JIPF (JURNAL ILMU PENDIDIKAN FISIKA)
p-ISSN: 2477-5959 | e-ISSN: 2477-8451 *Vol. 9 No. 2, May 2024, Page 241-252*

Analysis of Technological Pedagogical And Content Knowledge Teachers physics Overcoming Misconceptions Newton's Law

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Received: December 26th, 2023. Revised: June 26th, 2024. Accepted: July 1st, 2024

Keywords :
TPACK; Misconceptions; Newton's Law

ABSTRACT
Misconceptions in students must be corrected immediately so that there is no retention of misconceptions in subsequent knowledge. One way to prevent and reduce misconceptions that occur in students is with the ability of Technological Pedagogical and Content Knowledge (TPACK) of teachers. Teachers who integrate TPACK in learning can prevent misconceptions and find solutions to overcome the misconceptions that occur. This study aims to determine the TPACK ability of teachers in overcoming misconceptions,. The research method used in this study is a Mixed method with an unbalanced mixed research design (Concurrent Embedded design). The results showed that the teacher's TPACK ability can improve students' concept understanding. This is indicated by the N-Gain score= 0.72, which means that the teacher's TPACK ability is effective in improving concept understanding on newton's law material.

INTRODUCTION

Physics is a branch of science that requires students to understand the surrounding nature scientifically by prioritizing concept mastery [1]. Mastery of the concept itself is a learning outcome in the Merdeka 2022 curriculum [2] and is the main aspect that must be mastered by students [3]. However, in reality, many students have an understanding of concepts that are not the same as the initial concepts initiated by scientists [4]. Misunderstanding of concepts or misconceptions can be reduced by replacing old or incorrect knowledge with correct knowledge [5], the process of correcting this misconception will be difficult because the knowledge to be changed is basic knowledge that may be formed from the experience of the learners themselves or the results of previous knowledge misconceptions [6]. Misconceptions that are not immediately corrected will become retention of misconceptions in subsequent interrelated knowledge, thus hindering the understanding of concepts and the success of students' learning [6]. Newton's Law material is the material that has the most misconceptions, namely 300 out of 700 world studies discuss misconceptions in Newton's Law [1] [7]. Some examples of misconceptions on Newton's Law experienced by students (1) There is no force on a stationary object [8], (2) the mass of an object is equal to the weight of the object [9], and (3) objects with greater mass fall faster than objects with smaller mass [10]. Many factors cause misconceptions, misconceptions can come from the learners themselves such as learners' prior knowledge that is not in accordance with

scientific facts, learners' interests or learners' ability to accept learning, can come from sources, or learning media, and can also come from teachers such as teaching methods, differences in language used or even from misconceptions experienced by the teacher [11] [12]. Misconceptions caused by the teacher are more difficult to correct because of the learners' belief that the concept given is correct [13], to avoid this the teacher must master the subject matter broadly and deeply and be used as a teacher's basic competence.

Teachers have several basic competencies that are regulated in Law Number 14 of 2005 concerning teachers and lecturers, namely pedagogic competence, personality competence, social competence and professional competence. One competency that distinguishes teachers from other professions is pedagogical competence [14]. In addition to pedagogical knowledge, teachers must also have content knowledge and technological knowledge. The relationship between Technological Knowledge, Content Knowledge and Pedagogical Knowledge is presented as Technological Pedagogical and Content Knowledge (TPACK) which is the main component of the teacher [15]. In the TPACK scheme, there are components that support each other, namely technology, pedagogical and content, which means that teachers are able to develop material (content ability), develop teaching strategies that are in accordance with the material (pedagogical ability) and incorporate technology into learning to make it easier for students to understand concepts (technological ability) [16]. Research on one of the TPACK components, namely PCK, has been shown to improve motivation, learning outcomes and learning achievement as well as students' cognitive abilities [17] [18] [19] [20], where motivation and the aspects mentioned are one of the causes of high and low student misconceptions [21]. The integration of TPACK in learning can reduce and even prevent misconceptions [22] and improve the quality of learning in accordance with the demands and changes in finding solutions to overcome misconceptions by activating prior knowledge [23] [24].

Although there is a link between teachers' general abilities in Technological Pedagogical and Content Knowledge (TPACK) and misconceptions, there has been no in-depth or detailed study of teachers' abilities in which of the TPACK components are most dominant in remedying misconceptions in science learning. This is something new and has not been studied in much detail in an effort to reduce misconceptions among students. This study aims to determine the teacher's TPACK ability in overcoming misconceptions by looking at the improvement of concept understanding on Newton's Law material after being given concept understanding with the teacher's TPACK skills. After that, the teacher's TPACK ability in each of the TPACK components will be analyzed descriptively to see which TPACK components are mastered by the teacher or less mastered by the teacher and how it impacts reducing misconceptions in science learning.

METHOD

Research Approach

The Approach used in this research is a combination method (mixed method) with an unbalanced mixed research design (concurrent embedded design). In this research design, qualitative data and quantitative data are taken at almost the same time and have their respective roles. One of these data is supporting data for other data [25]. The main data in this research is qualitative data and the supporting data is quantitative data. In this study, the quantitative method used is the one group pretest posttest method, while the qualitative method used is descriptive analysis.

Population and Sample

Population in this study were all students of class XI MIPA and physics teachers of State High School No. 5 Banda Aceh, with sample is consisted of 28 students of class XI MIPA 2 State High School No. 5 in Banda Aceh who had studied and passed Newton's Law material and 1 Physics teacher of State High School No. 5 Banda Aceh.

Research Procedures

Students' concept understanding was measured using a three-level test based on the Force Concept Inventory question consisting of 15 items. A good diagnostic test is a diagnostic test that can describe the misconceptions experienced by students [26]. Teachers' TPACK skills were measured based on observation interviews and teacher perception questionnaires.

Data analysis

Misconceptions experienced by students on newton's law material are identified using the FCI test, the FCI test is used twice, namely the pretest to see the misconceptions of students and the post-test to see the results of misconceptions after being treated. Misconception analysis of the answers given by students using the three-tier test method consisting of answer choices, reasons and CRI (Certain of Responds Index) with six scales (0-5) based on Table 1.

Table 1. CRI Categories

Categories	Scale	CRI Criteria
Totally guessed	0	If the answer is 100% guessed
Almost guessed	1	If the answer is 75-99% guessed
Not sure	2	If the answer is 50-74% guessed
Sure	3	If the answer is 25-49% guessed
Almost Certain	4	If the answer is 1-24% guessed
Certain	5	If the answer is 0% guessed

After the test is given and answered by students, the answers are analyzed to distinguish students who do not understand the concept, experience misconceptions and understand the concept by looking at Table 2.

Table 2. Student Response Criteria

Tier 1 (Conception)	Tier 2 (Reason)	Tier 3 (Level Of Confidence)	Interpretation Of Categories
True	True	High (>2,5), Very confidence	Understand of Concept
True	False	High (>2,5), Very confidence	Misconception
False	True	High (>2,5), Very confidence	Misconception
False	False	High (>2,5), Very confidence	Misconception
True	True	Low, (≤2.5), Unsure	Not Understanding of Concept
True	False	Low, (≤2.5), Unsure	Not Understanding of Concept
False	True	Low, (≤2.5), Unsure	Not Understanding of Concept
False	False	Low, (≤2.5), Unsure	Not Understanding of Concept

After the data from the pretest and posttest results are obtained, then the N-gain test is carried out on the results of students' scores, this test is used to see whether there is a decrease in misconceptions after the teacher explains the concept of Newton's law using his TPACK skill. N-Gain categories can be seen in the Table 3.

Table 3. N-Gain value and category

N-Gain	Categories
(g) < 0,3	Low
0,3 < (g) ≤ 0,7	Medium
(g) < 0,7	High
(g)= 0,00	There was no increase

After obtaining the results of students' misconceptions, the next step is to measure the teachers' TPACK skills. Teachers' TPACK skills were analyzed with learning observation sheets, teacher perception questionnaires and interviews. The data will be analyzed using the Miles and Huberman model [25] where activities in analyzing data are divided into 3 phases, namely data reduction, data

display and conclusion drawing.

RESULTS AND DISCUSSIONS

The results and discussion in this study are explained in two parts, namely the part that explains the misconceptions experienced by students, and the part that explains teachers' TPACK skill.

Student's Misconceptions
The recapitulation of pretest and posttest scores and the percentage of misconceptions can be seen in Figure 1.

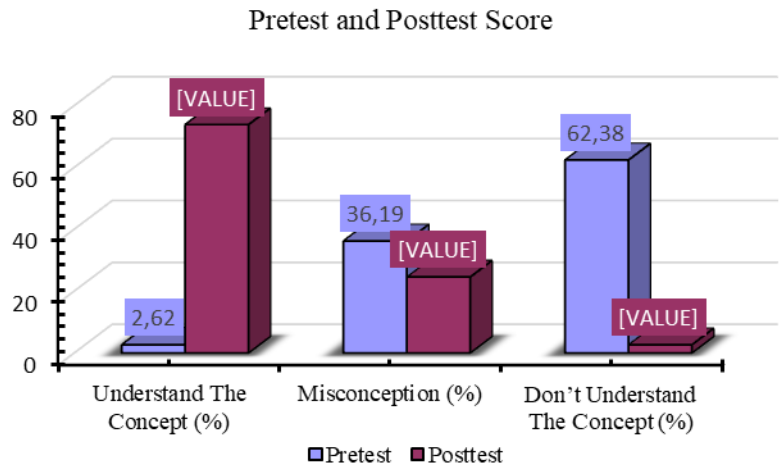

Fig 1. *Pretest and Posttest Score*

Based on Figure 1, it can be seen that there is a decrease in misconceptions by 11.6%, a decrease in misconceptions is accompanied by an increase in concept understanding by 71.2%. The magnitude of the increase in students' concept understanding occurred because previously physics learning only focused on applying formulas without going through the process of analysis or processing, causing students to be unable to understand learning concepts [27]. Low scientific literacy skills also indicate the cause of misconceptions [28]. The concepts with the most misconceptions based on the FCI three tier diagnostic test can be seen in the table 4.

Table 4. Misconception on FCI Concept

Concepts	Misconception Pretest (%)	Misconception Posttest (%)	Reduction
Free Fall Motion	58,92	14,28	44,64
Uniform Acceleration	32,14	25	7,14
Uniform Speed & Uniform Acceleration	42,85	25	17,85
Parabolic Motion	36,60	29,46	7,14
Uniforms Speed	20,23	16,66	3,57
Circular Motion	33,92	17,85	16,07

Based on Table 1, it can be seen that the concept of free fall motion is the concept with the greatest reduction in misconceptions, seen from the decrease in the percentage of misconceptions 58.9 to 14.28. The concept of free fall motion is a concept with high misconceptions due to the lack of media that shows the actual events that occur in free fall motion events [29]. Using realistic videos is one way to reduce misconceptions about the concept of free fall [30].

After the data from the pretest and posttest results are obtained, the next step is to conduct the N-Gain test of the students' test results. This N-gain test is used to see whether there is an increase in concept understanding before and after treatment. The results of the N-gain test using SPSS can be seen in Table 5.

Table 5. Result N-Gain Score

Descriptive Statistics	N	Minimum	Maximum	Mean	Std. Deviation
N-gain score	28	.470	.930	.725	.116
N-gain percentage	28	46.700	93.000	72.525	11.551
Valid N (leastwise)	28				

Based on Table 5, it can be seen that the N-Gain score = 0.72, this result shows that the N-gain value meets the requirements> 0.7 which means it is in the high category. The high category indicates that there is an increase in students' concept understanding or a decrease in misconceptions after being given an understanding of the teacher's TPACK-based concepts. So that the teacher's TPACK ability can overcome the misconceptions of students of newton's law material. The increase in students' concept understanding based on the N-Gain analysis test can be seen in Figure 2.

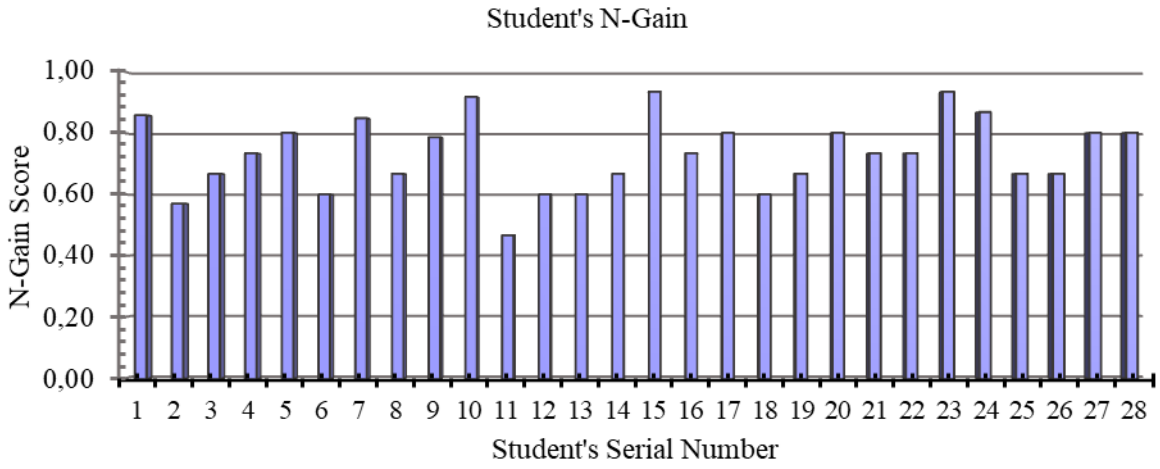

Fig 2. *N-Gain Score of Increases Students' Understanding of Concept*

Based on Figure 2, there are 16 learners with a high increase in concept understanding, namely the N-gain score> 0.7, while the rest are learners with a moderate increase in concept understanding, namely the N-Gain score> 0.3. Based on the N-gain score obtained by each learner, it can be seen that the teacher's TPACK ability is effective in overcoming misconceptions. These results are in line with research conducted by Prastyan, et al [31] that is TPACK-integrated learning can improve students' concept understanding.

Teachers' TPACK Skills

As we know that teachers' TPACK skill can reduce misconceptions that occur in students. Teachers' TPACK skill was measured using 3 methods, namely teacher perception questionnaires, lesson observations and interviews. The results of the teacher perception questionnaire, observations and interviews will be described based on the TPACK components to obtain qualitative data (Table 6).

Table 6. Observation Result

TPACK Components	Indicators	Observation Result
TK	Good command of technology used in the learning process (internet, powerpoint, browser or learning video).	The teacher uses Powerpoint and Phet virtual lab well and smoothly during the lesson.
	The technology used is easy to operate	The technology used by teachers in learning is easy to operate without the help of others.
PK	Have a variety of strategies or ways of learning	Teacher here has a variety of learning methods but is not accompanied by practice questions.
	Managing classroom well	Teacher's mastery of the class was not very good, as seen from some students who did not pay attention to the teacher's explanation and made a fuss.
	Conduct reflective action to improve learning quality	Teacher did not conduct any reflective action in the form of learning evaluation.
CK	Mastering the material being taught	Teacher really understood the concept of the material being taught, and during the learning process there were no mistakes and the teacher was confident in delivering the learning material.
	Provide relevant and familiar examples to enhance students' understanding of the material	The teacher provides examples that are easily recognised by students in conveying the concepts of
	Answer the student's question appropriately	Teacher was answers students' questions well, and is accompanied by explanations that are easy to understand.
	Using the latest sources such as journals, books, as learning references	Teachers use learning resources in the form of the latest package books (last 5 years)
TPK	Using computer applications in learning	Teacher presents the material using Microsoft office power point and is enhanced with a virtual lab.
	Choose technology that is appropriate for learning	The technology used is in accordance with the learning strategy and the teacher can instruct well
PCK	Provide familiar analogies to the learning material	Teachers provide examples that are familiar to students so that students are able to understand the concept of the material being taught.
TCK	Use technology to deliver and explain learning technologies	Teacher uses technology to deliver the material and explains the material well.
	Explain the concepts of Newton's laws that become students' misconceptions with appropriate learning methods and assisted by technology.	Teacher uses technology that is appropriate to the material and learning methods, and is able to explain the misconceptions that occur well.

Technological Knowledge

The result observation of TK, it can be seen that teachers have good technological skills. It is can support teachers in facilitating learning and presenting learning in a more varied manner [32].This is in accordance with teachers' perceptions on their technological knowledge, where the results of the

teacher perception questionnaire are supported by the results of teacher interviews which state that teachers have a high curiosity about the latest learning technology and do not hesitate to continue learning. The results of the teacher perception questionnaire can be seen in Table 7.

Table 7. Teacher's Perception of TK

Statement	Answer
I can learn technology easily	Agree
I am able to switch on and off the computer/laptop easily	Strongly agree
I have sufficient knowledge about the latest technology	Agree

Pedagogical Knowledge

The result observation of PK, which is teachers have considerable pedagogical knowledge. However, at point 3 the teacher did not conduct a learning perspective, which is a reflective action is one of the core competencies in the teacher's pedagogical ability [33]. Reflective action aims to determine the success or failure of the learning process that has been carried out [34]. Teachers' PK skills are also seen based on their perceptions, the teachers' perceptions of pedagogical knowledge can be seen in Table 8.

Table 8. Teacher's Perception of PK

Statement	Answer
I can use different approaches to teaching	Agree
I can choose appropriate learning models for students with different backgrounds	Agree
I can use various instruments to assess student understanding	Neutral
I can assess student performance in class	Agree
I can reflect to improve the quality of learning	Agree

Based on Table 8 in statement 3 the teacher answered neutral, which means that the teacher assesses student understanding with instruments that are not too varied. There are differences in answers to the observation results and the results of the teacher perception questionnaire. This difference in answers can be concluded that the teacher is actually able and able to take reflective action on learning, but due to several factors reflective learning during the observation cannot be done. Reflective action may not be carried out by teachers due to one of the factors, namely learning time arrangements [35].

Content Knowledge

The result observation of CK , it can be seen that the teacher's content knowledge is very good, but in the process of delivering the material the teacher only uses the last 5 years edition of the physics package book without including learning sources from articles and others. The results in the questionnaire on the perception of teachers' content skills are in the very good category, seen from the answers of teachers who strongly agree on each statement in the questionnaire. Mastery of learning content is a must for teachers because it is listed in the teacher's professional competence. Teacher perception questionnaire answers on content knowledge can be seen in Table 9.

Table 9. Teacher's Perception of CK

Statement	Answer
I know the basic concept of Newton's law, that its formula and definition.	Strongly Agree
I understand the topic structure of the material I teach	Strongly Agree
I can explain why this learning topic is important to study	Strongly Agree
I can relate the physics lessons I teach to everyday life	Strongly Agree

Technological and Pedagogical Knowledge

The result observation of TPK, it can be seen that teachers are able to choose technology and use technology in accordance with learning strategies (4.33) or methods, in this case the teacher has good TPK skills. This is supported by the results of the teacher perception questionnaire which gave a positive response to the statements given. The positive responses given by teachers in the perception

questionnaire show that teachers can assess technology-assisted learning, can utilize technology to improve the quality of teaching and can access internet facilities to communicate with students so that learning can occur outside school hours. The results of the teacher perception questionnaire can be seen in Table 10.

Table 10. Teacher's Perception of TPK

Statement	Answer
I can use technology to assess student learning	Agree
I can use technology to enhance my teaching in learning	Agree
I can access the internet facility to communicate with students, for example to collect assignments or provide teaching materials.	Strongly Agree

Several previous studies show that teachers who master TPK well will be reflected in their understanding of how teaching and learning change when particular technologies are used [38]. Besides that, it also shows that the mastery of the TPK domain by science teachers from different schools will be different. Meanwhile, in terms of gender, educational qualifications and school location, there are no differences [39]. Meanwhile, mastery of TPK has also been studied from the aspects of school level, gender and teacher educational qualifications. The results of the study show that mastery of TPK by science teachers does not differ according to school level, educational qualifications and gender [40].

Pedagogical and Content Knowledge

The results observation of the PCK, teachers provide analogies (3.00) that are more familiar to students in explaining learning materials, teachers also provide practical examples so that students are able to describe the situation in the material being taught. The teacher's PCK ability is also measured based on his perception, the teacher's response to all PCK indicators in the teacher perception questionnaire is neutral, this can be interpreted that the teacher does not always use approaches and strategies that are appropriate to the material, cannot always identify difficult parts of a discussion and find ways to explain them, cannot always develop questions to measure student understanding, and cannot always develop the subject matter effectively and in detail. The results of the teacher perception questionnaire can be seen in Table 11.

Table 11. Teacher's Perception of PCK

Statement	Answer
I can choose approaches and strategies that are appropriate to the material being taught	Neutral
I can identify difficult parts of a subject and find ways to explain those difficult parts to my students	Neutral
I can develop questions to measure students' understanding of the material taught.	Neutral
I can effectively develop a detailed lesson plan for each subject in a physics lesson	Neutral

Several previous studies show that teachers who master PCK well will be reflected in their understanding of how teaching and learning change when particular technologies are used [38]. Besides that, it also shows that the mastery of the PCK domain by science teachers from different schools will be different. Meanwhile, in terms of gender, educational qualifications and school location, there are no differences [39]. Meanwhile, mastery of PCK has also been studied from the aspects of school level, gender and teacher educational qualifications. The results of the study show that mastery of PCK by science teachers does not differ according to school level, educational qualifications and gender [40].

Technological and Content Knowledge

The result observation of TCK, teachers use technology that is in accordance with the learning

material very well, as for some of the technologies used by teachers in accordance with the material presented, namely Microsoft office PowerPoint, YouTube, quizzes and PhET virtual lab the use of technology in learning such as the virtual PhET lab will increase student motivation and problem solving [36]. Teacher also explained in the interview that determining the technology that suits the learning material is seen from the needs of the material. For example, abstract material needs to be used technology that can help visualize the material. The observation of the teacher's TCK is also supported by the results of teacher perceptions in the perception questionnaire, where teachers are able to use technology to support learning, especially in proving physics concepts (4.00). Teachers also stated in interviews that the use of technology in physics learning is very important to support learning. The results of the teacher perception questionnaire can be seen in Table 12.

Table 12. Teacher's Perception of TCK

Statement	Answer
I can use technology to explain the material in different ways	Agree
I can use technology to deepen learning materials	Agree

Technological Pedagogical and Content Knowledge

The result observation of TPACK, teachers are able to use technology in accordance with learning methods and materials, and reduce the misconceptions of newton's law material that occurs in students (4.00). Teachers' TPACK abilities are also measured based on their perceptions on the TPACK questionnaire, where in the TPACK questionnaire the teacher gives a positive response to the statement. This can be interpreted that teachers can use various strategies that combine subject matter, technology and teaching approaches in class, teachers can determine the technology that is in accordance with the strategies to be used in delivering subject matter so that technology can help teachers achieve learning goals [37]. The results of the teacher perception questionnaire can be seen in Table 13.

Table 33. Teacher's Perceptions of TPACK

Statement	Answer
I can use a variety of strategies that combine subject matter, technology and teaching approaches in the classroom.	Agree
I can use technology to facilitate students in learning certain subject matter	Agree
I use technology in various ways so that students are positively impacted in their learning of the subject matter.	Agree

From the results of observations and perception questionnaires that have been carried out, it is found that 6 out of 7 TPACK components that have been analyzed are well mastered by teachers. The six components are TK, PK, CK, TPK, TCK and TPACK components. While the teacher's skill in the PCK component is not very well mastered. Several previous studies show that teachers who master TK, PK, CK, TPK, TCK and TPACK components well will be reflected in their understanding of how teaching and learning changes when particular technologies are used [38]. Besides that, it also shows that the mastery of the TK, PK, CK, TPK, TCK and TPACK components domains by science teachers from different schools will be different. Meanwhile, in terms of gender, educational qualifications and school location, there are no differences [39]. Meanwhile, mastery of TK, PK, CK, TPK, TCK and TPACK components has also been studied from the aspects of school level, gender and teacher education qualifications. The results of the study show that mastery of TPK by science teachers does not differ according to school level, educational qualifications and gender [40].

CONCLUSION AND SUGGESTION

Teachers' TPACK skills are effective in overcoming misconceptions that occur in newton's law material. This can be seen from the increase in concept understanding based on the N-Gain value of 0.72, which means there is an increase in concept understanding with a high category. The teacher's

ability to effectively overcome misconceptions is supported by the teacher's ability in six TPACK components, namely TK, PK, CK, TPK, TCK and TPACK can be said to be good, while the PCK component is not too mastered by the teacher. This research was conducted on senior physics teachers, so it will be difficult to correct deficiencies in their TPACK skills. The suggestion for further research is to test a sample of physics teachers to test their TPACK skills in overcoming misconceptions about physics material on teaching students. so that deficiencies in TPACK skills can be immediately corrected.

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