The test is designed based on learning objectives. The multiple-choice test used had been reviewed by experts and obtained a score of 86% (valid). The percentage obtained indicates that the test is feasible to use. Two tests were given: before the learning process (pre-CLO) and after finishing the learning process (post-CLO). The same tests were used for pre-test and post-test. The scope of the test was the human digestive system material with four learning objectives. The comics media was made in a digital version. The digital comic was shared through the group's WhatsApp. The students downloaded the digital comic so that the comic was stored on their mobile devices. The online learning was done by using a video conference application. The implementation of tests in the XG and CG classes was done by using Google Forms.

3.5 Data analysis

The data that is going to be analyzed is the student answer result on the test given. This data is called as students' cognitive learning outcome (CLO). The analysis is done by calculating the score obtained by students. The score ranges from 0 to 100. The students' CLO descriptive data are in the form of mean and standard deviation (SD). In addition, the n-gain for each group is also displayed. Gain is said to be high if it gets a value > 0.7 ; $0.30 < \text{value} < 0.7$ is said to be moderate, and in other lower conditions, it is said to be below. Students' CLO data are analyzed using the independent t-test (It is parametric analysis). Calculation of normality using the Kolmogorov Smirnov test and homogeneity using the Levene test. SPSS 20 for windows is the application for calculating the data.

4 Results

This research focuses on the effects of digital comics in online learning during the COVID-19 pandemic on students’ cognitive learning outcomes (CLO). Students’ interest in the learning process during a pandemic requires the teachers to be creative in creating a good learning process. In this research, the digital comic applied in the learning process provides optimal results for increasing students’ CLO. Table 1 shows the mean and SD (standard deviation) of the CLO data of students.

Table 1. Description of the mean and standard deviation (SD) of CLO

Group	N	Pre-CLO				Post-CLO			
		Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
XG	21	39.05	20.71	10	80	79.52	16.27	50	100
CG	21	33.81	19.10	10	70	46.67	18.80	10	90

Table 1 shows that the two groups’ pre-test data were different, with a score difference of 5.24. This difference seems so small. On the other hand, the two classes’ post-test scores (groups) show a huge difference. The score difference is 32.85. These findings reveal that there is a difference in the score of CLO between these two groups. The significant difference between the pre-test and post-test data from CLO in these two groups is analyzed by t-test (see Table 3). But before that, the N-gain data for both groups (Figure 2), and the CLO attainment of each student (Figure 3) are shown.

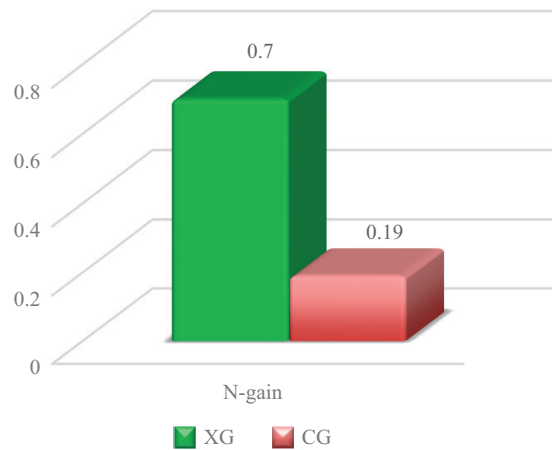


Fig. 2. N-gain comparison of XG and CG

Figure 2 proves a difference in the increase in students’ CLO after the learning process. The N-gain of the control group is less than 0.30. More precisely, the N-gain is only 0.19. The N-gain value revealed that the increase in CLO of students in online learning without comics was low. In contrast, the N-gain value of the experimental group reaches 0.70. It proves that the increase in CLO of students in online learning using comics is high. Figure 3 shows the CLO achievement of the students in both groups.

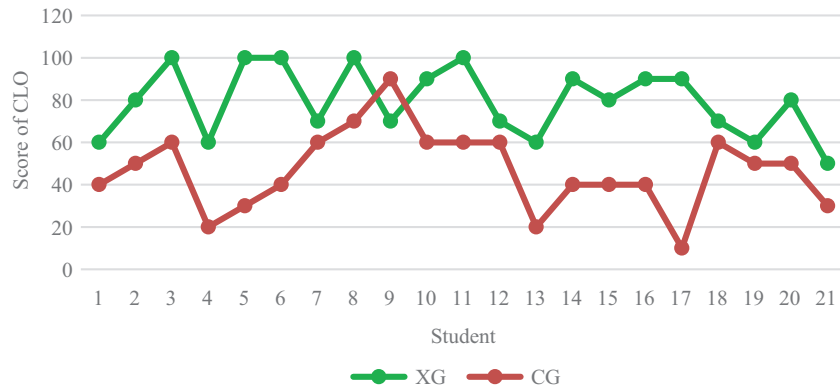


Fig. 3. Achievement of CLO for each student in both groups

Figure 3 presents the difference in each student’s CLO achievement in both X and C groups. As many as 19 students achieved a score of less than 70 (90.48%) in the C group. This fact proves the low CLO achievement of students in online learning without using comics. Only 2 (9.52%) students achieved a score of more than 60. Other facts are summarized in Figure 3. Meanwhile, in the online learning group that uses comics (X group), there are only 5 (23.81%) students with a score of less than 70. It means that 16 (76.19%) students achieve a score of more than 70. Here, it is proven that students will achieve better CLO when doing online learning that uses d-comic as learning resources. Before the t-test, data normality and data homogeneity are required. Table 2 presents the result data for these two conditions.

Table 2. Normality and homogeneity data of CLO

Data	Normality			Homogeneity			
	Statistic	df	Sig.	Levene statistic	df ₁	df ₂	Sig.
Pre-CLO-X	0.154	21	0.200	0.315	1	40	0.578
Pre-CLO-C	0.135	21	0.200				
Post-CLO-X	0.169	21	0.122	0.125	1	40	0.725
Post-CLO-C	0.144	21	0.200				

The normality of the data in the pre-CLO of both X (Sig = 0.200 > 0.05) and C (Sig = 0.200 > 0.05) indicates a normal distribution. The homogeneity data also shows the same thing. The pre-CLO data is homogeneous (Sig = 0.578 > 0.05). Meanwhile, the normality of the post-CLO of both X (Sig = 0.122 > 0.05) and C (Sig = 0.200 > 0.05) shows a normal distribution. Homogeneity test of post-CLO data indicates a homogeneity (Sig = 0.578 > 0.05). The results of the normality and homogeneity tests indicate that the t-test can be used.

Table 3. Test for the difference of the mean of student CLO

Data	t	df	Sig.	Mean Difference
Pre-CLO	0.852	40	0.399	5.238
Post-CLO	6.056	40	0.000	31.857

Table 3 presents the difference between pre-CLO and post-CLO test results. The findings reveal that CLO between students was not significantly different in the beginning of the learning process. After the learning process took place, the students' CLO experienced an increase. Post-CLO shows a significant difference between students that learn with comics and without comics during the COVID-19 pandemic (Sig > 0.05).

5 Discussion

This research confirms the improvement in students' CLO in online learning during a pandemic using d-comics. The research findings prove that d-comic can help students in enhancing their CLO. The increase in student CLO when learning online during pandemic assisted by comics is higher than those without comics. These findings reveal that it is true that online learning during the pandemic caused students to experience a decline. This fact is shown by the low achievements of students post-CLO. The use of comics shows a different matter. Students' CLO is getting better when learning with the help of comics. It is clear from the findings of this research that comics are an appropriate learning medium. It can solve students' learning difficulties during a pandemic. Comics improve students' science concepts [43] and provide benefits for learning during the COVID-19 pandemic [44].

On the other side, there are some studies contradict with the current study. Some research on offline learning observed the impact of using comics in the learning process. Various results were obtained. Some researchers revealed that there was no difference in the increase in students' knowledge. Both groups that use comics and non-comics experienced an increase in their knowledge [45], but not for male students [46]. The increase in participants' understanding of nanotechnology was associated with their increasingly positive attitude, but there was no significant difference in their understanding [47]. Other research showed that there was an impact of comics on students, but no control group was presented [48]. Another research by [49] revealed no difference in science students' knowledge between comics and non-comics groups. Researchers [50] found differences in knowledge level between experimental and control group, but the learning outcomes were still low. They found that students remember too much of the material given. The increase was only 23.5% in experimental group and 12.3% in the control group. They used an electronic Cartoon slide show. Although the findings of some of those researches indicate that comics do not improve student achievement, this research has succeeded in improving student CLO.

We believe that well-designed comics can enhance student CLO. This is proved by the research results showing that the students' CLO is good. Even better than non-comics group. The COVID-19 pandemic causes problems for Education. The compulsion to carry out online learning causes confusion for students and teachers. The quality of

students' CLO deteriorates under these conditions. Comics in digital form is the alternative for learning during a pandemic. The decline in student achievement during the pandemic can be corrected. In this research, it is supported by the disclosure of the student's achievements in the non-comics group (class). The low achievement in CLO is shown; even the increase in student CLO is low. It proves that the issue about the decline in student CLO due to a pandemic is correct. Our research suggests that the decline (deterioration) in student achievement can be handled. The use of comic media can enhance student CLO. There are also some other studies (e.g., [12], [51]). The comics were received positively by students who started learning with lower content knowledge and were also beneficial for students with intermediate achievement.

Science learning has many abstract concepts. A pandemic situation has made the students' conditions for understanding abstract concepts worse. In science learning, comics are learning tools to concretize abstract concepts [52], [53]. In this research, the comic media contains scientific content, namely the human digestive system. Students cannot observe through direct practice in the school laboratory. Schools are closed due to physical restrictions. Through comics, students are able to learn human body anatomy [46], [54]. It is clear that students can learn the human digestive system through comics. They can observe human digestive anatomy in comics displayed on their mobile devices. The cartoon design in the comic attracts students to read and observe it. The cartoons in comics arouse students' observation skills and creativity [55]. Observation skills are important because the students capture scientific information through their five senses. Students can remember scientific information if they look at the facts. It will last longer in their memories [56].

Pictures in comics help students build their cognitive abilities. Students with little knowledge will have their cognitive better when looking at pictures in learning [57]. Teaching with comic books expands the attractiveness of students in the learning phase. This research shows that students' cognitive changes. The students' cognitive is getting better. The high increase in student CLO indicates that the digital comics being used helped them learn during a pandemic. In the comic, the things presented are not only pictures. The digital comic being used is equipped with narratives or stories about how the digestive process occurs. The storytelling style of comics can aid in the comprehension of scientific material [51]. The scientific materials can be learned more easily by students due to the images and narratives in the comic that are easily understood.

The pictures shown in the design are in the form of cartoons. The pictures of humans and the human digestive organs are transformed into cartoons but still maintain the concept's correctness. The cartoons in comic book illustrations arouse curiosity [58] and are appropriate during the COVID-19 pandemic [59]. Cognitive development is encouraged and heightened using comics [60]. The cartoon images and narration in word balloons in a comic guides students to understand science content. Students can see the human digestive organs' visual images, enabling the images to be stored in their cognition. Student boredom when learning online can be overcome with the digital comics provided. Student cognitive is getting better. The measurement results at the end of the lesson show a good CLO of students. The comic becomes an appropriate learning resource to improve students' cognitive during a pandemic. The comic becomes a learning medium that can accompany students to study/learn from home.

6 Conclusion

This research concludes that d-comics have a significant effect on students' cognitive learning outcomes (CLO) (sig. < 0.05). As many as 76.19% of the students achieved a good CLO. This achievement is better than students' CLO in online learning during the COVID-19 pandemic without using d-comics. The increase in student CLO in online learning that uses comics is higher than those without a comic.

This research recommends that d-comics can be an alternative source of learning for students during the COVID-19 pandemic. Comics can improve student CLO. The decline in student CLO during the COVID-19 pandemic can be corrected by adding d-comics in teachers' learning. This research is limited to digital comics in the form of pdf files. Further research may design a digital comic application. Further research can also examine the effects of digital comics on other variables such as critical thinking, learning motivation, and other variables.

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