Development of E-Module PBL Model Learning to Improve Students' Mastery of Concepts

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Abstract: The teaching materials provided by the teacher have not been able to make students understand the material of mechanical waves. because it only contains an explanation of the material conveyed through writing. Therefore, innovative and interactive learning media are needed that are able to help students understand the concept material of mechanical wave submatter waves. This research is a type of development research (Research and Development). The development model used is the 4D model with define, design, develop and disseminate steps. This research was conducted at SMAN 1 Baitussalam in class XI students using 22 modeling field trial samples and 22 implementation field trial samples. Data collection tools were obtained from media validation questionnaires, pretest and posttest questions. The results of the validation of material and media experts show that the developed PBL-based e-module is very feasible. The N-Gain analysis shows that PBL-based e-modules are effective in increasing students' understanding of concepts. The practicality analysis results show that the e-module is very practical. Thus, the developed PBL-based e-module is suitable for use in mechanical wave learning.

Keywords: Conceptual understanding; E-Module Media; Mechanical waves; PBL

Introduction

Physics is a branch of science that plays an important role in various aspects of life. However, physics is not infrequently considered the most difficult science to learn and understand because it must have a high understanding of concepts. As Erviani (2017) Physics is a branch of science whose application can develop analytical thinking skills. In addition, physics lessons are lessons that provide knowledge about the universe to practice thinking and reasoning, through the reasoning abilities of a person who continues to be trained in understanding concepts so that the more developed the person will increase his thinking power and knowledge. One of the materials that is classified as difficult to understand and has a high conceptual understanding is the material of mechanical waves. Mechanical waves are one of the materials in physics subjects as Yana et al. (2020) mechanical waves are one of the important materials in the physics curriculum in

high school. Although mechanical waves are a phenomenon that often occurs in everyday life, students still have difficulty understanding this material. Although research related to the topic of wave mechanics has not been widely carried out, several studies in this field have resulted in important knowledge contributions, including the following. Wittmann et al. (1999) revealed the difficulty of students in determining what quantity the value of which depends on the way a wave is generated and which quantity depends on the characteristics of the medium in which the wave propagates. Riadi (2016) developed a diagnostic test to reveal students' understanding of the characteristics of traveling waves.

Tongchai et al. (2011) developed the Mechanical Waves Conceptual Survey instrument to reveal students' understanding as well as common misconceptions experienced by students regarding mechanical waves. Jumadin et al. (2017) investigated students' understanding of wave behavior when

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encountering a boundary surface between two different mediums, including the relationship between frequency, wavelength, and wave velocity. The researcher also investigated how students apply the relationship $v = \lambda f$ to solve wave interference problems, both for interference from two wave sources and for interference in thin films (Sutopo, 2016). Based on the explanation above, students' understanding of the relationship $v = \lambda f$ is an issue that is of great concern to researchers. This indicates that the relationship is very important to be well understood by students. However, previous studies have shown that the relationship is often misunderstood by most students. In general, students and teachers can mention the formula quickly and correctly. However, after asking follow-up questions, in general the students/teachers did not understand the formulation properly. They do not yet have the correct understanding that the frequency of a wave is determined by the way the wave is generated (the magnitude is the same as the vibrational frequency of the wave source), the speed of wave propagation is only determined by the characteristics of the medium, and the wavelength is determined by both so that it satisfies the relationship $v = \lambda f$. In addition to the relationship $= v = \lambda f$, this will also reveal students' understanding of the general form of the mathematical representation of traveling waves, namely: if the waveform at = 0 can be expressed by the function (x), then the waveform at any > 0 is $(x,) = (x)$ where represents the speed of wave propagation and the sign $(-/+)$ is used if the wave propagates to (right/left) (Syawaly & Hayun, 2020; Giancoli & Douglas, 2007). So far, students' understanding of the concept is still lacking. In addition, this representation is important for students to understand in order to fully understand the concept of waves so that they can distinguish traveling waves from stationary waves, for example. Students' understanding of the motion of medium particles has not been much of a concern to previous researchers. As is known, there are two kinds of motion (meaning also two kinds of speed) in the propagation of mechanical waves, namely the speed of wave propagation and the velocity of the particle movement of the medium when the wave travels. Therefore, it is important to know the extent to which students understand the two types of speed.

Research conducted by Istyowati et al. (2017) on high school students in Malang showed that as many as 21.11% of students considered the mechanical wave material as a difficult material. According to Yana et al. (2020), the difficulty that occurs is understanding the concepts of wave propagation and superposition, as well as particle motion in mechanical waves. Research conducted by Widiyanto et al. (2018) for class XI IPA MA Darul 'Ulum Sumber Bridal for the 2017/2018 academic year, 47.0% of students still do not understand the

relationship between wavelength, propagation speed, and frequency. Travel fast in rope waves. Good concept understanding is the basis of good problem solving skills. Students who have good problem solving skills will use their understanding of the concept in problem solving. Therefore, it is necessary to analyze the understanding of concepts in the mechanical wave material to analyze the types of misconceptions in students.

The use of technology in education can make physics learning more efficient and can change the quality of students' understanding of concepts. The low achievement of students' physics learning at school is caused by several factors, namely students are still required to study physics in the form of products only, while the process to get products is still neglected. According to Agustina et al. (2017) the low student learning outcomes are also caused by teacher-centered learning. The teacher requires students to memorize concepts and memorize formulas. In addition to students, educators are also required to master the competence of teachers. One of them is professional ability where educators must be able to make directed learning in accordance with the objectives and competencies of the material being taught. Educators must also be able to design and implement appropriate strategies, models, and learning tools in accordance with the circumstances of the educational process.

According to Rusman et al. (2018) Professional teachers are those who specifically have tasks based on teacher expertise with a deep understanding of the basics and references of education, and or academically master knowledge of educational theories and have the skills to be able to apply educational theories. The development of Science and Technology (IPTEK) has brought changes to every aspect of life, including aspects of education. The world of education is expected to be able to adapt so that interesting and developmentally appropriate teaching activities can be obtained. As Fitriyah (2021) states that "The development of Information and Technology (ICT) is currently experiencing a fairly rapid development. These developments have an impact on various fields, especially in the field of education, where strategies and patterns in learning continue.

With the development of today's technology, many learning activities are switching to online methods so that students can learn independently naturally, ICT continues to create new breakthroughs in learning (Amalia & Lestyanto, 2021). Technology can expand learning activities, it is evident that currently some learning has switched to the unlimited online method from previously only being done in the classroom, so that students in their learning can be done

independently, either without the help or guidance of teachers in the classroom or outside of school.

Results based on interviews with physics teachers at Baitussalam High School in the even semester of the 2021/2022 school year, the media that is often used in the learning process is physics textbooks. However, the books used are books that are printed on opaque paper and black ink and still contain brief material on physics and only contain questions. Physics learning at Baitussalam High School is rarely carried out with experimental activities which cause reduced understanding of concepts so that students are less developed and cause low learning achievement. The results of daily tests in class XI MIPA 1 show that only 23.53% of the total 34 students who complete the Minimum Completeness Criteria (KKM). While in class XI MIPA 2 only 29.41% of the total 34 students completed the KKM. In addition, the teacher explains the material using a direct learning model, namely the teacher focuses and continues by giving practice questions in the book, causing students to absorb the material only to the extent of receiving an explanation from the teacher and lack of understanding. Complex material and requires understanding more concepts, of course, it takes a long time for students to understand the material to be studied.

So to provide solutions to these problems in order to improve understanding of concepts and student learning outcomes, the teaching materials must be developed by providing questions with cognitive domains that are able to support students to improve conceptual understanding and improve student learning outcomes. In addition, teaching materials are designed by utilizing technology accompanied by materials, practice questions, and worksheets to support students in improving students' conceptual skills so as to improve student learning outcomes. The method is then packaged in teaching materials in the form of e-modules containing material and questions that are packaged with problem-based learning models by utilizing technology. The relationship between problem-based learning models and understanding concepts is that when students are faced with solving a given problem, students will use their conceptual understanding as initial knowledge and only provide simple explanations. Then when students collect data, students usually collect tactics and strategies to support the ability to understand concepts. The results of the problem-solving analysis are then linked to the theory that has been described previously. Furthermore, students are asked to explain further until students can find an argument. And at the last stage to support students' understanding of concepts, students conclude from their findings to the problem solving stage.

The development of problem based learning (PBL)-based E-modules has 6 stages to improve, namely recognizing problems, describing objectives, designing and improving artifacts, testing artifacts, evaluating results, and evaluating test results (Sari & Wulandari, 2020). Learning models with PBL for students can improve the analysis and interpretation of critical thinking elements (Zaintika et al., 2021). The application of PBL can also improve high-level cognitive (Salari et al., 2018), then research by Sutopo (2016) revealed that PBL can improve problem solving abilities and student satisfaction in the learning process.

The learning model that can be used in this mechanical wave material is Problem Based Learning (PBL). The problem-based learning model is a form of innovative student-centered learning model so that it can provide active, innovative, creative, and independent learning conditions and places the teacher as a facilitator and motivator, and can confront students with a problem. around concrete them or their daily environment (Rusman et al., 2018). Electronic modules using problem-based learning are non-print media learning resources containing material based on complex problem questions in real life that can spur the students' understanding process, are designed systematically and allow students to learn independently. This is evidenced by research conducted previously by Erviani (2017) entitled "Development of problem-based learning e-modules in chemistry subjects for class X students of SMA Negeri 8 Malang" showing that the e-modules developed are included in valid qualifications and suitable for use in learning with an average score of 91.45% material experts, 98% media experts, and 84% student responses. Then through the learning outcomes test, the developed e-module learning media was declared effective in learning with details of the posttest SKM percentage of 95% (Farenta et al., 2016).

The difference between this study and the previous research is that this research implements problem based learning (PBL) referring to a problem-based, process-oriented, discipline-integrated, and student-centered paradigm in groups (Widiyanto et al., 2018). It is hoped that the E-module based on the PBL model will have a positive impact on the teaching and learning process. According to Fatriani et al. (2018) that problem-based learning begins with forming small groups that aim to solve real-world problems by discussing each other and finding new knowledge together. Problem-based learning students have the freedom to carry out an investigation that is carried out either outside or inside the classroom. After that the teacher assists students in outlining problem-solving plans by providing simple examples to help complete tasks so that they can be

resolved properly. So, using e-modules using the PBL model can increase students' understanding of concepts.

PBL with the help of mobile applications has a positive effect on students' critical thinking (Amalia & Lestyanto, 2021). Learning with PBL requires students to understand the concepts being studied by looking at situations or problems that have been presented by the teacher at the beginning of learning with the aim of training students to solve a problem (Natalia et al., 2019). In line with the findings of Miqro (2021) that the strategy to improve students' critical thinking is to use learning with the PBL model.

The relationship between problem based learning and critical thinking is that when students are faced with solving a given problem, students will use their thinking as their initial knowledge and only provide simple explanations. Then when students collect data, students usually collect tactics as well as strategies to support critical thinking skills. The results of the problem solving analysis are then linked to the theory that has been described previously. Furthermore, students are required to explain further to the stage where students can find an argument. And at the last stage to support students' understanding of concepts, students conclude from the results of their findings to the stage of solving problems.

Based on the description above, the authors are interested in conducting research on class XI students with the title "Development of e-modules based on problem based learning (PBL) models on mechanical wave material to improve understanding of concepts for high school students in class XI"

Method

Refers to the product produced in the research project, namely in the form of a learning device in the form of a PBL-based e-module which refers to the 4D learning model as a result of the modification of the 4D model recommended by Thiagarajan which consists of Define, Design, and Develop (Development). The population in this study were all students of class XI MIPA 1 for the experimental class and XI MIPA 2 for the control class at SMA N 1 Baitussalam in the academic year 2021/2022 with a total of 44 students consisting of class 22 students of XI MIPA 1 and 22 X MIPA 2. The sample is part of the number and characteristics of the population (Sugiyono, 2016). The samples of this research were students of class X MIPA 1 and XMIPA 2 which were taken using a saturated sampling technique, that is, all of the population was used as a sample. Sampling considerations are based on the results of grades and discussions with teachers. The sample in this study were 44 students of class XI MIPA 1 and XI MIPA

2 at SMAN 1 Baitussalam, which would be tested 2 times. The initial trial was conducted on November 10 at SMAN 1 Baitussalam. The initial trial of the teacher gave a pretest after the students finished working on the teacher link E-module and provided instructions for using the PBL-based E-module, after the students finished reading and working on the questions contained in the E-module the teacher gave a posttest, followed by the distribution of questionnaires and learning activities closed. The data collection tool used is through a given test and a distributed questionnaire. Validation of Concept Understanding of Test Instruments The test instrument was analyzed for content validity using the V-Aiken equation, the interpretation of the value of V is presented in Table 1 be one of the teacher's alternative learning media in conveying learning. Data collection used by questionnaires, documentation and observation.

$$V = \frac{\sum s}{(c-1)} \qquad (1)$$

Table 1. Interpretation of V-Aikan

Value V-Aikan	Interpretation
$V \geq 0.8$	Valid
$0.4 < V\ 0.8$	Currently
$V \leq 0.4$	Less Valid

Then for the effectiveness of using N-Gain products. Next is the N-gain test to find out in detail the improvement of students' conceptual understanding. N-gain is used to prevent errors in interpreting the acquisition of increased data scores (Gunawan, 2013). In this study, the N-gain test was used to prevent the error of increasing scores from the students' initial and final test data, using the equation.

Table 2. Interval Criteria N-Gain

Interval	Criteria
N-gain > 76	Effective
55 ≤ N-gain ≤ 75	Effective enough
40 ≤ N-gain ≤ 54	Less effective
N-gain < 40	Ineffective

In the research conducted, namely developing an e-module for the initial appearance of the e-module there is a cover/title and identity of the e-module to be able to access this e-module, students can open it on Android which is shared by the teacher. On the cover display there is a mechanical wave title and the logo of the State University of Yogyakarta which is displayed using an e-module as well as the name of the developer and the identity of the e-module. Before entering the mechanical wave material, there are phenomena that often occur in everyday life, namely when someone vibrates their

hands, they form waves. Why does this usually happen? In the e-module there is also an answer column for students to answer the picture problem. And then there is material that will be studied by students and there are LKPD and LKPD steps. And there are practice questions. Then there is a finish button if the student has finished working on the LKPD.

Result and Discussion

The research trial was carried out twice, namely the Implementation class and the modeling class, which was the stage carried out to determine whether the PBL-based E-module learning media developed was feasible to use or not. The following is an explanation of the e-module: Figure 1 presents the initial display of the e-module, there is a cover/title and identity of the e-module. To be able to access this e-module, students can download the e-module on Android which is shared by the teacher on the WhatsApp group. On the cover display there is a mechanical wave title and the Yogyakarta State University logo which is displayed using an e-module and the name of the developer. Figure 2 presents the menus in the e-module, which include instructions, concept maps, KI, KD, materials, quizzes, and worksheets. In the LKPD Before entering the mechanical wave material, there are phenomena that often occur in everyday life, namely when someone vibrates his hand it will form a wave. Why does this usually happen? In the e-LKPD there is also an answer column for students to answer the picture problem. The following is the appearance of the developed e-module:

Figure 1. First view of cover/title and e-module identity

Figure 1 presenting the initial display of the e-module, there is a cover/title and identity of the e-module. To be able to access this e-module, students can download the e-module on Android which is shared by the teacher on the WhatsApp group.

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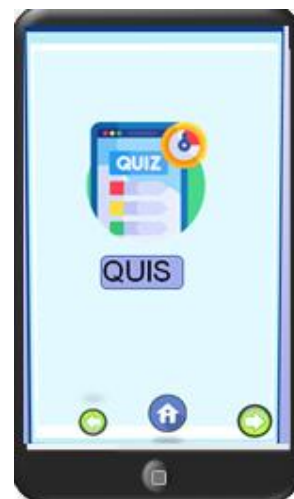

Figure 2. Menu in the module

Figure 3. Quiz

Figure 4. Presents the e-LKPD

Figure 3 presents a quiz consisting of 5 questions, the quiz aims to train students' conceptual understanding after using the e-module. Figure 4 presents the e-LKPD, the e-LKPD uses the help of phet simulation where the link is already available in this e-module. In e-LKPD Before entering the mechanical wave material, there are phenomena that often occur in everyday life, namely when someone vibrates their hand it will form a wave. Why does this usually happen? In the e-LKPD there is also an answer column for students to answer the picture problem.

The initial research was conducted in the form of pretest and posttest research with One-Group Pretest-Postest Design to determine the significant difference in student learning outcomes between before using PBL-based E-module media and after using PBL-based E-modules. In the field trial, the pretest to posttest scores increased from the average modeling pretest score of 28.11 to 73.77 posttest scores and the Implementation class from 30.23 to 74.79. The initial research was conducted in the modeling class. Learning begins with greeting and controlling student attendance followed by the distribution of pretest questions with 15 minutes of filling time and answers sent personally, the results of the work on average students can only answer number 1. The next activity is carried out by distributing PBL-based e-modules that shared on the WhatsApp media group, then students can download the application on their Smartphone. Students are given 1 week to read and solve the questions in the E-module, the results of working on the E-module on average students have difficulty working on quiz number 5. The activity closed with the distribution of posttest questions, students were given 15 minutes to complete the question and the answers were sent. Personally, the results obtained by students in the initial field trial averaged 28.22 for pretest and 73.777 posttest.

Table 3. Average Pre-Test and Post-Test

Trials Field	Amount Learners	Average Pre-test	Average Post-test
Modeling	22	28.1	73.7
Implementation	22	30.3	74.7

The research is also in the form of pretest and posttest research with a One-Group design Pretest-Posttest Design to find out the significant increase in students' conceptual understanding between before using PBL-based E-module media and after using PBL-based E-modules. In the field trial, the pretest to posttest scores increased by the implementation teacher and the researcher started the learning beginning with student attendance. Learning begins with greeting and controlling student attendance followed by the distribution of pretest questions with 15 minutes of

filling time and answers sent personally, the results of the work on average students can only answer number 1. The next activity is carried out by distributing PBL-based e-modules that shared on the WhatsApp media group, then students can download the application on their Smartphone. Students are given 1 week to read and complete the questions in the E-module. the results of working on the E-module, on average, students have difficulty working on quiz number 5. The activity closed with the distribution of posttest questions. Students were given 15 minutes to solve the problem and the answers were sent personally, the results obtained by students in the initial field trial were on average. The average pretest is 30.23 and the average posttest is 74.79.

Table 4. Frequency

Field Trial	Number of student	N
Modeling	22	0
Implementation	22	0

From the data in Table 2, it is known that 22 students have a post-test score that is higher than the pretest score. There were no students whose post-test scores for understanding the concept did not increase. That is, the value of students who apply this learning has increased results. Furthermore, to ensure the data using the t-test by using the Paired Sample Test. But the first step should be a normality test.

Table 5. Results of Modeling and Implementation Trials

Field Trial	Number of student	Average Pre-Test	Average Post-Test	N-Gain
Modeling	22	38.11	73.77	62.31
Implementation	22	30.23	74.79	61.31

Table 5 shows the values before and after using the E-learning media. PBL-based module with the difference between the pretest and posttest scores of modeling field trials and implementation test 73.77 and 74.79 respectively with this-based e-module PBL can help students the effectiveness of this E-module is included in the high criteria. The value of the effectiveness of the PBL-based e-module is 62.31% for the modeling class and 61.31% for the implementation class. The average value of Implementation with an N-Gain value of 0.61 (high category). In addition, this PBL-based e-module also has a media validity value of 95.8% (very valid). Comparison of Modeling and Implementation Classes. In this section, we will examine whether there are significant differences between the two classes after applying the PBL model to the implementation and modeling classes in the table below:

Table 6. Independent Test Sample t-Test

Field Trial	Number of student	Average Pre-Test	Average	t-Test
Modeling	22	38.11	73.77	0.001
Implementation	22	30.23	74.79	0.001

The analysis uses statistical testing, namely the Independent Sample t-test where the goal is to compare the values of two unpaired samples. Based on test results in the equal variances assumed section, it appears that the value of Sig. (2-tailed) < is 0.001 < 0.05. Thus, the decision taken is to reject 0 and the final conclusion is that there is an effect of PBL model on the understanding of students' concepts.
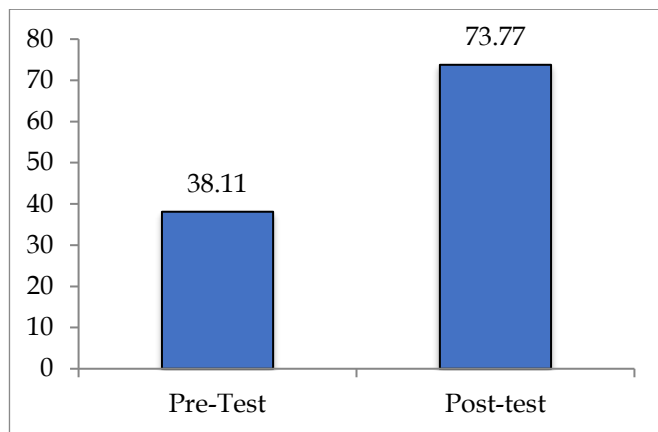

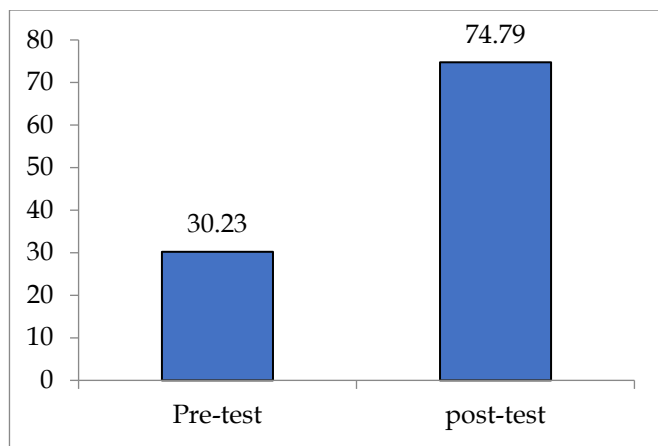**Figure 5.** Modeling graph

Figure 6. Implementation graph

Based on the picture above, it can be seen that both of them experienced an increase before being given treatment and after being given treatment. This means that e-module media can improve students' understanding of concepts.

Material Expert Results
The results of data analysis by learning material experts on each indicator can be seen in Figure 7.
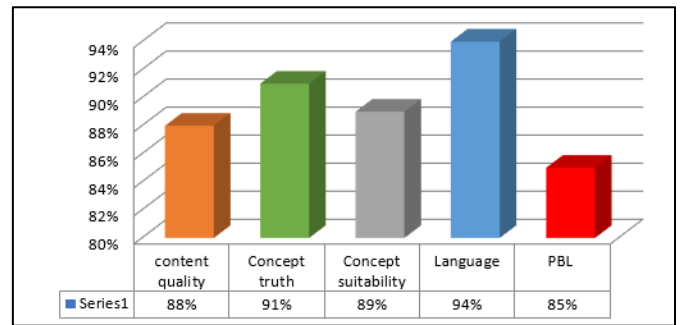

Figure 7. Results of material experts

Based on the results of the validation carried out by the learning material expert validator, the overall percentage value of the assessment indicators is 87.4% with the assessment criteria "very valid" but with a note that revisions must be made according to input and suggestions from the expert validator. The material expert validator's assessment consists of five assessment aspects. The first aspect is the quality of the content by assessing the suitability of the material with KI and KD having a feasibility percentage score of 94% according to Figure 9. This e-module discusses light material. The second and third aspects of the assessment are aspects of the correctness of the concept that receive suggestions from the validator to correct problems related to everyday life so that students can be actively involved. According to (Andriyani et al., 2020) Students' activeness in learning activities is none other than constructing their own knowledge. They actively build an understanding of the problems or everything they face in the learning process.

Conclusion

The PBL-based e-module learning media developed in this study are suitable for use as learning media on mechanical wave material. Learning media have met the criteria of validity, practicality and effectiveness. The validity of the material and media aspects shows the value of the validity criteria each has a very valid percentage of criteria and has N-gain field trials respectively (quite effective) and (quite effective). Thus, the developed PBL-based E-module learning media is suitable for use as a learning medium for students in class XI MIPA and XI MIPA 2 and teachers who teach physics subjects, especially at SMAN 1 Baitussalam.

Author Contributions

Nurfazliana, Conceptualized the research ide, designed of methodology, analyzed data, management and coordination responsibility. Jumadi J, Literatur review and provided critical feedback the manuscript.

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Conflicts of Interest

The authors declare np conflict of interest. The funders had no role in the design of the study.

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