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Analysis of the Ability of Prospective Physics Teachers In Developing Tpack-Based Learning Tools (Technolgical, Pedagogical, and Content, Knowledge)

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Abstract

This research is a type of descriptive research with a quantitative approach, with sampling using cluster sampling technique. The purpose of this research is to see the ability of prospective physics teachers in preparing TPACK-based learning tools. The results obtained on the ability of Content Knowledge (CK) were at a score of 52.66 in the sufficient category, the ability of Pedagogical Knowledge (PK) was at a score of 56 in the sufficient category, the ability of Tecknological Knowledge (TK) with a score of 83 in the excellent category, Technological Content Knowledge (TCK) with a score of 84 in the excellent category, Technological Pedagogical Knowledge (TPK) with a score of 85 in the excellent category, Pedagogical Content Knowledge (PCK) with a category of 83.33 and Technological Pedagogical and Content Knowledge (TPACK) with a score of 80 in the excellent category.

Keywords: Technology; Learning; Media; TPACK-BASED LEARNING TOOLS

Introduction

The fourth-generation industrial revolution, also known as industrial revolution 4.0, emerged as a result of rapid advances in science and technology. The era of industrial revolution 4.0 directs all sectors of life towards the use of digital technology, artificial intelligence, big data, and robotics. In the context of education, these changes encourage the need to integrate technology in learning. The concept of education 4.0 is used by education experts to describe how to implement technology in the learning process. Education is one of the crucial sectors in preparing the younger generation to face challenges in today's digital era. With the advancement of information and communication technology (ICT), it is important for educators to utilize technology effectively in the learning process. This applies not only to teachers who teach at the school level, but also to prospective teachers who are pursuing higher education.

The challenges of world development are increasingly oriented towards demanding the availability of human resources (HR) who master science, technology and art (IPTEKS). The rapid changes in the world must be accompanied by educational practices that are relevant to the demands of these changes. Such a phenomenon occurs prominently with regard to the development of information and communication technology (ICT). The development of information technology has changed various aspects of human life, including education (Wasitohadi, 2009). At the beginning of 2006, the development of educational technology developed towards solving learning problems. This paradigm is oriented to describe educational technology in order to overcome learning problems in a more directed and controlled manner (Raiser, 2008). Listening to its development, educational technology can be said to be a systematic process in helping to solve problems in learning (Miarso, 2004). Most teachers have only just realized the importance of technology for education/learning, but have not yet attempted to apply it (Wasitohadi, 2009). Teachers are one of the determining factors for success in the learning process. The quality of teachers is an important factor in improving the quality of education, as noted in the McKinsey report which states that "the quality of the education system cannot possibly exceed the quality of its teachers" (Barber and Mourshed, 2007, 16).

In education, the teacher is one of the factors that determine the success of learning. Traditional teaching methods carried out by teachers will affect the results obtained by students. Teachers are required to be professional not only

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able to convey knowledge to students (transfer of knowledge) but teachers must be able to connect students with diverse sources both inside and outside the school. Teachers are also required to be able to prepare learning facilities so that students can obtain maximum learning completeness (Huda, Sulisworo, & Toifur, 2017). Therefore, teachers are expected to have mastery of science and technology, especially in the era of the industrial revolution 4.0. This is a challenge in preparing future teachers with the ability to use technology effectively (Abbitt, 2011). The use of technology is not only in terms of the ability to use computers, but at the level of understanding and concern for information and communication with technology (Kozikoğlu & Babacan, 2019). One of the impacts of using ICT in the learning process is that teachers must have the knowledge and ability to plan lessons well so that teachers are not only competent in content and pedagogical knowledge but also technological skills (Oz, 2015).

Teachers in the 21st century and beyond are challenged to accelerate the development of information and communication. Classroom learning and classroom management, in this century, must be adjusted to the standards of advances in information and communication technology that already exist. There are 7 challenges for teachers in the 21st century, namely: 1) Teaching in multicultural society, teaching in a culturally diverse society with multilingual competence; 2) Teaching for the construction of meaning, teaching to construct meaning (concepts); 3) Teaching for active learning, teaching for active learning; 4) Teaching and technology, teaching and technology; 5) Teaching with new view about abilities, teaching with new view about abilities; 6) Teaching and choice, teaching and choice; 7) Teaching and accountability, teaching and accountability.

According to Koehler & Mishra (2009), the ability to use technology by paying attention to content and pedagogical aspects is called Technological Pedagogical Content Knowledge (TPACK). In the process of learning and teaching activities, teachers must also be able to convey material well because learning is a process of developing new knowledge, skills, and behavior in a person as a result of their interaction with various information and the environment. Therefore, students as prospective teachers must be taught early on to be able to convey the information they know correctly and on target, namely the correct material content through good pedagogical activities so that they become professional prospective teachers. Content is knowledge that includes facts, knowledge, principles, laws and theories and mastery of material. While pedagogics include ways that teachers can use to help students solve learning problems.

Pedagodics also means understanding and recognizing the characteristics and potential of students and knowing the theories and principles of effective learning (Zuhaida, 2018). In the era of the industrial revolution 4.0, there is a need for improvement in Indonesian education in order to compete with other countries. This improvement is related to the quality and competence of Indonesian teachers so that the goals of national education can be achieved properly. Based on the 2013 curriculum, with the elimination of information and communication technology (ICT) subjects and making ICT as one of the media in the learning process. This requires teachers to be able to use technology in every learning process. Therefore, prospective teacher students must be able to master this technology. The use of technology in the learning process is not an easy thing especially for prospective teachers. A prospective teacher must be able to master the material to be taught (Sholihah, Yuliati, & Wartono, 2016) in order to determine the right technology. Mastery of the material can be done by analyzing the characteristics of the material so that the appropriate learning strategy will be used in accordance with the technology chosen. So, for prospective biology teachers to be able to carry out learning well, they need the ability to master material, pedagogic and technology. The integration of these abilities forms Technological Pedagogical and Content Knowledge (TPACK). Technological Pedagogical Content and Knowledge (TPACK) consists of three main components, namely content knowledge, pedagogical knowledge and technological knowledge (Chai & Koh, 2017; Koehler & Mishra, 2009; Oz, 2015). The combination of these three components forms PCK (Pedagogical Content Knowledge), TCK (Technological Content Knowledge) and TPK (Technological Content Knowledge) and TPACK (Technological Pedagogical Content and Knowledge).

Most teachers have only just realized the importance of technology for learning, but have not yet made an effort to apply it (Wasitohadi, 2009). Teacher quality is an important factor in improving the quality of education, as noted in the McKinsey report which states that "the quality of the education system cannot possibly exceed the quality of its teachers" (Barber and Mourshed, 2007, 16). Teachers are in charge of planning and implementing the learning process, assessing, conducting research and studies and opening communication with the community (Sagala, 2009).

The facts in the field found that schools and teachers in Indonesia still have problems, among others, teacher standards, mastery of materials, and low media and technology / Literacy media and Technology. A major challenge facing education in Indonesia in the global complex is the ability of teachers to design teacher competency development plans called TPACK or Technological Pedagogical Content Knowledge. TPACK is a comprehensive integration of knowledge and skills in terms of materials, and pedagogy combined with

technological developments. TPACK was first coined by Shulman (1987) and developed by Koehler & Mishra (2008). TPACK is considered a potential framework that can provide new directions for teachers in solving problems related to integrating ICT into teaching and learning activities in the classroom (Hewitt, 2008).

Method

The population in this study were prospective physics teacher students at the Faculty of Teacher Training and Education, Nusa Cendana University, Academic Year 2022/2023 who had taken the Introduction to School Field (PLP) course. This type of research is descriptive with a quantitative approach, with sampling using cluster sampling technique.

Of the 6 schools where the Introduction to School Field Program (PLP) was implemented in Kupang City, 3 schools where the Introduction to School Field Program (PLP) was implemented were selected based on the criteria of school type, namely public schools. The number of respondents in each high school involved was determined using a random sampling technique, namely 1 student of the School Field Introduction (PLP) program from each school who taught in grade XI from 3 high schools in Kupang City.

Research Design

The second stage of this development research design began to be designed. Several steps need to be taken so as to produce output, namely (1) cover design, (2) making instructions for use, (3) compiling content/material, (4) making evaluation questions.

Participants

Of the 6 schools where the Introduction to School Field Program (PLP) was implemented in Kupang City, 3 schools where the Introduction to School Field Program (PLP) was implemented were selected based on the criteria of school type, namely public schools. The number of respondents in each high school involved was determined using a random sampling technique, namely 1 student of the School Field Introduction (PLP) program from each school who teaches in grade XI from 3 high schools in Kupang City. The purpose of making this State High School is because the curriculum applied is suitable for research studies and is appropriate for Class XI students who are preparing for the Final Examination.

Data Collection Tools

Data obtained in the field through observation were processed using quantitative analysis. Furthermore, the data were analyzed using the Miles and Huberman method of data reduction (Sugiyono, 2013). The techniques and tools used to collect research data are learning observation sheets. The research data obtained will be analyzed with descriptive statistics and document analysis.

Table 1: Likert Scale Categories

Interval	*Criteria*
3.25 < score ≤ 4.00	Very Good (SB)
2.50 < score ≤ 3.25	Good (B)
1.75 < score ≤ 2.50	Less (K)
1.00 < score ≤ 1.75	(Very Less)

Source: (Widyoko, 2014)

The data analysis procedure is generated from research instruments that use a Likert scale according to table 1:

The formula used to convert the scores obtained into the form of percentage, as follows.

The data obtained is then converted into qualitative criteria in table 2.

Table 2: Percentage Range and Qualitative Criteria

Value	*Range*	*Qualitative Criteria*
1	0 – 20	Very less
2	21 – 40	Less
3	41 - 60	Simply
4	61 - 80	Good
5	81 -100	Very good

Source: (Sugiyono, 2013)

Data Collection

To determine the practicality and effectiveness of the products developed, researchers compiled instruments that have been modified and adjusted to the needs of data collection in this study.

Data Analysis

Data obtained in the field through observation were processed using quantitative analysis. Furthermore, the data were analyzed using the Miles and Huberman method of data reduction (Sugiyono, 2013). The techniques and tools used to collect research data are learning observation sheets. The research data obtained will be analyzed with descriptive statistics and document analysis.

Fundings

This article is expected to provide benefits for many people and the funding will be managed by private individuals.

Discussion

Data obtained from observations of Introduction to School Field (PLP) participants at SMA Negeri 1 were coded F1,

PLP students at SMA Negeri 5 Kupang were coded F2, and PLP students at SMA Negeri 2 were coded F3. TPACK analysis is divided into several aspects, namely, Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK) and Technological Content Knowledge (TCK).

Content Knowledge (CK)

Content Knowledge is knowledge about the subject to be studied or taught (Schmidt, et al., 2009). Content knowledge is also important because this ability determines the specific way of thinking of the discipline in each study. Data from the analysis of content knowledge abilities in three schools obtained an average result of 52.66 in the sufficient category.

In tebel 3 it can be seen that F1 has a score of 55 in the sufficient category, F2 has a score of 45 in the sufficient category, and F3 has a score of 58 in the sufficient category. These results indicate that respondents have the ability to master good material and teach it to students well (Table 3).

Furthermore, all scores of each component in the CK section for all prospective teachers can be seen clearly in table 4. This data shows that the ability of each component is categorized as sufficient with an average score of 2.316 in the less category (Table 4).

Tables 3 and 4 provide an overview of the readiness of prospective Physics teachers in preparing themselves regarding professional competencies related to mastery of the material that will be given to students. Prospective teachers who do not have an understanding of learning content will have difficulty in delivering material and also contextualizing so that the content delivered has relevance to the current conditions of students. Therefore, it can be said that the ability of student content knowledge will have an impact on their abilities or competencies in other fields. Table 3 shows the analysis of CK abilities in physics teacher candidates participating in PLP is still in the sufficient category, this occurs because of the lack of teaching experience of colon teachers, causing the level of understanding of the material to be low. Table 4 shows the same thing as table 3 where the average CK component possessed by prospective physics teachers is still in the insufficient category so that it is necessary to pay attention to the CK category supporting courses to equip physics teacher candidates who will become teachers later.

Table 3. Analysis of CK aspect ability

No.	*Teacher Code*	*CK Score*	*Qualitative Criteria*
1	F1	55	Simply
2	F2	45	Simply
3	F3	58	Simply
Average		52,66	Simply

Pedagogical Knowledge (PK)

Pedagogical knowledge is the ability to manage the classroom, design learning plans, structure appropriate learning experiences, understand learner characteristics, and assessment (Padmavathi, 2017). Pedagogical knowledge describes the general purpose of knowledge in teaching. Teaching ability is a skill that must be developed by teachers in order to be able to manage and organize the class in learning activities and can achieve predetermined goals. The second aspect is Pedagogical Knowledge (PK) or knowledge which includes knowledge of educational objectives, classroom management, curricular planning, and development of lesson plans and management. Analysis of the ability of pedagogical knowledge aspects in three schools has an average of 56 in the Good category. In table 5, it can be seen that F1 has a score of 55 in the Fair category, F2 has a score of 58 in the Fair category, and F3 has a score of 55 in the Fair category. These results indicate that the ability to master learning pedagogy is sufficient (Table 5).

The average ability for each PK indicator for 3 teachers can be seen in Table 6.

Furthermore, all scores of each component in the CK section for all prospective teachers can be seen clearly in table 6. This data shows that the ability of each component is categorized as sufficient with an average score of 2.2 in the less category.

Table 4: Average score of each CK component

No.	*CK Component*	*Average*
1	Mastering the material taught	2
2	Providing relevant examples to improve student understanding	1,78
3	Delivering material logically, clearly and in accordance with the lesson plan	2,5
44	Use up-to-date sources such as books, journals, to increase the knowledge of biology	2,5
55	Use up-to-date sources such as books, journals, to increase your knowledge of biology.	2,8

Table 5: PK aspect ability analysis

No.	*Teacher Code*	*CK Score*	*Qualitative Criteria*
1	F1	55	Simply
2	F2	58	Simply
3	F3	55	Simply
Average		56	Simply

Table 6: Average value of PK components

No.	*CK Component*	*Average*
6	Have a variety of strategies / ways to instill concepts to students	2
7	Using varied assessment methods and techniques	2,6
8	Master and manage the class well	2
9	Taking reflective action to improve learning quality	2,2

In table 5 and table 6 provide an overview of PK skills for prospective teachers, the results of the analysis show results that are in the sufficient and insufficient categories, this is because the teacher colon does not have sufficient teaching experience besides that it is also influenced by changes in the curriculum that occur so that it causes difficulties in adjusting to existing device procedures so that in the process of preparing prospective teachers it is necessary to pay more attention to courses that are in line with curriculum developments.

Technological Knowledge (TK)

Technological Knowledge is the ability to use various kinds of technology both hardware and software, which are simple to digital (Padmavathi, 2017). Tecknological knowledge includes the ability to adapt and learn the latest technology. This ability needs to be owned because of the development and changes in technology that continue to grow. Analysis of technological knowledge abilities in 3 teachers in managing learning tools has an average score of 83 in the very good category. Table 7 shows the value of respondent F1 is 85 in the very good category, F2 is 82 in the very good category, and F3 is 82 in the very good category.

Table 7: Average score of TK aspects

No.	*Teacher Code*	*CK Score*	*Qualitative Criteria*
1	F1	85	Very good
2	F2	82	Very good
3	F3	82	Very good
Average		83	Very good

Furthermore, all the scores of each component in the CK section for all prospective teachers can be seen clearly in table 8. This data shows that the ability of each component is categorized as sufficient with an average score of 3.7 in very good (Table 8).

Table 8: Scores on the TK component

No.	*CK Component*	*Average*
10	Good command of the technology used	4
11	The technology used has an appeal to students	3.8
12	The technology used successfully increased student interest and motivation	4
13	Taking reflective action to improve learning quality	4
13	The technology used is easy to operate	4
14	The technology used is in line with the times	3
15	The technology used is appropriate for the students' level of understanding	3.8
16	Technology used to help solve problems	3.8

Based on the results of data analysis, it shows that the CK component of physics teacher candidates in preparing learning tools is in the very good category, this is because physics teacher candidates are at the age of 20-25 years where the prospective teacher is a millennial generation who is very familiar with information technology.

Technological Content Knowledge (TCK)

Technological Content Knowledge is the ability to use technology to provide learning experiences in accordance with the material (Padmavathi, 2017). Technological Content Knowledge (TCK) is one of the TPACK concepts which is a knowledge concept that is present to explain the three main components of teacher and prospective teacher knowledge (content, pedagogy, and technology). TCK is knowledge about how technology and content influence each other. Teachers and prospective teachers need to create multimedia and understand the concepts in the content with the help of specific technology. Analysis of technological content knowledge ability has an average score of 84 in the very good category. Table 9 shows varying abilities, respondent F1 has a score of 82 in the very good category, respondent F2 has a score of 85 in the very good category, and respondent F3 has a score of 85 in the very good category. Respondents have varying abilities in using technology (Table 9).

Data analysis of the average ability of TCK aspects for the three teachers can be seen in table 10.

Table 9: Average score of TCK aspects

No.	*Teacher Code*	*CK Score*	*Qualitative Criteria*
1	F1	82	Very good
2	F2	85	Very good
3	F3	85	Very good
Average		84	Very good

Furthermore, all the scores of each component in the TK aspect for 3 prospective teachers can be seen in table 10. This data shows that the ability of each component is categorized as sufficient with an average score of 3.4 in the very good category (Table 10).

Table 10: Values on TCK components

No.	*CK Component*	*Average*
17	Technology used is relevant to the material being taught	3, 2
18	The technology used can improve student understanding	3,3
19	Develop student activities and tasks that involve the use of technology	3,8

Based on the results of the analysis in tables 9 and 10, it shows that for the pseudo TCK category, prospective physics teachers do not have a very significant problem, this is due to several factors including:

The age of colon teachers is still between 22 and 25 years old and falls into the millennial category.

Many learning software exist and are free so that the development of ICT-based learning media is very easy to develop.

Technological Pedagogical Knowledge (TPK)

Technology Pedagogical Knowledge is the understanding of using various technologies in learning and practicing the use of technology in various matters related to learning (Padmavathi, 2017). TPK occurs because of the reciprocal relationship between technology and pedagogy. Technology can provide new methods used in the teaching process and can make it easier to apply in learning. Analysis of teacher ability in three schools in the aspect of TPK has an average score of 85%. Respondent F1 has a score of 85% in the sufficient category, F2 has a score of 88% in the good category, and F3 has a score of 82% in the sufficient category.

Furthermore, all the scores of each component in the TK aspect for 3 prospective teachers can be seen in table 12. This data shows that the ability of each component is categorized as sufficient with an average score of 3.7 in the very good category (Table 11).

Table 11: Average score of TPK aspects

No.	*Teacher Code*	*CK Score*	*Qualitative Criteria*
1	F1	85	Very good
2	F2	88	Very good
3	F3	82	Very good
Average		85	Very good

Table 12: Value of the TPK component

No.	*CK Component*	*Average*
20	Using computer applications in Learning	4
21	Select technology that is appropriate to the learning approach and strategy	4
22	Use internet facilities to communicate with students, for example to collect assignments or teaching materials.	3.2

In the TPK category, it shows that the ability of physics teacher candidates is already in the very good category, this shows that physics teacher candidates have been able to understand the concept of applying communication technology in physics learning.

Pedagogical Content Knowledge (PCK)

Pedagogical Content Knowledge is the ability to integrate content understanding with the teaching process. Pedagogical Content Knowledge will help prospective teachers to develop appropriate learning practices according to the characteristics of the material (Nuangchalerm, 2020; Padmavathi, 2017). PCK means more than just being a content expert or knowing general pedagogical guidelines, but rather understanding the particularities of the mutual influence of content and pedagogy. Analysis of the ability of 3 teachers in the PCK aspect has an average value of 83.33% in the very good category. Table 13 shows that respondent F1 has a score of 82% in the Very Good category, F2 has a score of 85% in the Very Good category, and F3 has a score of 83 in the Sangt Baik category. From these data it can be seen that respondents have the ability to present diverse materials (Table 13).

The average ability of each PCK Component of the three subject teachers can be seen in Table 14.

Furthermore, all the scores of each component in the TK aspect for 3 prospective teachers can be seen in table 14. This data shows that the ability of each component is categorized

Table 13: Average score of PCK aspects

No.	*Teacher Code*	*CK Score*	*Qualitative Criteria*
1	F1	82	Very good
2	F2	85	Very good
3	F3	83	Very good
Average		83,33	Very good

as sufficient with an average score of 3.5 in the very good category.

Table 14: Values on TCK components

No.	*CK Component*	*Average*
23	Choosing learning approaches and strategies that are appropriate for the chemistry material being taught	3,8
24	Providing questions to measure students' understanding of the material being taught.	3,2
25	Prepared lesson plans by myself and consulted with the supervisor.	3,6

Based on the analysis of the TCK component in tables 13 and 14, it shows that the TCK category is in a very good category, this is because prospective physics teachers are in a very good category, this is because prospective physics teachers have good technology mastery skills.

Technological Pedagogical and Content Knowledge (TPACK)

Technology Pedagogical Knowledge is the understanding of using various technologies in learning and practicing the use of technology in various matters related to learning (Padmavathi, 2017). TPACK is a framework for understanding and describing the type of knowledge needed by a teacher to streamline pedagogical practices and concept understanding by integrating technology in the learning environment. The TPACK framework also serves as a theory and concept for researchers and educators in measuring the readiness of prospective teachers or teachers in teaching effectively with the use of technology. TPACK will have an impact on teachers given the inseparable relationship of technology, pedagogy and content. The TPACK framework describes the various types of knowledge that teachers need to teach effectively with the help of technology and various complex procedures in the field of knowledge interaction. Analysis of the ability of 3 teachers in the TPACK aspect has an average of 80 in the very good category. Table 15 shows the percentage score of 3 respondents. Respondent F1 has a score of 81 in the sufficient category, F2 has a score of 75 in the good category, and F3 has a score of 84 in the excellent category. From the data it can be seen that the 3 respondents have sufficient mastery of material integration, presentation and use of technology, but there must be maximum efforts in the application in learning so as to improve learning outcomes and student motivation.

Table 15: Average score of TPACK aspects

No.	*Teacher Code*	*CK Score*	*Qualitative Criteria*
1	F1	81	Very good
2	F2	75	Good
3	F3	84	Very good
Average		80	

The results of the average score in the TPACK aspect can be seen in Table 16.

Table 16. Average score of each TPACK component

No.	*CK Component*	*Average*
26	Select learning strategies and technologies that are appropriate to the material chemistry that will be used in learning activities	3.8
27	Integrate biological knowledge, pedagogical knowledge, and technological knowledge to realize effective learning.	3,8
28	Applying appropriate learning strategies and using various computer applications in learning implementation	4

To address identified deficiencies hindering the practical application of findings for educational improvement, a multifaceted approach is required. Strategies such as teacher training and professional development, personalized learning experiences, prioritizing mental health and well-being, and ensuring content-strong staff provide interventions and support can be implemented to enhance the quality of education. Additionally, guest speakers can relate to students and inspire them by describing problems, likes, dislikes, and challenges throughout. Research suggests that blended teaching mode can be improved by addressing deficiencies such as lack of interaction, inadequate feedback, and insufficient support. Traditional grading systems can be improved by separating the feedback component from grades themselves, so that students focus only on the feedback, and by implementing grading practices in ways that are more evidence-based and less reliant on historical practices.

Conclusion

The results obtained on the ability of Content Knowledge (CK) are at a score of 52.66 in the sufficient category, the

ability of Pedagogical Knowledge (PK) is at a score of 56 in the sufficient category, the ability of Technological Knowledge (TK) with a score of 83 in the excellent category, Technological Content Knowledge (TCK) with a score of 84 in the excellent category, Technological Pedagogical Knowledge (TPK) with a score of 85 in the excellent category, Pedagogical Content Knowledge (PCK) with a category of 83.33 and Technological Pedagogical and Content Knowledge (TPACK) with a score of 80 in the excellent category.

Based on the results of the analysis of prospective Physics teachers in developing learning tools, it can be concluded that the ability of prospective teachers to apply technology in the learning process is classified in the very good category.

Suggestion

This research recommends that prospective teachers continue to develop themselves in order to create enjoyable learning. To address identified deficiencies hindering the practical application of findings for educational improvement, a multi-faceted approach is required. Strategies such as teacher training and professional development, personalized learning experiences, prioritizing mental health and well-being, and ensuring content-strong staff provide interventions and support can be implemented to enhance the quality of education. Additionally, guest speakers can relate to students and inspire them by describing problems, likes, dislikes, and challenges throughout. Research suggests that blended teaching mode can be improved by addressing deficiencies such as lack of interaction, inadequate feedback, and insufficient support. Traditional grading systems can be improved by separating the feedback component from grades themselves, so that students focus only on the feedback, and by implementing grading practices in ways that are more evidence-based and less reliant on historical practices.

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