



The Influence of Problem Based Learning (PBL)-Based Student Worksheets on Sustainable Development Goals (SDGs) to Improve Students' Critical Thinking Skills

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Abstract

The development of 21st century science and technology in the field of education requires students to be able to master the 4C skills, one of which is critical thinking. Critical thinking skills can improve students' ability to solve problems, draw conclusions and find appropriate solutions from various aspects and perspectives they will face. PBL-based student worksheets and PBL learning models are the right choice to improve critical thinking skills and can be linked to SDGs problems which will later make students solve various problems to be able to achieve SDGs goals and targets. This study aims to analyze the improvement in aspects of students' critical thinking skills after applying PBL-based student worksheets on SDGs problems. The research was conducted at a public high school in Bogor Regency, while the method used was an experiment. The population that was used as the object of research was students in several public high school classes in Bogor Regency, with cluster random sampling taking the sample. Based on the results of research and analysis, it shows that PBL-based student worksheets can improve students' critical thinking skills in SDGs problems, seen from the N-Gain score in the experimental class of 0.48 and the control class 0.32 in the medium category. The activeness of the students in the class which was assessed through the attitude and skill aspects, showed that the experimental class was higher than the control class which affected the improvement of students' critical thinking skills. The conclusion of this research is that the alternative research hypothesis is accepted, so that there is an influence of PBL-based student worksheets on SDGs issues to improve students' critical thinking skills.

Keywords: critical thinking skills; PBL; SDGs

INTRODUCTION

The development of science and technology in the 21st century will continue to increase, so that students as Human Resources (HR) must be equipped with skills that not only support knowledge, but creativity, critical thinking, communication, and collaboration (4C). Critical thinking is a person's mental activity in collecting, categorizing, analyzing, and evaluating information or evidence in order to make a conclusion to solve a problem (Hamdani *et al.*, 2019; Wasahua, 2021; Yessy *et al.*, 2017). Critical thinking skills can improve students' ability to solve problems, draw conclusions and find appropriate solutions from various aspects and perspectives

they will face. Training students' critical thinking skills can be done through appropriate teaching materials and learning strategies. Learning resources and learning media that can help students and teachers in the learning process, one of which is student worksheets (Latifah, 2016; Ariani & Meutiawati, 2020; Pawestri & Zulfiati, 2020).

PBL-based student worksheets are teaching materials containing activities which include steps of student worksheets and PBL learning models. So that the steps in student worksheets and PBL are combined and become learning steps for PBL-based student worksheets that will be used during the learning process. PBL-based student worksheets use problems in learning activities that enable students to think analytically and try to solve problems on their own. PBL-based student worksheets are the right choice for improving critical thinking skills and can be linked to SDGs problems which will later make students solve various problems to be able to achieve SDGs goals and targets. Student worksheets are a guide used to develop cognitive aspects as well as all aspects of learning in the form of guidelines for investigation or problem-solving activities according to indicators of achievement of learning outcomes that must be achieved (Novelia, 2017; Ardianti *et al.*, 2021; Huda *et al.*, 2021). One of example is golden apple snail problem in paddy field, then students try to give recommendation as solution like changing them as fish meal alternative (Pertiwi & Saputri, 2020). Based on preliminary tests of students' critical thinking skills and teacher interviews. The process of learning biology in schools on biodiversity material, student worksheets used by teachers are less able to attract students' interest and hone critical thinking skills. Students' critical thinking skills are still relatively low with an average of 41%. In addition, students' critical thinking skills are less trained in the biology learning process. Most only focus on cognitive learners only. These cognitive skills are also measured only during daily tests, PTS, and PTA. So this study aims to analyze the improvement in aspects of students' critical thinking skills after applying PBL-based student worksheets on SDGs problems.

Education as a means of preparing students in the world of work later to be able to think analytically, solve problems and be critical so that they can become a productive workforce and generate knowledge, be able to exchange information and encourage progress that helps build community welfare (Supriadi, 2016; Inanna, 2018; Sasson *et al.*, 2018). Therefore students need to develop and improve critical thinking skills in everyday life in society which are closely related to environmental problems. Introducing the SDGs to students will help achieve the goals and targets of the SDGs. Education for Sustainable Development (ESD) is seen as education that assists in developing attitudes, skills and knowledge to make the right decisions for the benefit of present and future generations (Segara, 2015; Anyolo *et al.*, 2018; Hanifah & Purnamasari, 2021). So that students can care more about the environment and know about any programs that can protect the environment and they can also contribute to protecting the environment. The issue of sustainable environmental development is increasingly important to be realized through education because it is one of the important factors in achieving sustainable development (Anyolo *et al.*, 2018; Irawati *et al.*, 2018; Wilujeng *et al.*, 2019). The existence of student worksheets helps students to practice critical thinking skills in solving problems in everyday life and in problems given by the teacher. The purpose of this study to determine the influence of problem based learning (PBL)-based student worksheets on sustainable development goals (SDGs) to improve students' critical thinking skills.

METHOD

This research was conducted from July to September at high schools in Bogor Regency. This research is a quantitative research with the method used namely like an experiment in the shape of non-equivalent control group design. This method is to determine the effect of research results by applying certain treatments to one group, then determining how the two groups determine the final result (Creswell, 2014; Hastjarjo, 2019; Abraham & Supriyati, 2022). The population that was used as the research object were students of SMAN 1 Cibinong, Bogor Regency, each of which consisted of 10 classes. Sampling is done with cluster random sampling and the instruments used in this study included instruments to measure critical thinking skills in the form of 10 essay items, attitude aspects and skill aspects in the form of observer checklist

sheets, implementation of learning in the form of observer checklist sheets, and student responses in the form of questionnaires.

Testing the critical thinking skills instrument is in the form of a validity test and a reliability test. Test the validity of using the technique Product Moment Pearson by Pearson (Arikunto, 2016; Manuaba *et al.*, 2018; Jabnabillah & Margina, 2022), instruments that already have valid criteria, will be tested for reliability with the formula Alpha Cronbach. As for the aspects of critical thinking that are used to provide simple explanations, build basic skills, conclude, make further explanations, strategies and tactics according to Ennis' theory in (Fitriyanti, 2017). Analysis of statistical descriptive data to describe the results of the test, the data is presented through the distribution of frequencies, histograms, mean, standard deviation, variance, and N-Gain which were analyzed using Microsoft Excel 2013. Meanwhile, for the analysis of normality test data using the test Kolmogorov Smirnov Z, homogeneity test using test Homogeneity of variances, and test the hypothesis using the test Independent sampel T-test using help Statistical Program For Social Sciences (SPSS) version 25. According to Sundayana (2015) The following criteria are used $n\text{-Gain} < 0,3$ as low, $0,3 \leq n\text{-Gain} \leq 0,7$ as currently, and $n\text{-Gain} \geq 0,7$ as height.

RESULT AND DISCUSSION

This study discusses two groups, consisting of the dependent variable, namely students' critical thinking skills, and the treatment variable, namely PBL-based student worksheets. There are two groups of research samples, including the experimental class group and the control class group. Students' critical thinking skills in the cognitive aspect are measured using a test instrument in the form of essay questions, with a total of 10 questions in the instrument. The following is a descriptive analysis of critical thinking skills in the SDGs problems in the control class and the experimental class which are presented in table 1 as follows.

Table 1. Descriptive analysis of critical thinking skills

	N	Range	Min	Max	Mean	Std. Deviation	Variance	N-Gain
<i>Pre-Test</i> Eksperimental	35	54	3	57	28	13,569	184,118	0,48
<i>Post-Test</i> Eksperimental	35	70	17	87	62	14,948	223,457	
<i>Pre-Test</i> Control	35	50	7	57	34	13,287	176,551	0,32
<i>Post-Test</i> Control	35	67	13	80	55	14,745	217,412	

Based on the calculation results presented in table 1, it shows descriptive statistical pre-test and post-test on the critical thinking skills of students in the experimental class and control class. Whereas the pre-test and post-test scores obtained an N-Gain value of 0.48 in the experimental class while 0.32 in the control class, it can be categorized that critical thinking skills are in the moderate category. Pre-test assessment and the post-test showed a significant change in students' critical thinking skills. The results showed that the experimental class scored higher critical thinking skills than the control class. After the treatment using PBL-based student worksheets, students' critical thinking skills increased. This can be influenced by several factors, one of which is student worksheets. Student worksheets are teaching materials made to make it easier for students to study material independently or in groups. The types of methods used to teach critical thinking are similar across subjects, for example questioning techniques and class discussions (Wilujeng *et al.*, 2019; Bellaera *et al.*, 2021; Putra *et al.*, 2023). Students can be more active in solving the problems given in the student worksheets. That presenting the problems presented will encourage curiosity, so that students find out strategies and tactics for solving these problems (Dewi *et al.*, 2022; Murtavia *et al.*, 2022; Nurmaardi & Ikrom, 2022). The activeness of students is assessed through group discussions in working on student worksheets. Analysis of observation of learning skills is one of the most important elements to determine student activity during the learning process. This is necessary to see whether in the learning process students look active or passive (Nurfazillah, 2018; Solikin & Sukirman, 2020; Nurrohim *et al.*, 2022) . Aspects of assessing student activity include aspects of attitudes and aspects of skills. The following is an

analysis of attitude aspects and skills aspects in the control class and experimental class which are presented in Figure 1 and Figure 2 as follows.

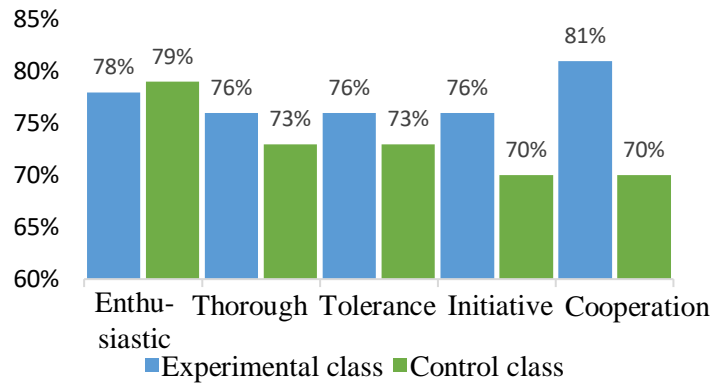


Figure 1. Analysis of the attitude aspect

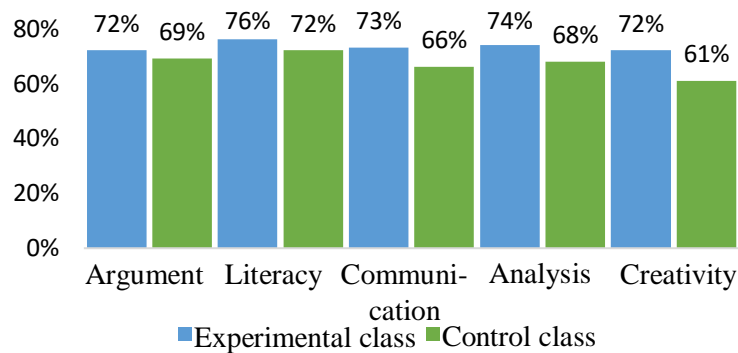


Figure 2. Analysis of the skills aspect

The percentage of attitude aspects and skills aspects of the experimental class is superior to the control class when seen from Figure 1 and Figure 2. Students' critical thinking skills are not only assessed through cognitive aspects, they only focus on knowledge when doing tests. Cognitive, affective, behavioral, application and curriculum-oriented aspects of sustainability competencies are part of SDG integrated learning (Ghany, 2018; Cebri *et al.*, 2020; Safitri *et al.*, 2022). That students who have more social skills are students who often hold group discussions (Jamali, 2013; Febnasari *et al.*, 2019; Hutahaeaan, 2019). Through discussion activities in answering problems, students will be more active in learning, compared to only one-way learning, such as a teacher center. Because through this group discussion, students are trained to be social individuals, respect others and have high empathy.

Aspects of the enthusiastic attitude and argumentation skills of students influence the active participation in learning, especially the teacher's performance in carrying out learning activities. That applying a variety of methods will have a positive impact on students' enthusiasm for participating in learning (Kurniawan *et al.*, 2017; Solikin & Sukirman, 2020; Nurmaardi & Ikrom, 2022). Learning problem solving in group discussions can improve students' skills in arguing. Discussion in small groups can reduce disputes and increase the creativity of group members when compared to discussions with large groups because it can lead to disagreements that lead to impolite actions (Jamali, 2013; Febnasari *et al.*, 2019; Istiana & Herawati, 2019). Aspects of a conscientious attitude and literacy skills of students with literacy habits will go hand in hand with a high conscientious attitude. Read, analyze and determine carefully in solving problems and appropriate solutions. That a conscientious person is shown to be careful, full of interest, and careful in doing something so that mistakes do not occur, and get good results (Ashari, 2015; Oktriani & Ekadiansyah, 2020; Rohman, 2022). The interest in literacy and critical thinking skills is an inseparable combination because reading can stimulate critical abilities (Oktriani & Ekadiansyah, 2020; Annisa *et al.*, 2021; Rohman, 2022). Aspects of tolerance and communication skills are important in the learning process, especially discussions. The existence of

communication both intrapersonally (thinking, remembering, and perceiving) and interpersonally (sharing ideas, respecting opinions, and listening to arguments) greatly influences the learning process (Masdul, 2018; Fauzia & Fajrie, 2021; Mahadi, 2021). Students can communicate well when there are differences of opinion so that conflicts never occur between students in the class due to these differences of opinion (Famela *et al.*, 2021; Fauzia & Fajrie, 2021; Mahadi, 2021). There is a close relationship between tolerance and communication which must run in balance, with tolerance students are able to communicate their opinions. Vice versa, students who are able to communicate must also be able to tolerate between opinions.

Aspects of the attitude of initiative and analytical skills related to the attitude of cooperation and creativity skills. Students who are more inclined to think critically are also more open to diversity and challenges and have a stronger creative self-concept. These results highlight the importance of increasing students' behavior to use critical thinking so as to strengthen their creative self-concept (Dewi & Sari, 2017; Álvarez-Huerta *et al.*, 2022; Murtavia *et al.*, 2022). Found that the critical thinking behavior of high school students is positively related to their creative self-concept and scientific creativity, namely their ability to produce new products or ideas that have scientific value (Nuraini & Suparman, 2017; Qiang *et al.*, 2020; Putra *et al.*, 2023). Students who have a sense of initiative are used to being independent, without the need for orders, they can invite their friends to work together. Working with friends will increase the creativity of students because they discuss exchanging information and giving everyone's opinion. So that they will be able to analyze the problem, this will also be related to other aspects. Collaboration during discussions can create a more effective and efficient learning atmosphere. Learners are able to do more things in groups than working individually (Hapsari & Yonata, 2014; Novelia, 2017; Huda *et al.*, 2021). The collaboration that is carried out is part of the stages of the PBL learning model with group learning. The characteristics of the PBL learning model are that the problems presented are related to everyday life, so that students are able to understand and apply them in life, new information is obtained through independent learning, learning in small groups, and the teacher acts as a facilitator (Hapsari & Yonata, 2014; Shoimin, 2014; Novelia, 2017). Whether or not the stages in the PBL learning model are fulfilled or not are assessed and the implementation of learning is observed during the learning process by the observer. The results of the observations of each group of students are presented in table 2 as follows.

Tabel 2. Analysis of the implementation of learning

Observed aspect	Experiment class	control class
Introduction		
Core activities		
Problem orientation		
Organize	88%	71%
Guiding research		
Develop and present the work		
Analyze and evaluate the problem solving process		
Closing		

The percentage of learning implementation in the experimental class was higher than the control class, according to the aspects observed in the experimental class, more points were implemented than the control class. The readiness of the teacher in mastering the learning model also influences the success of the learning process, in carrying out learning using the PBL model assisted by student worksheets. Because the PBL model is so familiar among high school teachers. The stages in PBL learning assisted by these student worksheets place more emphasis on students' critical thinking skills on SDGs issues related to real life. The learning process in the experimental class using the PBL model assisted by student worksheets emphasizes student-centered learning activities, where the teacher only acts as a facilitator, a motivator who guides students during learning activities. Not only when learning activities take place with the teacher, but when students discuss with their groups.

Strategies and tools are very important to motivate learners. This includes clear messages to learners or highlighting learning objectives, reasons for learning, expectations from learners, course structure, and learning and assessment processes (Febnasari et al., 2019; Nurrohim *et al.*, 2022; Singh *et al.*, 2022). The learning process that has been going on besides using PBL-based student worksheets, in the learning process also uses the PBL learning model. The PBL learning model is very helpful for improving students' critical thinking skills and is appropriate when used with PBL-based student worksheets. PBL is a learning model that emphasizes student activity, as something students must learn by using real-life problems to improve critical thinking skills as well as problem solving (Nafiah, 2014; Solihat, 2017; Yulianti & Gunawan, 2019). This PBL learning model provides space for students to learn to be more independent, active and creative and improve students' critical thinking skills through the problems faced by students in the material for Efforts to Preserve Biodiversity (Shoimin, 2014; Maiyuni & Maharani, 2016; Hamdani *et al.*, 2019). The achievements of the students after the implementation of the learning process took place were seen from the responses given after using the PBL-based student worksheets. A recapitulation of the results of student responses to the use of PBL-based student worksheets is presented in Figure 3 below.

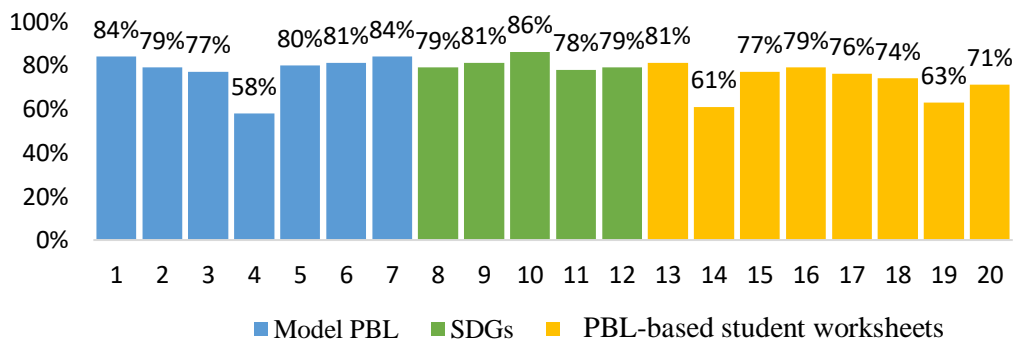


Figure 3. Analysis of student responses

The percentage of student response analysis agreed that students' insight and knowledge increased after participating in learning. On the perception of the PBL model, students agree that the PBL model is able to improve critical thinking skills. The PBL learning model is able to improve their critical thinking skills by examining a problem, discussing and finding problems and solutions. Critical thinking skills make students have thoughts that are always curious about information to achieve a deep understanding (Segara, 2015; Yustina *et al.*, 2015; Gagnidze, 2018). In the perception of SDGs, students agree to study SDGs points 14 and 15 related to the material for efforts to conserve biodiversity. Learning about the SDGs will enable them to take part in finding solutions and relate them to everyday life for a better future. Attitude of awareness towards the environment needs to be instilled as early as possible in students and properly evaluated (Perkasa *et al.*, 2017; Ghany, 2018; Cebri *et al.*, 2020). In addition to learning models and Student Worksheets that are applied and given to students, articles on SDGs issues are also very helpful in students' critical thinking skills. Discussion of SDGs in articles that are closely related to everyday life, makes students more critical in analyzing each problem. Education and science play an important role in realizing sustainable development in everyday people's lives (Perkasa *et al.*, 2017; Gagnidze, 2018; Safitri *et al.*, 2022). Learning for sustainable development (education for sustainable development) provides an opportunity for the government and academics to achieve learning objectives related to the competence of students to be able to maintain environmental sustainability in the future (Segera, 2015; Inanna, 2018; Hanifah & Purnamasari, 2021). Therefore by introducing SDGs to students starting from secondary education and in learning they are able to contribute to implementing the goals of SDGs. The problems of everyday life are closely related to the environment which can be learning for students.

On the perception of PBL-based student worksheets, students agree that PBL-based student worksheets are able to improve critical thinking skills. Students' positive responses were also seen

in research (Latifah, 2016; Novelia, 2017; Astuti *et al.*, 2018) which stated the effectiveness of PBL with student worksheets in honing students' critical thinking skills based on student responses in implementing the model. Students easily understand the instructions in the student worksheets, considering that student worksheets are designed in a simple way and focus on activities that stimulate students to think critically. Placement of student worksheets in the PBL model is in accordance with PBL steps because it involves student investigations in problem solving. Student worksheets guide students in terms of investigations to solve problems (Astuti *et al.*, 2018; Islamiah *et al.*, 2018; Pawestri & Zulfiati, 2020). This PBL also can stimulate students to explore if the environment good enough for living creatures because it's often being used as tourism like in Cibuya Beach (Triacha *et al.*, 2021; Putri *et al.*, 2023) and Tanjung Rising Beach (Fatonah *et al.*, 2023). The steps and advantages in the PBL model have succeeded in influencing students' critical thinking skills.

Based on several aspects that have been described, it can support the process of improving students' critical thinking skills. So that there is an influence that causes an increase in students' critical thinking skills. Therefore it is necessary to test the hypothesis to ensure systematically the truth that exists. The requirement to carry out a hypothesis test is that the data being analyzed is stated to be normally distributed and the variance is homogeneous. The next step is to do a hypothesis test or parametric statistical test in the form of an independent sample t-test. Aims to find out whether the proposed hypothesis can be accepted or rejected. Analysis of hypothesis testing can be seen in table 3 as follows.

Tabel 3. Analysis of hypothesis testing

Hypothesis testing	Significance value	Significance level	Results	Conclusion
Critical thinking skills	0,000	0,05	Sig. value < Sig. level	Ha is accepted, Ho is rejected

Analysis of the hypothesis test in table 3 obtained a significance value of $0.000 < 0.05$, then the alternative hypothesis (H_a) was accepted and the null hypothesis (H_o) was rejected. This means that there is an influence between the independent variables on the dependent variable, so it can be concluded that there is an influence of PBL-based student worksheets on students' critical thinking skills in SDGs problems. This effect can be seen from the increased critical thinking skills after using PBL-based student worksheets. This can be influenced by several factors, one of which is student worksheets. In accordance with research (Jamali, 2013; Novelia, 2017; Saputra & Kuntjoro, 2019) that PBL-based student worksheets effectively support the implementation of student-centered learning. Student worksheets that direct students to discuss are not only able to add insight to students, but are also able to train students' attitudes and skills. Improving critical thinking begins with problem-solving activities in the student worksheets (Astuti *et al.*, 2018; Bellaera *et al.*, 2021; Dewi *et al.*, 2022). Students who learn to use PBL-based student worksheets are more stimulating to be active in conducting question and answer discussions such as at the stages of formulating problems, determining and testing hypotheses, and determining problem solving options given during group discussions. Ability to ask questions, activeness, ability to express opinions and cooperation of students can be done using the group discussion method (Shoimin, 2014; Ermi, 2015; Istiana & Herawati, 2019). In other word, PBL also can increase students learning motivation and critical thinking (Wini *et al.*, 2022; Pratiwi *et al.*, 2023). The link between PBL-based student worksheets and the PBL learning model for improving critical thinking skills is very close. Because in every process and stage, students are required to think critically. In addition, the SDGs problems which become material for students in formulating problems, solving problems, analyzing, and solving problems are very appropriately linked to PBL-based student worksheets and PBL learning models in improving critical thinking skills. This is because the SDGs are closely related to the problems of everyday life and are solutions for today's world and future generations. PBL-based student worksheets on the material for efforts to conserve biodiversity to improve critical thinking skills are stated to have an effect on being used in the learning process in terms of cognitive, affective, and psychomotor aspects of critical thinking skills and student responses.

CONCLUSION

Based on the results of the research and analysis that has been carried out, it shows that PBL-based student worksheets can improve students' critical thinking skills in dealing with SDGs issues. The improvement of students' critical thinking skills can be seen from the N-Gain score in the experimental class of 0.48 and the control class of 0.32 in the moderate category. Critical thinking skills show higher results in students who use PBL-based student worksheets compared to non-PBL-based student worksheets. This is proven through hypothesis testing which shows that there is a significant effect on PBL-based student worksheets in improving students' critical thinking skills. The activeness of students in the class is able to influence the improvement of students' critical thinking skills, assessed through aspects of attitudes and aspects of skills which show higher results in the experimental class than the control class. The implementation of learning in the class shows that the experimental class is higher than the control class which affects the success of the learning process using PBL-based student worksheets. Student responses generally agreed that PBL-based student worksheets were able to improve critical thinking skills and were used appropriately in studying the SDGs on biodiversity conservation efforts. These findings are useful for national teachers in specific, because this research provides knowledge to improve student critical skill in class.

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