Jurnal Pembelajaran Dan Biologi Nukleus p-ISSN: 2442-9481
Vol 10 (1): 276-293, March 2024 e-ISSN: 2685-7332

Developing a TPACK-Based Question Bank for Biology Education Comprehensive Exam

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Submitted November 06th 2023 and Accepted February 28th 2024

Abstract

Comprehensive exams are administered to assess the abilities and knowledge of students in their respective scientific disciplines. However, the material's scope is quite extensive, particularly in light of the absence of a question bank or grid-based guide. However, advancements in the twenty-first century necessitate that educators possess not only knowledge of subject matter and the learning process but also proficiency in technology. TPACK (Technological Pedagogical Content Knowledge) refers to the amalgamation of stated components. The objective of this research is to develop a valid and practical question bank for biology education comprehensive exam, utilizing the TPACK framework. Research and development (R&D) was employed in accordance with the ADDIE development model. The instruments were validation sheets to determine the validity of the developed question bank and response questionnaires to assess its practicality. The validation sheet was intended for experts in learning evaluation and TPACK, whereas the response questionnaire was intended for students and examining lecturers who delivered comprehensive exams. The research findings indicated that the TPACK-based comprehensive exam question bank that was created exhibited a very high level of validity, as confirmed by 87.92% of learning evaluation experts and 88.69% of TPACK experts. The practicality test yielded a 91.68% passing rate among the examining lecturers and a 96.04% passing rate among the students. This value falls under the category of being extremely practical. Hence, it can be inferred that the developed question bank possesses validity and utility. This question bank aims to assist in preparing comprehensive exams for both students and lecturers, while also serving as a guide for developing TPACK, specifically designed for graduating students in the biology education program.

Keywords: *Evaluation, Prospective teacher, TPACK, Question bank*

https://doi.org/10.36987/jpbn.v10i1.5486

INTRODUCTION

Presently, information and communication technologies are advancing at an extremely rapid rate. This is the consequence of developments that have occurred in the twenty-first

century. The realm of education is not exempt from the ongoing advancements in science and technology, which in turn impact the proficiency of educators. In this era, educators are obligated to cultivate proficient students, with a particular emphasis on the 4C competencies—communication, collaboration, critical thinking, creativity, and problem-solving. Preparing highly skilled individuals with expertise in technological advancements poses a significant challenge in the education sector (Hosnan, 2004; Mutiani et al., 2021)

In order to improve the quality of education and address global challenges effectively, educators must ensure that students are technologically proficient. It is crucial to have educators who have the required skills and expertise in using technology to ensure a seamless teaching and learning experience and the successful accomplishment of established goals. For organizing learning in this manner, an educator needs to have specialized knowledge to effectively package educational content. Integrating pedagogical knowledge and the ability to use technology effectively is essential, alongside having access to learning materials (content) and the skill to design engaging learning experiences (Srisawasdi, 2012). Technological Pedagogical Content Knowledge (TPACK) refers to the amalgamation of these qualities.

Content, pedagogy, and technology are interconnected and intersect in TPACK (Mishra & Koehler, 2006; Niess, 2005). TPACK is also defined as teacher knowledge, abilities, and competencies related to integrating technology in learning activities (Pamuk et al., 2015; Yurdakul & Coklar, 2014). TPACK emphasizes how to effectively integrate technology into the learning process as opposed to the utilization of technology itself (Alqurashi et al., 2017; Kereluik et al., 2011). TPACK encompasses a comprehensive comprehension of the intricate and dynamic interrelationships that occur when technology influences teaching and learning, as well as how specific concepts, subjects, or material are represented and communicated to students (Chien et al., 2012).

There are three primary components and four combined components that comprise the TPACK framework. Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK) are the primary components. Effective teaching requires the integration of these elements (M. J. Koehler & Mishra, 2016), particularly in the twenty-first century (Loseñara & Jugar, 2023). Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical and Content Knowledge (TPACK) are the four components that comprise the integration of these primary components. These seven essential elements encompass a comprehensive understanding of all facets of learning, including mastery of subject matter concepts, pedagogical expertise, and the utilization of technology to facilitate students' comprehension of a given idea. TPACK serves as an indicator for attaining the status of a professional educator by reflecting two of the professional teacher competencies outlined in Law No. 14 of 2005 concerning teachers and lecturers—namely pedagogical competence and professional competence.

The formation of teacher TPACK begins with the Institute for Educators and Education Personnel (LPTK), which produces prospective lecturers, including biology teachers (Mutiani et al., 2021). To meet current demands, the study program within the LPTK also contributes to developing graduates' profiles focused on TPACK. This aligns with the teacher professional education program (PPG), where its curriculum adheres to the principles of an activity-based approach. This includes workshops focused on

developing teaching materials, which embody the TPACK framework (Sativa et al., 2023). In addition to incorporating TPACK into the learning process, learning evaluations should take the form of comprehensive exams of study programs, with a particular emphasis on biology education (Supriyatno et al., 2020).

Comprehensive exams are carried out in order to measure students' abilities and mastery of their scientific fields. This exam is carried out by students who have completed all the courses in their program (Guloy et al., 2020). Comprehensive exams in the biology education study program at UIN Sumatra Utara Medan take place verbally and face-to-face between students and examining lecturers consisting of four people with different test fields. The fields tested include religion I (basics of the Islamic religion), religion II (integration of biology with Islam), education I (general education), and education II (biology material). The material tested in the comprehensive exam covers all subjects according to the study program curriculum, which means that the scope of material that prospective teacher students need to study is quite extensive. Generally, examining lecturers ask questions randomly without any specific guidance or indicators. This makes students feel anxious (DiPietro et al., 2010) and have difficulty preparing for comprehensive exams because the material is too broad. This has an impact on the success of prospective teacher students in completing their exams.

To overcome this, there needs to be a guide regarding grids that can be a reference for students and lecturers in carrying out comprehensive exams so that comprehensive exams can be more focused. Therefore, this research aims to produce a valid and practical TPACK-based question bank for biology education comprehensive exam. This question bank aims to facilitate students and lecturers in preparing for comprehensive exams, while also focusing on developing TPACK for students graduating from the biology education study program.

METHOD

This research was conducted from April to August 2023 at UIN Sumatera Utara Medan. The research subjects were eighth semester students of biology education study program who took a comprehensive exam. This research employed a Research and Development (R&D) approach by applying the ADDIE model (Figure 2).

The research and development procedures for question banks refer to the five stages of ADDIE, namely: analyze, design, develop, implement, and evaluate. Furthermore, the data collection technique was conducted by interview guidelines for examining lecturers and students who took comprehensive exams as a needs analysis, validation sheets from learning evaluation experts and TPACK experts to obtain validity data, as well as lecturer and student response questionnaires to obtain practicality data. Validity and practicality are determined using a Likert scale with the conditions in Table 2.

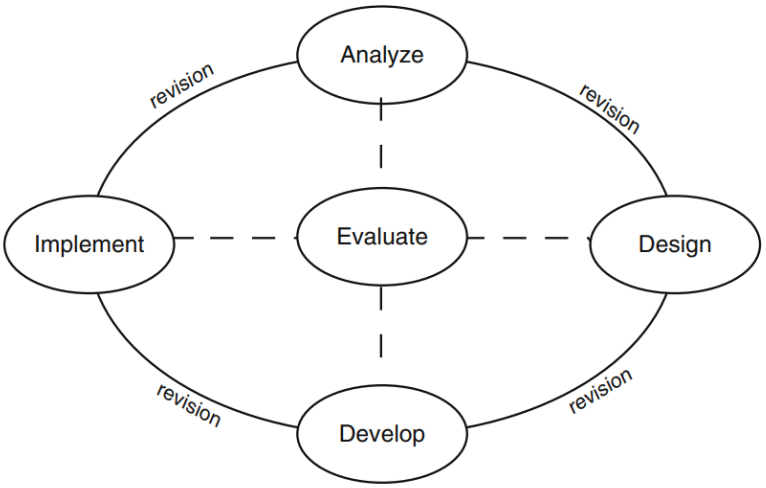


Figure 2. ADDIE model (Branch, 2009)

Table 2. Validity and practicality test assessment scale categories

Score	Category
1	Not valid
2	Less valid
3	Valid
4	Very valid

Filling in the validation sheet and response questionnaire was done by signing a check list mark (√) to each statement on the assessment criteria according to the score given. And the validity and practicality test results were calculated from the average score of all aspects assessed using the following formula.

$$P = \frac{\sum X}{\sum Xi} X\ 100\% \quad (1)$$

Information:
P = Validity percentage
∑X = Number of validator scores
∑Xi = The total number of ideal scores (Sudijono, 2009)

Before calculating the percentage results, calculating the ideal score using the following formula was presented as follows.

$$K = \sum BP\ X\ L \quad (2)$$

Information:
K = Criteria (ideal score)
∑BP = Number of questions
L = Maximum Likert scale score (Jaya, 2013)

Then, the gained percentage is interpreted using the criteria as shown in Table 3.

Table 3. Interpretation of product validity and practicality test results

Percentage (%)	Information	Follow-up
76 – 100	Very valid; Very practical	A new product is ready to be used in learning
51 – 75	Valid; Practical	The product needs to be revised on a scale that is not too large and not basic
26 – 50	Less Valid; Less Practical	The product needs to be revised carefully and carefully by examining the weaknesses in the product
0 – 25	Not Valid; Not Practical	The product needs to be revised on a large scale and fundamentally

(Source: Fitriyana et al., 2021)

RESULTS AND DISCUSSION

The results of the research and development of a valid and pratical TPACK-based question bank for comprehensive exam of biology education study program are described as follows.

ANALYZED

The analysis is carried out to identify specific needs in developing a comprehensive exam question bank. Identification of these needs becomes the basis for designing and developing an appropriate question bank. The results of the needs analysis through observations and interviews with examining lecturers and students who have taken comprehensive exams obtained results including:

a. The scope of material to be studied is too broad so students find it difficult to learn it
b. There are no specific guidelines for the comprehensive exam
c. The students focus solely on questions frequently posed by the examining lecturer in past comprehensive exams as study material. However, there is no assurance that these questions will be included when when it is the turn of other students to take the exam.
d. Examining lecturers must prepare a suitable set of questions themselves to be tested on students. There is concern that this could cause the questions prepared by the examining lecturer to only focus on the lecturer's area of expertise, not evenly distributed to other material.
e. Lecturers do not have consistency in giving equal questions to each student, which can lead to different assessment standards (unfairness in assessment).

In addition to the aforementioned concerns, the outcomes of the needs analysis indicate that an assessment of the responses provided by students subsequent to comprehensive examinations is imperative. This can assist students in avoiding misconceptions and preventing them from misinterpreting the material. Additionally, a question bank that can assist lecturers or students in administering comprehensive exams is required (Hambleton & Swaminathan, 2013). The presence of a question bank will facilitate the assessment of graduates' competency achievement goals by teachers in accordance with the profile of study program graduates. Aside from that, Choppin explained in Latuconsina & Yunanto (2017) that parallel tests can be created using a

question bank, and results can be compared since the abilities of the test taker can be measured on the same scale.

Based on this, steps were taken to identify the need for question sources that would be used in developing a product in the form of a question bank. Identification refers to the biology education study program curriculum and analysis of learning outcomes for each study program subject. The analysis results are also adjusted for aspects of TPACK framework.

DESIGN

The next stage was to design the product based on the results of the previous analysis. Mapping the courses for which the questions will be created initiated this stage. The courses that are included in the scope of this question bank development are biology education study program courses, which are included in the fields of education I and education II studies (Table 4).

Table 4. Details of course coverage in the question bank developed

Education I	Education II
1. Study of the Madrasah/School Biology Curriculum 2. Biology Learning Strategy 3. Developing Biology Learning Media and Resources 4. Biology Learning Planning 5. Evaluation of Biology Learning	1. General biology 2. Laboratory Techniques 3. Zoology (Invertebrates & Vertebrates) 4. Botany (Cryptogamae & Phanerogamae) 5. Population and Environmental Education 6. Biochemistry 7. Physiology (Animals & Plants) 8. Ecology (Animals & Plants) 9. Cell Biology 10. Human Anatomy and Physiology 11. Reproduction and Embryology (Animals & Plants) 12. Genetics 13. Biotechnology 14. Evolution 15. Entomology 16. Microbiology

Furthermore, a draft of question bank is created based on course learning outcomes (CPMK). The question indicators do not only refer to CPMK but also TPACK aspects. The design of the question bank was made systematically starting from the cover, foreword, table of contents, instructions for using the question bank, criteria for comprehensive exam results, and questions grouped according to courses. The question bank was also accompanied by an assessment rubric which was created as a reference for lecturers in giving scores to students being tested (found on Table 5).

Experts in learning evaluation and TPACK received a validation sheet, which was served as the constructed validity measurement instrument. The TPACK expert validation sheet comprises material, construction, and TPACK aspects, whereas the learning evaluation expert validation sheet comprises material, construction, and language aspects. Researchers developed a response questionnaire as a practicality measurement instrument and distributed it to examining lecturers and students

administering comprehensive examinations to assess the test's practicality. The response questionnaire comprises elements pertaining to material, construction, language, and implementation.

Table 5. Question bank assessment rubric

Score	Description
85 – 100	The question bank consists of correct and accurate answers, the order of presentation of answers is coherent and systematic, in accordance with the questions given.
75 – 84	The question bank's answers are precise and accurate, the order of presentation of answers is less coherent and less systematic, according to the questions given.
65 – 74	The question bank's answers are less precise and less accurate, the order of presentation of the answers is less coherent and less systematic, according to the questions given.
55 – 64	The question bank's answers are less precise and less accurate, the order of presentation of the answers is less coherent and less systematic, and does not match the question given.
0 – 54	The question bank does not have any suitable answers, the answers do not match the questions given.

(Source: Tim Penulis, 2022)

DEVELOPMENT

The development results of the question bank product design were determined by the following specifications,

a. The question bank was prepared on UNESCO paper size (15.5 x 23 cm) with cambria type, writing size 10, spacing 1, and portrait orientation.
b. The structure of the question bank consisted of a cover (Figure 3A), foreword, table of contents (Figure 3B), instructions for using the question bank, criteria for comprehensive exam results, and questions divided into each course (Figure 4) and grouped according to field of educational I and education II. This involves determining the content or information that will be conveyed in the product. Apart from that, the product structure is also adapted to the development goals and needs of biology students.
c. The preparation of the questions was designed in the form of essay questions with 10 questions for each course. As a consideration for making questions, questions from the mid-semester and final semester exams were also analyzed. This step was followed by creating an assessment rubric based on guidelines from the faculty's academic book (Tim Penulis, 2022).

The question bank was validated by learning evaluation experts and TPACK experts. The data obtained comes from giving scores on the validation sheet with a scale range of 1-4. The validation sheet was given indirectly (online) to learning evaluation experts, specifically biology education lecturers at UIN Raden Mas Said Surakarta, and given directly to TPACK experts who are biology education lecturers at Universitas Negeri Medan.

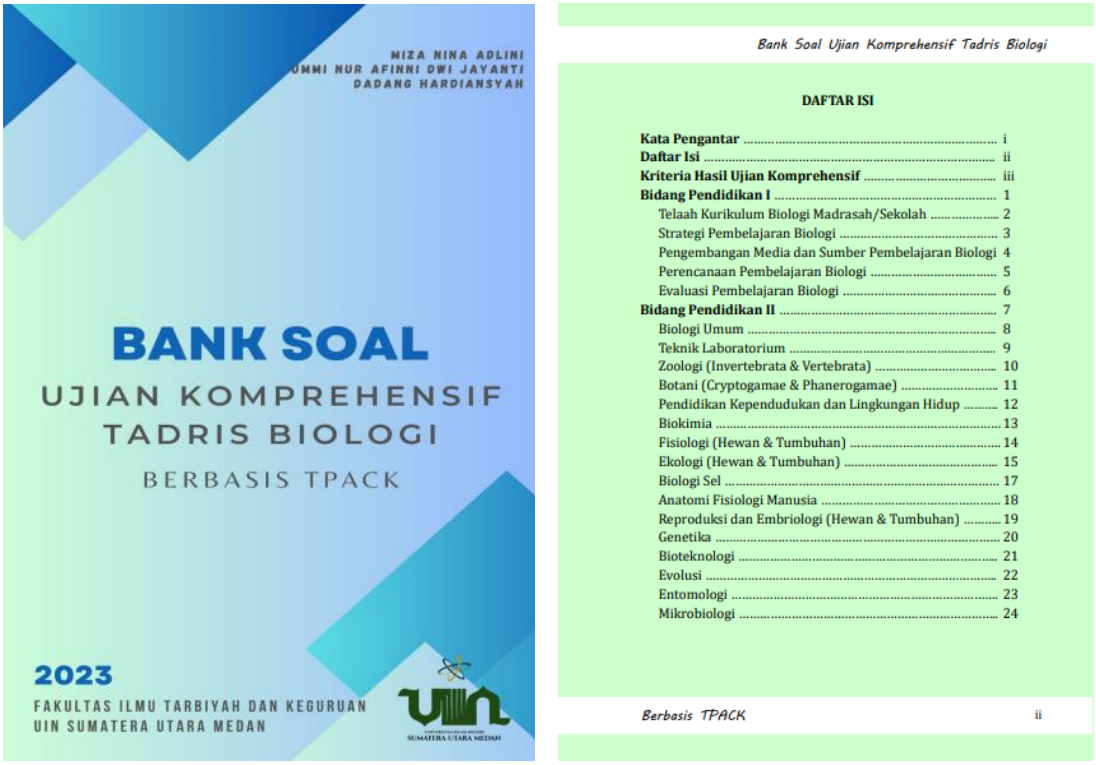
The assessment results from each validator as quantitative data are described as follows.

Learning evaluation expert validator

The learning evaluation expert's assessment of product quality yields 15 evaluation criteria comprised of three review aspects: construction, material, and language. Table 6 contains a summary of the question bank assessment results as reported by learning evaluation expert validators. Based on the results of the assessment carried out by learning evaluation experts in Table 5, the average product percentage value was 88.69%. This value shows that the question bank developed from the learning evaluation aspect meets the very valid category. Based on comments from learning evaluation expert validators, this question bank product is suitable for implementation after revising several questions that are not suitable.

Table 6. Question bank validation results by learning evaluation experts

No.	Rated aspect	Number of Indicators	Maximum Score	Score (%)	Category
1	Material	7	28	78.57	Very valid
2	Construction	4	16	87.5	Very valid
3	Language	4	16	100	Very valid



(A) (B)

Figure 3. (A) Question bank cover; (B) Table of contents of the question bank

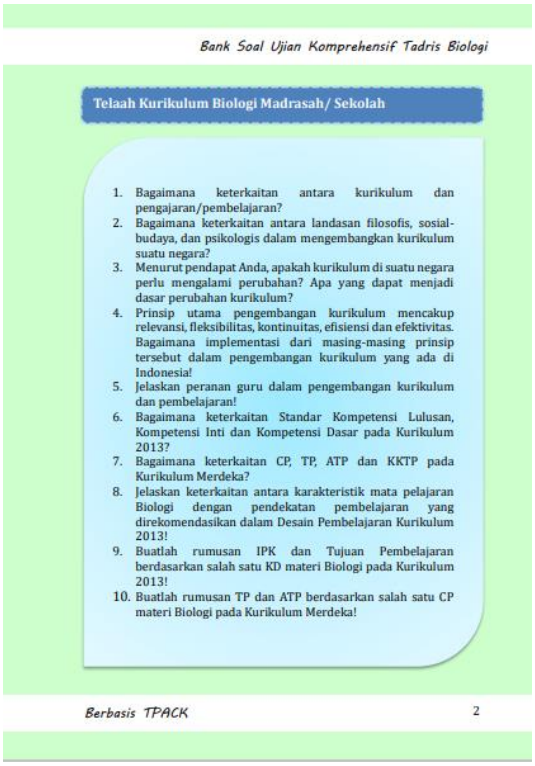


Figure 4. Display of question structure

TPACK expert validators

The results of the TPACK expert's assessment of product quality include 14 assessment criteria with 3 review aspects, namely material, construction and TPACK. A recapitulation of the question bank assessment results by TPACK expert validators can be seen in Table 7.

Table 7. Question bank validation results by TPACK experts

No.	Rated Aspects	Number of Indicators	Maximum Score	Score (%)	Category
1	Material	6	24	100	Very valid
2	Construction	4	16	93.75	Very valid
3	Language	4	16	100	Very valid

Based on the results of the assessment carried out by TPACK experts in Table 7, the average product percentage value was 97.92%. This value shows that the question bank developed from the TPACK aspect meets the very valid category. Based on comments from TPACK expert validators, this question bank product is suitable for implementation after revising several question adjustments to the appropriate TPACK aspects. Meanwhile, comments and suggestions from validators, learning evaluation experts and TPACK experts became qualitative data in this research. Comments and suggestions from validators regarding the question bank are listed in Table 8.

Table 8. Comments and suggestions for validating the question bank

No	Validator	Comments and Suggestions from Validators	Revision Results
1	Learning evaluation expert	- Certain questions are inappropriate and incapable of assessing sub-CPMK. Questions should be able to measure sub CPMK, at least according to the sub CPMK level. - The question bank should be more thorough in determining CK and PCK aspects. - The question bank should use one verb in formulating sub-CPMK.	- The operational verbs in the questions have been adjusted to a cognitive level that is equal to or higher than the CPMK sub. - The determination of the CK and PCK aspects in the questions has been adjusted - The sub CPMK has been corrected to only use one verb
2	TPACK expert validators	- For biology learning strategy questions No. 9 can enter the realm of TPACK, question No. 10 can enter the PCK realm because the biology teacher mentioned it. - For Biology Learning Planning questions, Question No. 8 and 9 include TPACK.	- The TPACK aspect of the questions has been adjusted - The TPACK aspect of the questions has been adjusted

IMPLEMENTATION

At this stage, the TPACK-based question bank that has been validated was then tested on a small scale to test its practicality. The instrument used is a response questionnaire consisting of material, construction, language, and implementation aspects. Valid question banks and response questionnaires are given to examining lecturers and students who carry out comprehensive exams. The results of the practical test assessment by the examining lecturers and students as quantitative data are described as follows:.

Practicality test by examining lecturer

The results of the examining lecturer's assessment of the practicality of the product are divided into 18 assessment criteria with 4 review aspects, namely material, construction, language and implementation. A recapitulation of the results of the question bank practicality assessment by the examining lecturers can be seen in Table 9.

Table 9. Summary of the results of the question bank practicality test by the examining lecturer

No.	Rated Aspects	Examining Lecturer	Value from Examining Lecturers (%)	Average Value (%)	Category
1	Material	DP1	96.43	92,14	Very practical
		DP2	100		
		DP3	75		
		DP4	100		
		DP5	89.28		
2	Construction	DP1	87.50	86,25	Very practical
		DP2	93.75		
		DP3	75		
		DP4	87.50		
		DP5	87.50		
3	Language	DP1	100	95	Very practical
		DP2	100		
		DP3	75		
		DP4	100		
		DP5	100		
4	Implementation	DP1	100	93,33	Very practical
		DP2	100		
		DP3	75		
		DP4	100		
		DP5	91,67		

The examining lecturer in Table 8 carried out the response questionnaire assessment, revealing an average product percentage value of 91.68%. This value indicates that the question bank developed fits the very practical category.

Table 10. Summary of the results of the question bank practicality test by students

Rated Aspects	Student	Value from Student (%)	Average Value (%)	Category
Material	M1	91.67	93.34	Very practical
	M2	100		
	M3	91.67		
	M4	91.67		
	M5	91.67		
Construction	M1	100	97.5	Very practical
	M2	87.5		
	M3	100		
	M4	100		
	M5	100		
Language	M1	100	100	Very practical
	M2	100		
	M3	100		
	M4	100		
	M5	100		

Implementation	M1	100	93.33	Very practical
	M2	91.67		
	M3	100		
	M4	83.33		
	M5	91.67		

Practicality test by students

The results of student assessments regarding product practicality are divided into 9 assessment criteria with 4 aspects of study, namely material, construction, language and implementation. A recapitulation of the results of the question bank practicality assessment by students can be seen in Table 10. Based on the results of the response questionnaire assessment carried out by students in Table 9, the average product percentage value was 96.04%. This value shows that the question bank developed meets the very practical category. Meanwhile, the qualitative data for the practicality assessment were comments and suggestions provided by examining lecturers and students regarding the question bank being developed. The comments and suggestions given included clearer instructions regarding the use of question banks.

EVALUATION

As a form of evaluation, a Forum Group Discussion (FGD) was carried out by inviting expert speakers on TPACK and learning evaluation, also including all lecturers who taught biology education study programs. This activity wass carried out by discussing and receiving input from resource persons and course lecturers regarding the question bank that has been created. From the FGD, the following results were obtained:

a. The question bank grid was created in one table containing the course name, TPACK aspect, sub-CPMK, and question indicators
b. The seven aspects of TPACK had to be present in the entire question bank. These seven aspects did not have to be fulfilled in just one course, but can be spread across other courses
c. The preparation of an assessment rubric containing specific answers for each question could be discussed with each course lecturer.

Based on those points above, improvements had been made to the question bank so that a valid and practical resource for lecturers and students to utilize during comprehensive exams. After completing all the improvements, the question bank could be socialized to seventh semester students who are preparing for the comprehensive exam. This socialization activity includes the presentation and provision of a TPACK-based comprehensive biology exam question bank so it can be a reference for students in carrying out comprehensive exams later. With this question bank, it is hoped that students can prepare themselves optimally to take the comprehensive exam.

Discussion

As a result of this development research, a valid and practical biology education TPACK-based question bank has been produced. The primary objective of the comprehensive examination is to conduct a meticulous assessment of the scientific

proficiencies that are mandatory for aspiring teacher candidates to acquire throughout their academic careers (Mardianto, 2021). By ensuring that the exam material covers all mandatory subjects and gauging the preparedness of prospective teacher students to transition into the profession, the question bank was created. A question bank was formulated in alignment with the biology study program curriculum, which is predicated on course learning outcomes and the evaluation of abilities in accordance with established standards, through a comprehensive examination of the curriculum and relevant learning standards. The purpose of this question bank is to assist examining lecturers and prospective biology teacher students in their preparation for the comprehensive examination.

The objective of creating a comprehensive exam question bank based on TPACK is to aid in the assessment of prospective teacher students' preparedness and competence in administering comprehensive exams. TPACK orientation is a response to the challenges of the twenty-first century, particularly the impact of technology-driven tools like artificial intelligence on TPACK (Mishra et al., 2023). This approach serves to reinforce and enhance the integration of technology in the educational process (Kartal & Çınar, 2022). Moreover, it ensures the long-term viability of the PPG program. Teachers must possess technological proficiency (Weidlich & Kalz, 2023), along with expertise in pedagogy and subject matter.

The integration of TPACK in the development of a comprehensive exam question bank has important implications for the competency of students in the biology education study program,

a. Measurement of deeper understanding

The integration of TPACK into the development of a comprehensive exam question bank enables students to measure their deeper understanding of the knowledge they have acquired while following the lecture program. By combining content, pedagogical, and technological knowledge, exam questions can be designed to test student understanding holistically. This means students are not only tested on memorized facts or information but also on their ability to apply concepts in different contexts.

b. Consistency and uniformity

The existence of a question bank ensures that the questions asked in the comprehensive exam are of a consistent standard and reflect the desired curriculum objectives (Latuconsina & Yunanto, 2017). Consistency refers to consistency in the formulation and presentation of questions in the question bank. This means that the questions in the question bank must be arranged and formulated in a uniform way. This includes the use of clear, easy-to-understand language and a consistent question format. For example, using a uniform language style, using a consistent format in terms of the types of questions in the form of essay questions that are answered orally. Then uniformity, of course, relates to the extent to which the questions in the question bank measure similar criteria and have an equivalent level of difficulty. This ensures that each question is of a balanced level of difficulty and complexity and covers a wide range of relevant aspects of the material being tested.

By maintaining consistency and uniformity in the question bank, positive things can be achieved, including: 1) ensuring that all students are tested to the same standards so that evaluation results are more controlled; 2) reducing the risk of questions that are ambiguous or not in accordance with the evaluation objectives; 3) providing representation that is balanced and complete regarding what students have learned during lectures; and 4) facilitating the process of analyzing and interpreting comprehensive exam results.

c. Maximum preparation

With a question bank, students can prepare better, understand expectations, and focus their learning on TPACK concepts. By providing a TPACK-based question bank or information about the types of questions that may be asked, students can understand evaluation expectations. This does not mean providing answers or questions before the exam, but rather giving a general idea of the types of questions or topics that may arise.

On the other hand, comprehensive exams often raise concerns for students. Understanding the structure and focus of the exam can help relieve anxiety and allow students to better prepare mentally and emotionally. When students understand that TPACK is the primary focus of evaluation, they can develop and implement learning strategies that target specific aspects of TPACK. This includes collaborative learning, the use of particular technology, or the exploration of other relevant educational resources. Understanding the importance of TPACK allows students to reflect on their learning experiences in the context of TPACK (Nilsson, 2022). They can see how technology, pedagogy, and content interact in their own learning experiences (Mishra & Koehler, 2006) and integrate those understandings into their preparation for exams.

d. Fair evaluation

A fundamental component of any educational evaluation system is the implementation of a fair evaluation process. This practice guarantees that every student is afforded an equitable chance to showcase their comprehension and capabilities, devoid of prejudice or superfluous obstacles. To ensure a just assessment, the standards or criteria utilized for evaluation must be explicit and precisely defined. This guarantees that students are cognizant of the requirements and the methods by which they will be evaluated. As previously stated, a consistent question bank guarantees that all students, irrespective of the time or location of the examination, are evaluated according to the same benchmark. It is critical to guarantee the absence of cultural, gender, age, and other forms of prejudice in exam questions.

It is essential that the design of questions be objective, with no preference or disadvantage shown to any specific student group. An equitable evaluation process accounts for the unique requirements of each student, thereby guaranteeing an equivalent chance for them to showcase their capabilities. A fair evaluation entails more than mere grading; it also entails offering students constructive feedback. Students can identify and comprehend their areas for improvement with the assistance of constructive criticism. Such feedback enables them to recognize and address their areas of weakness. An equitable representation of the learning material should be found in the question bank. This entails ensuring that no subject is overshadowed or

disregarded, thereby permitting students to be evaluated on the comprehensive range of material that has been instructed.

Fair evaluation in the context of TPACK entails that students are not solely judged on their content knowledge but also on their ability to integrate technological and pedagogical approaches within that context. It is essential that assessments account for the multifaceted and varied nature of the connections that exist among technology, pedagogy, and content while also providing every student with an equitable chance to exhibit their comprehension and proficiency in each of these domains.

e. Improved evaluation quality

Developing a question bank with pedagogical, technological, and content-aware considerations in mind can enhance the evaluation process and guarantee that the examination accurately assesses the intended proficiencies. Enhancing quality guarantees not only that evaluation instruments are valid and reliable but also that they remain pertinent, up-to-date, and conducive to facilitating the intended learning outcomes. Denotes the degree to which a given test item assesses the construct it claims to evaluate. This means that, within the framework of TPACK, questions should assess students' comprehension of the interrelationships and mutual reinforcements between technology, pedagogy, and content.

Exam questions must assess the extent to which students comprehend, implement, and integrate content, pedagogy, and technology in their learning practices. This guarantees that the assessment genuinely mirrors the intended learning outcomes and offers a precise evaluation of the students' level of proficiency.

f. Feedback for the program

Using specific question banks can provide feedback to educational programs, in this case the biology study program, about which areas may require more attention or emphasis in the curriculum. In this case, it is important to note that TPACK is included in the learning process so that students get used to using TPACK not only during comprehensive exams.

CONCLUSION

Based on the findings of the research, it can be inferred that the developed comprehensive exam question bank, which is TPACK-based, possesses a validity percentage of 97.92% according to TPACK experts and 88.69% according to experts in learning evaluation. This places the bank in a very valid category. The practicality test outcomes, as assessed through a response questionnaire, revealed that 96.04% of students and 91.68% of examining lecturers categorized the material as highly practical. With the inclusion of religious topics, it is hoped that additional research will contribute to the development of a comprehensive exam question bank.

ACKNOWLEDGMENTS

We would express our gratitude to UIN Sumatera Utara Medan, generously supported this research, with a special acknowledgement to the Faculty of Education and Teacher Training. Additionally, we would like to extend our gratitude to the biology education lecturers and students who assisted in the execution of this study.

REFERENCES

Alqurashi, E., Gokbel, E. N., & Carbonara, D. (2017). Teachers' knowledge in content, pedagogy and technology integration: A comparative analysis between teachers in Saudi Arabia and United States. *British Journal of Educational Technology*, *48*(6), 1414–1426. https://doi.org/10.1111/bjet.12514

Branch, R. M. (2009). *Instructional Design*. Springer. 120p

Chien, Y.-T., Chang, C.-Y., Yeh, T.-K., & Chang, K.-E. (2012). Engaging pre-service science teachers to act as active designers of technology integration: a Magdaire framework. *Teaching and Teacher Education*, *28*(4), 578–588. https://doi.org/10.1016/j.tate.2011.12.005

DiPietro, J. C., Drexler, W., Kennedy, K., Buraphadeja, V., Liu, F., & Dawson, K. (2010). Using Wikis to Collaboratively Prepare for Qualifying Examinations: *TechTrends*, *54*(1), 25–32. https://doi.org/10.1007/s11528-009-0360-0

Fitriyana, Z. N., Mailizar, M., & Seruni, S. (2021). Pengembangan Modul Pembelajaran Matematika dengan Pendekatan Matematika Realistik. *Jurnal Kajian Pendidikan Matematika)*, *6*(2), 279–292. http://journal.lppmunindra.ac.id/index.php/jkpm/

Guloy, S., Hum, G., & O'Neill, D. K. (2020). Voices at the gate: Faculty members' and students' differing perspectives on the purposes of the PhD comprehensive examination. *Assessment & Evaluation in Higher Education*, *45*(2), 279–291. https://doi.org/10.1080/02602938.2019.1637819

Hambleton, R. K., & Swaminathan, H. (2013). *Item Response Theory: Principles and Applications*. Springer.

Hosnan, M. (2004). *Pendekatan Saintifik dan Kontekstual dalam Pembelajaran Abad 21: Kunci Sukses Implementasi Kurikulum 2013*. Ghalia Indonesia.

Jaya, I. (2013). *Penerapan Statistik untuk Pendidikan*. Citapustaka Media Perintis.

Kartal, B., & Çınar, C. (2022). Preservice mathematics teachers' TPACK development when they are teaching polygons with geogebra. *International Journal of Mathematical Education in Science and Technology*, 1–33. https://doi.org/10.1080/0020739X.2022.2052197

Kereluik, K., Mishra, P., & Koehler, M. J. (2011). On Learning to Subvert Signs: Literacy, Technology and the TPACK Framework. *The California Reader*, *44*(2), 12–18. http://tpack.org/

Koehler, M. J., & Mishra, P. (2016). *Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators* (M. C. Herring, M. J. Koehler, & P. Mishra (eds.)). Routledge. https://doi.org/10.4324/9781315771328

Koehler, Matthew J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record*, *108*(6), 1017–1054.

Latuconsina, N. M., & Yunanto, P. W. (2017). Pembuatan Bank Soal Dan Analisis Butir Soal Mata Kuliah Kriptografi Untuk Mahasiswa Program Studi Pendidikan Teknik Informatika Dan Komputer Universitas Negeri Jakarta. *PINTER : Jurnal Pendidikan Teknik Informatika Dan Komputer*, *1*(2), 142–145. https://doi.org/10.21009/pinter.1.2.7

Loseñara, J. M., & Jugar, R. R. (2023). Technological, pedagogical, and content knowledge of diploma in professional education graduates teaching biology. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *9*(1), 1–14. https://doi.org/10.22219/jpbi.v9i1.24070

Mardianto. (2021). *Buku Panduan Komprehensif PGMI FITK UIN Sumatera Utara Medan*.

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record: The Voice of Scholarship in Education*, *108*(6), 1017–1054. https://doi.org/10.1177/016146810610800610

Mishra, P., Warr, M., & Islam, R. (2023). TPACK in the age of ChatGPT and Generative AI. *Journal of Digital Learning in Teacher Education*, *39*(4), 235–251. https://doi.org/10.1080/21532974.2023.2247480

Mutiani, M., Supriatna, N., Abbas, E. W., Rini, T. P. W., & Subiyakto, B. (2021). Technological, Pedagogical, Content Knowledge (TPACK): A Discursions in Learning Innovation on Social Studies. *The Innovation of Social Studies Journal*, *2*(2), 135. https://doi.org/10.20527/iis.v2i2.3073

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education*, *21*(5), 509–523. https://doi.org/10.1016/j.tate.2005.03.006

Nilsson, P. (2022). From PCK to TPACK - Supporting student teachers' reflections and use of digital technologies in science teaching. *Research in Science & Technological Education*, 1–25. https://doi.org/10.1080/02635143.2022.2131759

Pamuk, S., Ergun, M., Cakir, R., Yilmaz, H. B., & Ayas, C. (2015). Exploring relationships among TPACK components and development of the TPACK instrument. *Education and Information Technologies*, *20*(2), 241–263. https://doi.org/10.1007/s10639-013-9278-4

Sativa, F. E., Musaddat, S., Wira, L., Amrullah, Z., Dwi, A., Wahab, A., & Artikel, R. (2023). Pofil kemampuan TPACK mahasiswa PPG dalam jabatan kategori 1 jenjang PAUD. *JMP (Jurnal Mutiara Pendidikan)*, *3*(2). https://jurnalfkip.unram.ac.id/index.php/JMP/index

Srisawasdi, N. (2012). The Role of TPACK in Physics Classroom: Case Studies of

Preservice Physics Teachers. *Procedia - Social and Behavioral Sciences*, *46*, 3235–3243. https://doi.org/10.1016/j.sbspro.2012.06.043

Supriyatno, T., Susilawati, S., & Hassan, A. (2020). E-learning development in improving students' critical thinking ability. *Cypriot Journal of Educational Sciences*, *15*(5), 1099–1106. https://doi.org/10.18844/cjes.v15i5.5154

Tim Penulis. (2022). *Buku Panduan Akademik FITK UINSU Tahun Ajaran 2022/2023*. Pusdikra.

Weidlich, J., & Kalz, M. (2023). How well does teacher education prepare for teaching with technology? A TPACK-based investigation at a university of education. *European Journal of Teacher Education*, 1–21. https://doi.org/10.1080/02619768.2023.2243645

Yurdakul, K. I., & Coklar, A. N. (2014). Modeling preservice teachers' TPACK competencies based on ICT usage. *Journal of Computer Assisted Learning*, *30*(4), 363–376. https://doi.org/10.1111/jcal.12049

How To Cite This Article, with *APA style* :

Adlini, M.N., Jayanti, U.N.A.D., Hardiansyah, D., & Tanjung, I.F. (2024). Developing a TPACK-Based Question Bank for Biology Education Comprehensive Exam. *Jurnal Pembelajaran dan Biologi Nukleus*, 10(1), 276-293. https://doi.org/10.36987/jpbn.v10i1.5486

Conflict of interest : The authors declare that they have no conflicts of interest.

Author contributions : All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was submited by [**Miza Nina Adlini**]. All authors contributed on previous version and revisions process of the manuscript. All authors read and approved the final manuscript.