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BIOMIND Portal for Developing 21st Century Skills and Overcoming Students' Misconception in Biology Subject

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ABSTRACT

This research was conducted to investigate the effectiveness of BIOMIND portal in enhancing students' 21st century skills and overcoming their misconceptions in Biology subject. 118 Indonesian high school students were involved in this quasi-experimental study. The experimental group underwent learning experiences using BIOMIND portal whereas the control group experienced conventional learning approaches. The effectiveness of the BIOMIND portal was measured based on the students' 21st century skills development and their level of misconceptions. There were significant differences in the 21st century skills development found between the experimental group and the control group. In addition, this research has found that the BIOMIND portal could overcome misconceptions among students due to the trainings given during interventions. This study concluded that teaching and learning using BIOMIND portal has brought positive impacts especially in developing the 21st century skills and overcoming students' misconceptions in Biology subject.

KEYWORDS

21st Century Skills, BIOMIND Portal, Misconception, Problem-Based Learning (PBL)

INTRODUCTION

The 21st century poses many global challenges whereby in this decade, technology, research, knowledge and the society changes and evolves almost in every second (Tan, 2003; NCREL & Metiri Group, 2003). Today's schoolchildren will be the leaders of tomorrow, and the education system was responsible to equip them with the competencies required to thrive in the digital era. There was an increasing demand for students to have good verbal competence to communicate and explain ideas and to have the competencies to manage technology (Ilhan et al., 2011). However, school leaders today faced a serious dilemma; whereby the community expect their graduates to be ready to thrive in the digital age, nevertheless the 21st century skills required for such successes were not well defined. The 21st century skills were not included in many state learning standards or measured on most state and local assessments (NCREL & Metiri Group, 2003). Without adequate competencies of the 21st century skills, students were being prepared only to succeed in yesterday's world, but not tomorrow's (NCREL & Metiri Group, 2003).

In this sense, the education system must provide the students with the education that they need to survive in a knowledge-based, global society. The science curriculum being implemented in Indonesia has always focused on competence mastery, not solely on subject content mastery (Vebrianto &

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Kamisah, 2014). The teachers played important roles in determining the appropriate learning materials to fulfil the students' learning needs; yet in many cases, teachers still find difficulties in arranging adequate and appropriate learning materials to cater to the students' learning requirement. As a result, the effectiveness of the teaching and learning process is hampered (Kunandar, 2010).

Biology subject is a part of science curriculum where it consists of many concepts that the students must comprehend. Consequently, conceptual understanding is very important as it acts as a basis for the students to think and to promote higher order thinking process such as formulating principles and generalizing (Chin & Chia, 2004). Besides mastering concepts, students must also be able to apply and correlate one concept with another by using the concepts in problem-solving processes and formulate new ideas. As a highly conceptual subject, Biology was always perceived to be one of the most difficult subjects by students; where this perception was shown in their Biology learning evaluation test results (Vebrianto & Kamisah, 2014). The students' results in monthly tests, term exams, and the national exam were not satisfying enough; this showed relatively poor conceptual understanding of Biology. According to Yustina et al. (2011), the students' low score in Biology can be accounted by their difficulty in learning Biology especially in understanding and mastering biological concepts.

Not limited to that, the science subject scores of grade 8 Indonesian students were low, according to the 2011 Trends in International Mathematics and Science Study (TIMSS). There was a decrease by 21 points in 2011 results compared to the results in 2007. Indonesia was at the 40th position out of 63 countries and 14 states participated. Indonesia's position was slightly above Morocco and Ghana (Martin et al., 2012). In addition, the 2011 Progress in International Reading Literacy Study (PIRLS) revealed that the reading literacy of grade 4 Indonesian students was at the 41st position out of 45 countries participated, with an average score of 405, which was below the average score of 500 for international students with a standard deviation of 100 scores. Even though Indonesia has scored higher than Qatar (score=353), Kuwait (score=330), Morocco (score=323) and South Africa (score=302), still the scores in reading literacy were not satisfying enough (Mullis et al., 2012; Balitbang, 2013). Reading literacy includes the skills to find information, to understand and interpret readings, as well as to reflect and evaluate the readings (Bahrul & Suhendra, 2010).

The unsatisfactory reading literacy results of Indonesian students compared to other countries might be due to the scenario that while constructivism has started to be applied in the classroom teaching and learning in other countries, the Indonesian classroom still highly practices behaviourism, which was highly teacher-oriented (Yustina et al., 2011). Indonesian students still perceived knowledge as a set of facts that must be memorized (Vebrianto & Kamisah, 2014). Students would just listen to the teachers' explanation, scribble notes and complete the exercises given. Hence, there were no concept construction processes in teaching and learning among students, whereby they tend to memorize the materials or concepts without deep understanding, only to do the exercises given. As a result, the students would fail to master the concepts and misconception would frequently happen (Vebrianto & Kamisah, 2014).

Misconception was defined as "ideas that are different from the ones generally accepted by scientists". According to Aydin and Balim (2009) and Odom and Barrow (1995), misconception could be avoided by means of meaningful learning. A significant amount of research has indicated that most people has develop ideas about scientific phenomena before beginning of formal science education; these ideas, even if they were scientifically incorrect, tend to remain persistent, despite effort to teach scientifically accepted theories and concepts (Stein et al, 2007).

Students' ability to understand a concept depends on the complexity of the concept and the cognitive development of the students (Mohd Ali et al, 2007). Therefore, every student must possess various knowledge levels about various biological concepts. The information about students' knowledge level was very important in order to induce the students to achieve comprehensive learning, where the students would be able to apply the knowledge learnt in daily life (Vebrianto & Kamisah, 2011). To help the students in achieving conceptual comprehension and in reaching various

competences needed in 21st century, educators need to carefully select and analyse the scientific theories that were applicable in real daily life so that students can overcome their misconception and improve their understanding and competencies.

Besides having deep conceptual understandings in various subject matter everyone was required to be competitive, possess good verbal competence to convey ideas effectively and be competent to manage technology, especially to be able to thrive in this digital era (Duran et al., 2011). In this case, the educational policymakers were responsible for devising teaching methods or approaches in the education system that could help in developing the 21st Century Skills among students for them to be able to face the global challenge of the 21st century. In facing the challenges of the 21st century, the competency in understanding concepts was not something new; nevertheless, the development of traditional competences that combines technology with new working environment are (NCREL, 2003).

The importance of the 21st century skills was studied in vast amount of researches and many educational models have been established to describe its importance. Some of them can be reviewed in the study of information literacy standards for students' learning (AASL) (1998), the enGauge 21st century skills: literacy in the digital age (NCREL, 2003), the partnership for 21st century skills (2006) and the Malaysian 21st century skill instrument (M-21CSI). In this paper, the conceptual framework developed was based on The Malaysian 21st century skill instrument model (Kamisah et al, 2010). The model was selected because of the similarities between Indonesian and Malaysian educational curriculums. The elements in M-21CSI were almost the same as those of enGauge 21st century skills: literacy in the digital age (NCREL, 2003) such as digital-age literacy, inventive thinking, effective communication, high productivity, and moral values.

In fostering the 21st century skills among students, many scholars suggested that problem-based learning (PBL) method was effective; where it could empower students not only to take advantage of the knowledge accessibility, also to discover the means of knowledge sharing, knowledge propagation, and knowledge enterprise through the use of learning management systems, web-based learning (portal) and internet communication (Tan, 2003; Artino, 2010). Problem-based learning is one of the alternative learning models that were based on the principle of using problems as starting points to obtain new knowledge. PBL could create an active teaching and learning environment where the teachers act as facilitators and the focus of the learning process was the students, or in other word, student-centred (Tan, 2003). Students were encouraged to hold discussions beyond the tutorial sessions. This type of learning was suggested to be effective in improving and developing students' subject mastery and their communicative ability (Terry & Moore 2011), improve understanding of concepts, logical problem-solving, and communication and teamwork skills (Sungur & Takkaya, 2006; Kim, 2014). Active participation of students in the teaching and learning processes was meaningful as students can get more experiences and competences (Kim, 2014).

Currently with the advances of technology, many web-based learning management systems provide convenient online communication tools and learning resources such as announcements, course information, course documents, assignments, books, communication systems, virtual classrooms and discussion boards (Tan, 2003; Ying, 2012). With rapid improvements in technology, the tools have become more flexible and user-friendly, meaning that users will be able to customize the learning management system to suit a particular PBL program. Furthermore, problems can be easily presented in a variety of innovative ways (Tan, 2003; Herrington et al., 2007). The e-learning environment was claimed to be perfect for PBL cycles, where PBL approaches provide the motivation for online learning engagement in terms of connectivity to resources, peers and experts (Kinzie & Berdel, 1990; Caballé et. al, 2011). Interactive online learning can improve students' knowledge and skills during the learning interaction (Caballé et. al, 2011). At the same time, the online learning interaction can increase the learning efficiency by means of developing strategies to control the content and direction of web-based learning. When students are actively involved in learning, they will pay attention to the teaching and learning process, and obtain the satisfaction, skills and achievement (Salomon et al.,

1991). According to Feng et al. (2010) web-based learning instruction has the potential to increase and sustain students' problem-solving skills over a long period of time.

Problem-based learning in an e-learning environment could be effective for the teaching of Biology, which were highly conceptual (Tan, 2003). In addition, students' indirect use of technology during the teaching and learning could improve their 21st century skills. Hence, a learning module for the teaching and learning of Biology was developed for this purpose, named BIOMIND portal. The BIOMIND portal was an e-learning and problem-based learning module.

This research was carried out to evaluate the effectiveness of BIOMIND e-learning portal module in improving students' 21st century skills and misconception. Specifically, this study was carried out to fulfil the following objectives:

1. To determine the effectiveness of BIOMIND e-learning portal module in improving students' 21st century skills.
2. To determine the effectiveness of BIOMIND e-learning portal module in improving student's misconception.

This study would contribute to the growing knowledge of teaching and learning of Biology, particularly in the effort to improve students' 21st century skills and students' conceptual understanding of Biology via problem-based learning model. Hence, the BIOMIND portal could be an innovative platform for students to solve problems using higher order thinking skills. This innovation was important for educational improvement in facing the challenges of the 21st century.

Conceptual Framework

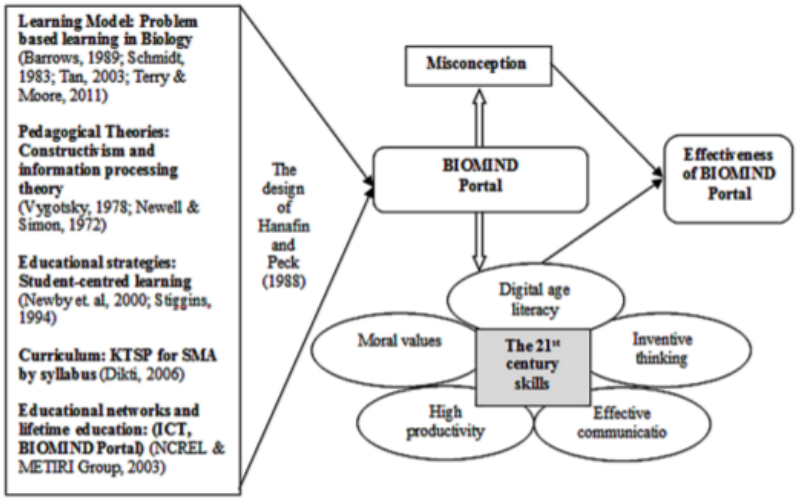
Based on the study background and problem, a conceptual framework that relates all variables involved was constructed (see Figure 1), which acted as the basis for this study. The conceptual framework of this study consisted of the relationship between the BIOMIND portal module, models of learning, pedagogy, curriculum, 21st century skills, misconceptions, and instructional strategies. Based on the conceptual framework above, innovation was initiated by a new problem-based learning approach in the process of teaching and learning.

The BIOMIND Portal was developed based on the design by Hanafin and Peck (1988) to enable students to improve their conceptual knowledge while mastering various 21st century skills. In constructing the BIOMIND Portal module, the researchers have associate variables that were related to effective education, which were the method and curriculum, pedagogical theories, educational strategy, networks, and lifetime education. The 21st century skills included digital age literacy skill, inventive thinking, effective communication, high productivity and good moral values (character).

The researchers have modified the PBL model and considered a variety of theories, especially Vygotsky's theory of constructivism and the theory information processing, which were the core philosophy of PBL (Savery & Duffy, 1995; Harland 2002). The student-centred strategies and classroom assessments on students were also considered and integrated by the researchers to support the implementation of the teaching and learning process that was based on the PBL model of a student-centred learning (Stinggins 1994).

By implementing the modified PBL model, students would be more active in resolving various issues and problems given, which would create students with autonomy in learning. Hence, students would have a variety of skills, deep understanding and better motivation (Terry & Moore, 2011; Chin & Chia, 2004; Tan, 2003).

Figure 1. The conceptual framework



RESEARCH METHODOLOGY

Research Design

This research employed a quasi-experimental design with non-equivalent control group to determine the effectiveness of the BIOMIND module in improving students' 21st century skills and student's misconception (Campbell & Stanley, 1963). This design was employed as the study was done on students in an existing classroom where the students were not chosen randomly (see Table 1).

There were two groups involved in this study which were the treatment group and the control group. The treatment group experienced learning using BIOMIND portal module, whereas the control group experienced conventional problem based learning experiences with limited use of learning technology.

Population and Sample of the Study

The population of this study was all Senior High School 2 students in Riau Province. The samples were chosen via purposive sampling and random sampling methods. Purposive sampling was used to choose the samples based on their degree of school, school levels, ICT facilities and schools' location while simple random sampling was used to divide the samples into two groups under study, which were the treatment and control groups. In this research, the samples were the Senior High School 8 students in Pekanbaru, Riau, Indonesia.

Table 1. Non-equivalent control design

Group	Pre-test	Teaching Strategy	Post-test
Treatment Group 1	O_1	X_1 (BIOMIND module)	O_2
Control Group	O_3	X_2 (Conventional strategy)	O_4

Research Procedure

A pre-test on the 21st century skills and misconception were given to both treatment and control groups before the study was started to determine the equality between groups. A test of normality was also conducted to determine the equality of abilities between groups.

During the study, the treatment group underwent teaching and learning of Biology using BIOMIND Portal, whereas the control group experienced conventional teaching. The teaching and learning of the treatment group was done in the classroom provided with internet connection to access the BIOMIND portal module. For control group, the teaching and learning was done using conventional teaching method that was not problem-based. The learning activities done in the control group was not given any information and material related to the treatment group.

The treatment group experienced teaching and learning of Biology using BIOMIND Portal for eight weeks, with five hours of Biology class each week. After experiencing the teaching interventions, both groups were given a post-test to analyse the difference in scores between groups for the 21st century skills development and levels of misconception.

Research Instruments

BIOMIND Portal Module

BIOMIND module was an e-learning portal developed and designed specifically for the implementation of problem-based learning (PBL) in Biology. This portal can be assessed at http://modul-biomind.myprofil.info/. The BIOMIND portal was designed to teach the topic motion and circulatory system in Biology. Based on the needs analysis done prior to the development of the portal, the topic motion and circulatory system is the hardest topic to master in Biology as perceived by the students and teachers themselves.

Eight menus were consisted in the BIOMIND e-learning portal for the implementation of an effective and efficient learning.

The menus have the following objectives:

1. Menu of competency: contains the indicators of competencies that must be known and understood by teachers and students.
2. Menu of teacher guidance: consists of the annual and semester program, syllabus, the learning implementation plan, and PBL modules to help teachers understand the implementation of problem-based learning equipment.
3. Menu of content: consists of a concept map, descriptions of matter, bio info, summary and a glossary to assist teachers and students in understanding the material or the subjects that will be taught.
4. Menu of problem: consists of main and additional case for problem-based group discussion.
5. Menu of enrichment training: consists of training, reflection and enrichment to enhance the understanding and skills of the students.
6. Menu of answer key: contains the correct answer sheet for each key questions and enrichment training.
7. Menu of games: consists of science puzzles and concept maps as learning materials, which use games as entertainment that simultaneously improve students' thinking and understanding of the science puzzle pattern and concept maps.
8. Menu of windows: consists of facilities for various forms of information, such as bio-web and links to the virtual machine information seekers, Electronic School Book (BSE), and E-Video.

The BIOMIND portal was built using the Hanafin and Peck (1988) design and was supported by the theories of learning. The portal was built with the aim to facilitate teachers and students in the

application of PBL in the teaching and learning process that could increase the 21st century skills among students and would able to overcome the misconception of students.

The BIOMIND portal has already been validated by experts, teachers and students. The assessment was done twice during the construction phase and the implementation of the formative and summative assessment. Analysis of the formative and summative assessment were analysed using SPSS 18. In the formative research, findings showed that there was a shortage in the construction and development of this portal. However, the suggestions given by the experts, teachers and students have been considered in the improvement to the perfection of the BIOMIND portal. During the summative assessment carried out after the review of the portal, findings showed that the experts, teachers and students agreed that the portal was eligible to be applied in the teaching and learning for high school students' Biology subject, in the topic of motion system and circulatory system.

The 21st Century Skills Test

To determine the 21st century skills of the students, a 21st century skills test was constructed according to the researches by Maria and Kamisah (2010), Kamisah et al. (2010) and *enGauge 21st Century Learning Skills* (2003), which were later modified according to the degree and the ability of students. The test consisted of 30 objective questions that included five constructs, which were digital-age literacy, inventive thinking, effective communication, high productivity, and moral values. The 21st century skills test was piloted to students of an excellent high school, which was the Plus Senior High School of Riau Province, Indonesia and obtained 0.91 scores of Kuder Richardson 20 (KR20) using ANATES4. According to Best and Khan (1986), even though there were no limitations that could be used to determine the reliability coefficient of a research instrument, reliability coefficient of more than 0.60 could be used to determine the reliability of the test objective used in the research.

Misconception Test

To determine the level of misconception of Biology concepts among students, a misconception test was constructed based on the topic of motion and circulatory system. The test questions were developed by the researchers and were later validated and modified by expert panels according to Fadilah et al. (2012) by taking into account the cognitive level of Anderson and Krathwohl (2001). The test consisted of five essay questions. The misconception test was piloted to students of an excellent high school, which was the Plus Senior High School of Riau Province, Indonesia and obtained 0.80 scores of Kuder Richardson 20 (KR20) using ANATES4. According to Best and Khan (1986), even though there were no limitations that could be used to determine the reliability coefficient of a research instrument, reliability coefficient of more than 0.60 could be used to determine the reliability of the test objective used in the research.

RESEARCH FINDINGS

Pre-Test Analysis

Independent t-test was conducted to compare the scores between the treatment and the control groups. Based on Table 2, the results indicated that there was no significant difference between the treatment and the control groups in students' 21st century skills and misconception in Biology subject before the intervention of the study (21st century skills, $t = -1.034$, $p > 0.05$; misconception, $t = 0.559$, $p > 0.05$).

Accordingly, the equality of the groups at the baseline suggested that it was appropriate to conduct the experiment and subsequently compare the 21st century skills and misconception in Biology on the topic of motion and circulatory system between the two groups.

Table 2. Differences between groups on the 21st century skills and misconception in pre-test

Variable	Group	N	Mean	Standard deviation	t	Sig.
The 21st century skills	Treatment	61	61.79	7.38	-1.034	0.303
	Control	57	63.21	7.48		
Misconception	Treatment	61	55.41	10.93	0.559	0.578
	Control	57	54.29	10.67		

Table 3. Differences in the 21st century skills at post-test

The 21st century skills	N	Mean	Standard deviation	Value of t	Sig.
Treatment	61	81.69	7.07	4.939	0.000
Control	57	75.25	7.03		

Post-Test Analysis

Differences between Groups in the 21st Century Skills

Based on Table 3, the independent t-test analysis showed significant differences between groups in 21st century skills, $t = 4.939$, $p < 0.05$, (see Table 3). This indicated that the students in the treatment group had a higher 21st century skills compared to the control group. Hence, the null hypothesis was rejected.

Differences between Groups in Misconception

Based on Table 4, the independent t-test analysis showed significant differences between groups in misconception in Biology subject on the topic of motion and circulatory system, $t = 8.779$, $p < 0.05$. This indicated that students in the treatment group had a higher conceptual knowledge after learning intervention compared to the control group. Hence, the null hypothesis was rejected.

DISCUSSION AND CONCLUSION

The findings showed that students who underwent teaching and learning using BIOMIND portal had higher 21st century skills compared to the control group that used conventional strategies. In this study, each activity in the process of teaching and learning based on PBL model was designed to train students to attain a variety of 21st century skills. Additionally, the use of instructional media such as BIOMIND portal can improve students' 21st century skills by using real objects, models, diagrams and exciting game as well as providing information relevant to the learning topic (Rohaida 2004). Further findings of Chin and Chia (2004) suggested that PBL made students better at applying

Table 4. Differences in misconception at post-test

Misconception	N	Mean	Standard deviation	Value of t	Sig.
Treatment	61	85.06	10.34	8.779	0.000
Control	57	67.98	10.81		

the communication knowledge and skills as well as encourage them to be autonomous in finding knowledge. Furthermore, 70% to 80% of the total information could be absorbed when they performed activities and shared experiences in PBL (Watson & Glasser, 1980). De Porter and Hernacki (2000) suggested that a human can absorb a total of 50% from what was heard and seen (audio-visual); whereas only 30% of what was seen, 20% of what was heard, and 10% of what was read. Therefore, the use of technology in teaching and learning process has a great potential in helping students to develop the various competencies, higher order thinking skills and interest in science subjects. The BIOMIND portal module could improve students' 21st century skills and could make the process of teaching and learning effective and efficient so it would enable students to participate actively in developing their minds. This was supported by Sungur and Takkaya (2006) and Kamisah and Marimuthu (2010) whom reported that students could improve their educational 21st century skills if the students discuss local and global issues. In this era, student's achievement must be broadened to include the 21st century skills that were required by the students to thrive in the future. Information and communication technologies are raising the bar on the competencies needed to succeed in the 21st century. The portal held so much benefit with its conveniences of anytime and anywhere accessibility for distance education students. Furthermore, full-text searching tools would come in handy for effective learning. Through these features, the students can improve the 21st century skills indirectly while using them to learn.

In addition, the findings also showed that students who underwent teaching and learning using BIOMIND portal had higher conceptual knowledge in Biology compared to the control group that used conventional strategies. According to Gardner (1991), a deep understanding occurs in the presence of new information that supports the emergence of cognitive structures that cause students to rethink the ideas that they have before and to improve it. In the learning process, the use of the BIOMIND portal occurring in a two-way interaction can enhance the skills and understanding of the students. According to Tjosvold and Tjosvold (1995), communication should take two ways, between the giver and the receiver so that the information can be communicated clearly. This learning process will support the learning process based on the theory of constructivism, which has changed the pattern of study from "teacher-centred" to "student-centred" to create a culture of learning motivation of students. The study conducted by Salih et al. (2006) found that the use of technology in computer-assisted instruction material could effectively improve students' understanding to overcome misconceptions in Biology topics in secondary schools. This was further reinforced by the findings of Esra and Pinart (2010), which stated that misconceptions on the biological concept of photosynthesis and respiration could be overcome by using computer-assisted technology. From the research development, BIOMIND portal that was based on PBL model could improve new students' self-understanding in solving problems during a discussion. The BIOMIND portal also helped to develop lifelong learning, so that the students have a good and correct understanding. This was according to Palennari (2011) who found that the facilities and media based teaching learning theory would reduce, even eliminate, misconceptions of students (Aydin & Balim 2009; Günes et. al. 2011; Chin & Chia 2004).

The BIOMIND portal was an effort of innovation in the teaching and learning, which aimed to provide opportunities for students to construct knowledge by themselves to improve their digital-age literacy skill. Innovative learning based on constructivist paradigm help students to develop and transfer information more effectively. The findings by Caballé et al (2011) showed that learning could be delivered online to improve the knowledge and skills of the students as a whole that might arise during the interaction with technology. In addition, the analysis by Ying (2012) showed that the use of online portal was a critical factor in promoting the satisfaction of web-based learning environment. A rich-content online learning environment could connect short-term experiences on the level of each individual's long-term experiences. They also suggested that online learning encouraged active learning.

The findings showed significant differences in the 21st century skills between the experimental and control group. In addition, the research found that BIOMIND portal could overcome students'

misconception due to students having their skills trained by understanding to formulate, instil and combine their ideas in completing the project issue that has been given during interventions to improve their conceptual knowledge. This study concludes that teaching and learning using BIOMIND portal brought a positive impact especially in developing the 21st century skills and solve students' misconception in Biology subject.

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