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Practicality test of SaLDI biology learning model integrated with TPACK on biology materials

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Abstract

The existing learning models in biology education still have limitations in practically integrating technology, pedagogy, and content, often resulting in passive student learning and suboptimal critical thinking development. Therefore, it is necessary to explore and test the feasibility of biology learning models, specifically TPACK-integrated SaLDI biology learning model, in creating active and student-centred biology learning that aligns with the demands of the 21st century. The purpose of this study was to test the practicality of the SaLDI learning model integrated with TPACK. This type of research is descriptive quantitative which tests the practicality of the TPACK-integrated SaLDI biology learning model. The population in this study were all students and teachers who participated in Biology learning at SMAN 14 Makassar which became the research location. The sampling technique used was random sampling, as many as 32 students and 2 teachers. The instrument used was student and teacher response questionnaire. The instrument that has been developed is used to collect data on the practicality of the TPACK-integrated SaLDI biology learning model. The data generated was then analysed quantitatively. Based on the results of the study, it can be seen that the practicality of the TPACK-integrated SaLDI learning model, as viewed from the perspective of teachers and students, is very practical. The conclusion of this study is that this learning model is very practical to use by teachers and students. This practicality encourages more effective, interactive, and adaptive Biology learning. The suggestion of this research is that it is still necessary to test the implementation of the TPACK-integrated SaLDI learning model on a wider scale.

Abstrak. *Model pembelajaran yang ada dalam pendidikan biologi masih memiliki keterbatasan dalam mengintegrasikan teknologi, pedagogi, dan konten secara praktis, seringkali mengakibatkan pembelajaran peserta didik yang pasif dan pengembangan pemikiran kritis yang kurang optimal. Oleh karena itu, perlu untuk mengeksplorasi dan menguji kelayakan model pembelajaran biologi dalam hal ini adalah SaLDI yang terintegrasi dengan TPACK dalam menciptakan pembelajaran biologi yang aktif dan berpusat pada peserta didik sesuai dengan tuntutan abad ke-21. Tujuan dari penelitian ini adalah untuk menguji kepraktisan model pembelajaran SaLDI terintegrasi TPACK. Jenis penelitian ini adalah kuantitatif deskriptif yang menguji kepraktisan model pembelajaran Biologi SaLDI terintegrasi TPACK. Populasi dalam penelitian ini adalah seluruh peserta didik dan guru yang mengikuti pembelajaran Biologi di SMAN 14 Makassar yang menjadi lokasi penelitian. Teknik pengambilan sampel yang digunakan yaitu random sampling, sebanyak 32 peserta didik dan 2 guru. Instrumen yang digunakan adalah angket respon peserta didik dan guru. Instrumen yang telah dikembangkan digunakan untuk pengumpulan data kepraktisan model pembelajaran Biologi SaLDI terintegrasi TPACK. Data yang dihasilkan kemudian dianalisis secara kuantitatif. Berdasarkan hasil penelitian menggambarkan bahwa tingkat kepraktisan model pembelajaran SaLDI terintegrasi TPACK ditinjau dari kepraktisan guru dan peserta didik tergolong sangat praktis. Kesimpulan penelitian ini yaitu model pembelajaran ini sangat praktis digunakan oleh guru dan peserta didik. Kepraktisan ini mendorong pembelajaran Biologi yang lebih efektif, interaktif, dan adaptif. Saran penelitian ini yaitu masih perlu menguji implementasi model pembelajaran SaLDI terintegrasi TPACK pada skala lebih luas.*

A. Introduction

A learning model is a conceptual framework used as a guide in carrying out the teaching and learning process. This model includes the entire set of teaching material presentations, which includes aspects before, during, and after learning, as well as all related facilities (Clement, 2000; Lu & Wu, 2018). In line with that, a learning model is a plan or pattern used as a guide in planning classroom or tutorial learning. The learning model refers to the learning approach that will be used, including teaching objectives, stages in learning activities, learning environment, and classroom management (Whittington & Yacci, 2008; Trianto, 2013).

Teaching models can actually also help learners acquire information, ideas, skills, values, ways of thinking, and the purpose of expressing themselves, we are actually teaching them to learn (Hendracipta, 2021). The learning model serves as a guide for teachers in planning and implementing learning activities. It can help in structuring the curriculum, organizing materials, and providing instructions to teachers in the classroom. The model also facilitates learning designers in planning learning activities so that learning objectives can be achieved (Cheng, 2023). Learning models can be useful to improve learning effectiveness so that learning becomes effective (Ferla et al., 2009; Panadero, 2017).

The general characteristics of an effective learning model are based on; (1) Oriented to clear learning objectives. Each learning model is designed to achieve specific learning objectives. The model helps teachers in designing relevant and directed learning materials and activities (Joyce et al., 2014). (2) Systematic use of strategies: learning models have systematic and repeatable stages, from introduction and development to evaluation. The systematization allows teachers to follow a planned structure in delivering material and assessing student progress (Arends, 2012). (3) Student-centred, an effective learning model places students as the main subject. The main focus is to facilitate students to students' discover discovery, explore exploration, and apply application of knowledge, thus promoting deep understanding (Bransford et al., 2000). (4) Active learning, an effective learning model, requires students to be actively involved in learning through discussions, experiments, or project activities. This approach leads students to take more responsibility for their learning process, improving critical and analytical thinking skills (Prince, 2004).

TPACK has components that include technology (TK), pedagogic (PK), content (CK), as well as a combination of the three. In the context of Biology education, CK is essential for teachers to master the material in depth (Mishra & Koehler, 2006; Mölgen et al., 2024). PK can make it easy for teachers to choose teaching strategies that suit the characteristics of students, for example experimental activities. TK allows the utilisation of digital technology of video observation, animation to explain biological processes. The integration of TCK, TPK, and PCK can support the delivery of material in an interesting, appropriate, and easy-to-understand way. TPACK as a whole provides teachers with assistance to design Biology lessons that are innovative, interactive, and contextualised. This supports the development of 21st century skills.

The current learning model has advantages, various weaknesses accompany it. The weaknesses of using the Project-Based Learning (PJBL) learning model, according to Niswara (2019) are: teachers need skills and are willing to learn, need a lot of money and time, need adequate equipment, materials and facilities, less suitable for students who give up easily. In line with this, Sriartha et al. (2020) revealed that the weaknesses of this PJBL model are (1) some students dominate activities so that they do not want to appreciate the ideas of peers who are considered less capable, (2) there is a possibility of students who are less active in group work, (3) when the topic given to each group is different, it is feared that students cannot understand the topic as a whole. SaLDI Biology learning model integrated with TPACK based on e-learning can overcome the weaknesses of PJBL with a directed learning process, learning community, integrated with TPACK. The e-learning feature can monitor group dominance and limited understanding of topics. In addition, this model assists teachers in developing TPACK competencies and helps students learn flexibly which does not need to be very dependent on expensive infrastructure.

The findings of Tyas (2017) show that there areas for improvement in the application of the Problem-Based Learning (PBL) learning model. These obstacles include: (1) teachers find it difficult to determine the right problem to stimulate students to discuss the problem, (2) obstacles in a long time for teachers who are not familiar with the PBL model, (3) at the stage of assisting independent and group investigations, teachers are not easy in positioning themselves as facilitators, guiding, digging deeper understanding, supporting students' initiatives. Some weaknesses of the inquiry model are (1) students must have mental readiness and maturity, (2) students must be brave and willing to know their surroundings well, (3) the number of students is large, then the model will not achieve satisfactory results, (4) this model is too concerned with the process alone, paying less attention to the development of attitudes in students (Hanafiah and Suhana, 2012). The inquiry learning model is less effective if applied to students who do not have above-average intelligence; classes that have many students will find it difficult to get inquiry learning because not all in the class have critical thinking (Shonim, 2014). The TPACK-integrated SaLDI Biology

learning model with learning tools, lesson plans, teaching materials, Student Worksheets, digital assessments and e-learning helps teachers define problems, facilitate investigations, and assist students effectively. Learning can be flexible and students can learn independently or collaboratively according to their abilities and pace.

In addition to the various weaknesses of existing learning models, many teachers and educational institutions still use conventional learning methods, where the teacher acts as the only source of information and students only act as passive recipients (Abdullah, 2012). This method is less effective in fostering deep understanding and critical thinking skills in students. In the world of learning, we should choose a model that is effective in achieving good learning outcomes. One of the innovative learning models is the SaLDI Biology learning model integrated with TPACK.

TPACK can overcome the limitations of conventional methods in Biology education by integrating technology, pedagogy and content knowledge. This approach emphasises active learning methods. Students are directly involved in exploratory activities in the learning process. TPACK allows teachers to use technology, such as simulations and interactive videos, to explain concepts that are difficult to understand. In addition, TPACK helps teachers choose teaching strategies that are suitable for students' characteristics, making learning more effective. Recent studies have shown that TPACK is essential in Biology education to improve teacher competence and student engagement (Aumann et al., 2024). Koehler et al. (2013) emphasised integrating technology in teaching, while research by Bandarlipe et al. (2024) showed an increase in student learning outcomes. Thus, the application of TPACK creates a more effective and engaging learning experience in Biology education.

The TPACK-integrated SaLDI (Stimulation, Learning Community, Discovery, Inferring) learning model comes as an innovative solution to the weaknesses of conventional methods and existing learning models that have not fully integrated technology. The TPACK framework combines content knowledge, pedagogy and technology so that teachers can design more effective and relevant learning. The saldi.id LMS becomes the centre of learning activities that provide teaching materials, student worksheets, Power Points, and digital assessments. This integration initiates students to play an active, collaborative, and independent role in learning biology. The TPACK-integrated SaLDI learning model makes technology a means of learning not just a tool, so as to minimise the negative impact of internet use. This model is also able to overcome time constraints, the dominance of certain students, and lack of group participation. Teachers can more easily facilitate student investigations and support independent exploration. The teaching materials and LPDs in the SaLDI learning model integrate content knowledge and pedagogy deeply. The LMS connects technological and pedagogical aspects, thus creating student-centred learning. Therefore, the SaLDI Biology learning model integrated with TPACK is able to create biology learning that is active, directed, and according to the demands of the 21st century.

This practicality test serves to assess the extent to which this model can be applied for learning. In addition, it identifies challenges and advantages that may be felt by teachers and students. Feasibility testing through practicality provides relevant data on the ease of use and attractiveness of the model. This is very important, especially in learning biology is still considered complex by students. Through practicality testing, it can be seen that the learning model is not only theoretical, but can be applied practically. Therefore, this study aims to explore and test the practicality of the SaLDI learning model integrated with TPACK on biology material for high school students, so that it can make a significant contribution in the development of better learning models.

B. Material and method

This type of research is descriptive quantitative. The population of this study were all students and teachers who participated in Biology learning at SMAN 14 Makassar. The sampling technique was random sampling, as many as 32 students and 2 teachers. The research instrument used was a questionnaire. The questionnaire has learning model indicators which include syntax, social system, reaction principle, support system, instructional impact, complementary impact, learning implementation, learning environments and management tasks, evaluation.

In addition, there is also a questionnaire of learning tools for the SaLDI Biology learning model integrated with TPACK. The reason for the importance of the learning tools tested in this study in addition to the learning model is the teaching module, student worksheet, teaching materials, e-learning and power point, each of which is designed to support the effective implementation of the TPACK-integrated SaLDI Biology learning model. Student worksheet is used to facilitate discovery and inferring activities that can encourage students to organise information, solve problems and draw conclusions independently or in groups. The practicality test of student worksheet aims to assess the extent to which the instructions in the worksheet are easy to understand and support learning community and discovery in the learning model. Teaching materials supporting stimulation syntax and learning community are loaded in saldi.id e-learning so that they can be easily accessed by students. Practicality testing of teaching materials is focused on knowing aspects of ease of understanding, readability, and suitability of

materials with curriculum demands and student learning needs. Meanwhile, the teacher teaching module contains the steps of implementing the SaLDI learning model integrated with TPACK. The practicality of the teacher teaching module was assessed based on its ease of use in designing, implementing, and managing learning by teachers. The use of PowerPoint reflects TPACK because it can effectively combine Biology content, learning strategies, and technology in supporting the implementation of the TPACK-integrated SaLDI learning model. This media helps teachers deliver material visually, interactively, and easily accessible, thus improving students' understanding and learning independence.

The research procedure used is starting with implementing the SaLDI Biology learning model integrated with TPACK to students. Then, asking for student and teacher responses in the form of a response questionnaire to the learning model and its tools. The questionnaire has a Likert scale of one to five. This research uses data analysis by calculating the average. Average data analysis is measured by calculating all values obtained then dividing them by the total number of values. The results of the average value will be categorised into the interval table. The average value is continued with the interval of determining the practicality category of the learning model and its devices presented in Table 1.

Table 1 The practicality criteria

Percentage (%)	Practicality criteria
81% ≤ % R ≤100%	Very practical
61% ≤ % R < 80%	Practical
41% ≤ R < 60%	Practical enough
21% ≤ R < 40%	Less practical
% R < 20%	Not practical

(Source: Riduwan, 2018)

C. Results and discussion

Teacher response to the learning model and tools

The results of teachers' responses showed a very positive response to the learning model of TPACK-integrated SaLDI Biology learning model, student worksheet, teaching materials, modules, as well as e-learning and online learning platforms. The teachers considered that the learning model and the tools support the achievement of learning objectives and facilitate the teaching process. In addition, the integration of technology through e-learning is considered to be able to increase students' active involvement in learning. The following can be observed teacher responses to the SaLDI Biology learning model integrated with TPACK.

Table 2 Teacher response to the learning model

Assessment aspect	Teacher response (%)	Category
Syntax	96	Very practical
Social system	90	Very practical
Reaction principle	92	Very practical
Support system	96	Very practical
Instructional impact	90	Very practical
Complementary impact	90	Very practical
Learning implementation	88	Very practical
Learning environments and management tasks	85	Very practical
Evaluation	90	Very practical
Total average	**91**	**Very practical**

Based on the Table 2, the TPACK-integrated SaLDI learning model looks very practical to use in learning, which obtained a score of 91. All aspects of assessment such as syntax, social systems, reaction principles, and evaluation are included in the "very practical" category. The highest score is found in the syntax and support system aspects which give a sign that the flow of the learning model has been very well designed (Joyce & Weil, 2000). This makes it easier for teachers to implement the model effectively.

Explicitly, the components of the SaLDI learning model can be mapped to the TPACK domain. Technological knowledge (TK) is reflected in the use of the saldi.id platform that provides quizzes, forums, wikis, case study assignments, and online uploads of teaching materials, supporting digital learning activities. Then, pedagogical knowledge (PK) appears in lesson plans oriented towards constructivist and collaborative approaches, such as in the syntax of learning community and discovery; while content knowledge (CK) is focused on Biology materials compiled based on the curriculum and student learning needs. This makes it easier for teachers to implement the model effectively.

These findings are in line with the results of research by Uluçinar et al. (2021) who stated that the TPACK-based constructivist learning model can increase student involvement in Biology learning. Although the aspects of learning implementation *and* learning environment received slightly lower scores, maish showed a high level of practicality that ensured smooth learning (Rumithi et al., 2019). This model also encourages social interaction through learning communities, in accordance with Vygotsky's theory of the importance of social-based learning The integration of the TPACK framework allows teachers

to combine content, pedagogy, and technology in a balanced and effective manner (Mishra, 2006; Azzahra & Darmiyanti, 2024). Therefore, TPACK-integrated SaLDI advocacy model helps teachers and students face 21st century learning challenges, such as the development of critical thinking, collaboration, and creativity skills (Trilling & Fadel, 2009). Therefore, the learning model can be further developed as an effective Biology learning innovation that is effective, adaptive, and relevant to the challenges of the times. A practical learning model can be easily implemented and make students active in learning (Hooshyar et al., 2019; Swiecki et al., 2019).

This study shows that the integration of the SaLDI learning model with the TPACK framework can be very practical. The main advantage of this model lies in its ability to synergize scientific approaches (stimulants, discoveries, inference) to social interactions supported by powerful technology. This can be an important indication that this model is capable of being widely used by teachers in a real-world context in schools. The main problems in education that are trending, especially in science learning, are the low interest in learning of students (Relawati et al., 2024), lack of active student involvement (Saqinah, 2017), lack of meaningful technology application, and weak teachers' ability to design flexible but structured learning. TPACK-integrated SaLDI learning model answers all four of these problems.

Based on Table 3, the average teacher response to the learner worksheet or student worksheet I obtained a score of 95%. This shows that the student worksheet is classified as very practical. Therefore, the student worksheet used in the TPACK-integrated SaLDI learning model is very effective in providing assist with teaching materials that can support learning. Student worksheet can make it easier for teachers to manage student learning activities and optimize student participation in the learning process. These very practical student worksheets are supported by content that provides a more meaningful learning experience.

The student worksheet has language and illustrations that can help students understand the concept more optimally. The student worksheet is very interesting and easier to understand. The flow of the student worksheet presentation is very supportive of learning activities in general. Student worksheet assessment is very supportive of innovation and optimizing the quality of learning activities as a whole. Practical student worksheet can be used easily. Student worksheet can be useful for making students active in learning activities and increasing student understanding (Amalia et al., 2018; Magdalena et al., 2021; Aldi et al., 2022 [a]).

Table 3 Teacher's response to the student worksheet

Assessment aspect	Teacher response (%)	Category
Content of student worksheet	94	Very practical
Language/illustration	96	Very practical
Presentation	96	Very practical
Assessment of student worksheet in supporting innovation and quality improvement of teaching and learning activities	94	Very practical
Total average	**95**	**Very practical**

Table 4 Teacher response to teaching materials

Assessment aspect	Teacher response (%)	Category
Content eligibility	88	Very practical
Presentation eligibility	95	Very practical
Language eligibility	91	Very practical
Graphics of teaching materials	94	Very practical
Total average	**92**	**Very practical**

Based on Table 4, the average teacher response to teaching materials reached 92%, which is very practical. Teaching materials meet the standards of content, language, visual presentation, and graphic feasibility. This shows that the teaching materials are prepared with attention to ease of use for teachers and students. This practicality has a direct impact on the effectiveness of the learning process in the classroom. Teachers find it helpful in delivering material because teaching materials support a systematic learning flow. In another point of view, students find it easier to understand Biology concepts because of the informative illustrations and schemes. The presentation aspect that received the highest score indicates that the potential of teaching materials in encouraging student creativity. The collaborative structure of teaching materials can support team learning activities, in accordance with the syntax of learning community in the TPACK-integrated SaLDI Biology learning model. Overall, the practicality of teaching materials can contribute to the empowerment of 21st century skills such as critical thinking, creativity, communication, and collaboration and strengthen the relevance of the TPACK-integrated

SaLDI Biology learning model. Practical teaching materials can make students active in learning activities and make the experience meaningful (Adnan et al., 2019; Restantri, 2021; Sahirah et al., 2023)

Teaching materials that are very practical in the TPACK-integrated SaLDI learning model are caused by the material contained in the teaching materials supporting the achievement of expected competencies with predetermined objectives. The information and concepts presented in the teaching materials are accurate. This can ensure that students learn based on valid information. These teaching materials are also supported with attractive images. This can make it easier for students to understand concepts and increase their enthusiasm for learning. Furthermore, the presentation of learning is very good such as material, bio-concept, bio-key, bio-info, bio-challenge and bio-advancement. Teaching materials are in accordance with the level of student development so that the material is easy to understand. The teaching materials are communicative, presented coherently, the layout is attractive, has a proportional layout, has typography and illustrations in the teaching materials support the optimization of students' understanding.

Based on the Table 5, the average teacher response to the teaching module in the SaLDI learning model integrated with TPACK is very positive, with a score of 94.8%. The teaching module is practical to support the learning process starting from the presentation of clear information to adequate attachments. The teaching module can make it easier for teachers to manage the class and provide assistance to students in achieving the desired competencies. It can provide support for innovative learning with the help of technological media. Practical teaching modules can make it easier for teachers in the learning process at school (Restantri et al., 2021; Safithri & Saputri 2023).

Table 5 Teacher's response to the teaching module

Assessment aspect	Teacher response (%)	Category
Teaching module identity	96	Very practical
Learning outcomes, initial competencies, guidelines for the appreciation and practice of Pancasila	96	Very practical
Facilities and infrastructure, target learners, learning model	94	Very practical
Core competencies	96	Very practical
Appendix	92	Very practical
Total average	**94.8**	**Very practical**

Table 6 Teacher response to e-learning

Assessment aspect	Teacher response (%)	Category
Display	90	Very practical
Content	87	Very practical
Functionality	83	Very practical
Accessibility	87	Very practical
Benefits	97	Very practical
Language	92	Very practical
Total average	**89.3**	**Very practical**

Table 7 Teacher response to online learning

Assessment aspect	Teacher response (%)	Category
Relevance of material	94	Very practical
Knowledge construction	94	Very practical
Ease of access	96	Very practical
Total average	**94.7**	**Very practical**

Based on the Table 6, the average teacher response to e-learning saldi.id in the TPACK-integrated SaLDI learning model obtained a score of 89.3%, which means very practical. It indicates that saldi.id e-learning is very supportive of learning activities both online and offline. The appearance of saldi.id e-learning is very good, contains relevant and complete content, and has features that function strongly, in general saldi.id e-learning is easy to access, helps optimise learning efficiency, and using language that is easy and clear to understand. Practical e-learning platforms can provide effective solutions to optimize the learning process, especially in the digitalization era. E-learning is a medium used by teachers to improve the quality of student learning (Hanum, 2013; Anshori, 2018).

Based on the Table 7, the average of teachers' responses to online learning on the TPACK-integrated SaLDI learning model is very practical with a score of 94.7%. This is due to the relevance of the material

that is well structured, the ability to build structured personal understanding, provide easy access rights and can significantly support the smooth running of learning activities. It can optimize the quality of learning in the digitalization era. The benefits of online learning are that it can provide support for the flexibility of online learning, allowing students to access materials anywhere and enabling students to learn independently (Naidu, 2019; Brown & Green, 2019).

Student response to the learning model and tools

Students' responses to the learning model, student worksheet, teaching materials, modules, as well as e-learning and online learning generally showed positive appreciation. Students feel that these learning tools help them understand the material more easily and enjoyably. In addition, e-learning-based learning is considered to provide flexibility and a more interactive learning experience.

Based on Table 8, TPACK-integrated SaLDI Biology learning model has a very practical score by students of 86.8%. This reflects a positive response to all aspects. Aspects such as syntax, social systems, reaction principles, as well as instructional impact to evaluation, which are categorized as very practical. The highest scores were found in reaction principle, support system, and instructional impact, each at 89. This indicates that students can be encouraged to interact and provide adequate mutual support during learning. These results are consistent with the research of Saerang et al. (2023) which states that TPACK integration improves student efficiency and engagement in learning. The application of elements of community learning and discovery learning in the SaLDI learning model can provide students with critical thinking skills (Handayani et al., 2024). These findings are in line with Vygotsky's theory of social constructivism, which emphasizes the importance of social interaction to construct knowledge (Witasari, 2023). SaLDI's learning model has also been proven to be able to create an active learning environment, as well as support classroom management and fair assessments. Facing the challenges of the 21st century, this learning model is very relevant to develop collaboration skills, critical thinking, creativity. So, TPACK-integrated SaLDI learning model can be used as an innovative alternative to improve the quality of Biology learning in schools.

The results of this study show that TPACK-integrated SaLDI learning model is not only feasible to implement, but also very supportive of the formation of meaningful learning experiences and makes students actively involved. This learning model also addresses the challenges of 21st century education, such as the need to improve students' collaboration skills, creativity, and technological literacy (Trilling & Fadel, 2009). Practical learning models show that they can support students in improving learning activities and providing interesting learning nuances (Pino-James, 2018; Adnan et al., 2023). Furthermore, the high score in the evaluation aspect of 86 indicates that students feel that the assessment process is fair, transparent, and supportive of their learning. Implications for the current educational problem, which still faces the challenge of low active student involvement in science learning (Witasari, 2023), the application of models such as TPACK's integrated SaLDI offers strategic solutions. This learning model can design learning that is responsive to student needs, both in terms of approaches, media, and assessment strategies. The impact of this learning model can be an innovative alternative in improving the quality of Biology learning nationally, especially in strengthening students' 4C skills.

Table 8 Student response to the learning model

Assessment aspect	Student response (%)	Category
Syntax	84	Very practical
Social system	88	Very practical
Reaction principle	89	Very practical
Support system	89	Very practical
Instructional impact	89	Very practical
Complementary impact	88	Very practical
Learning implementation	86	Very practical
Learning environments and management tasks	82	Very practical
Evaluation	86	Very practical
Total average	**86.8**	**Very practical**

Table 9 Students' response to the student worksheet

Assessment aspect	Student response (%)	Category
Concept associations	85	Very practical
Benefits	90	Very practical
Design	88	Very practical
Language	87	Very practical
Total average	**87.5**	**Very practical**

Based on Table 9, the average student response to student worksheet in the integrated problem learning model is 87.5%, with a very practical category. It indicates that the student worksheet can provide support to students in terms of understanding learning concepts, providing various benefits such as increasing understanding of concepts, solving problems, and linking concepts with everyday presence. Attractive design that can encourage students to be motivated to work on student worksheets using effective language assist to students in working on unambiguous assignments. Very practical student responses can provide reinforcement to the student worksheet as teaching materials that can make students easy to learn effectively and increase student activity (Aslam et al., 2021; Aldi et al 2022[b]; Adnan et al., 2022).

Based on Table 10, the average value of student responses to the use of teaching materials in the TPACK-integrated SaLDI Biology learning model is 88.3%. This shows that the teaching materials have a very practical response. In line with the theory of constructivism which emphasises the importance of active and meaningful learning experiences for students (Aldi, Adnan & Azis, 2025). In that context, well-designed teaching materials not only help students understand concepts, but also encourage them to connect various concepts effectively.

Teaching materials can support students in deepening their understanding of biological concepts for learning purposes. The design of teaching materials that are not boring and interactive contributes to increasing student motivation, which is in line with Deci & Ryan's (2000) findings showing that intrinsic motivation can increase student engagement in the learning process. Teaching materials can provide meaningful learning experiences and train students to construct their own knowledge (Adnan et al., 2017; Amaly et al., 2022; Adnan et al., 2023).

The language used is very effective and clear, and is supported by communication theory in education which contains clarity in conveying information can increase student understanding (Mayer, 2009). Positive responses to the use of teaching materials in the SaLDI Biology learning model integrated with TPACK indicate that this model can help students in learning motivation, activity and learning outcomes that can sustain independence (Aldi et al., 2024).

The implications of this study indicate that the implementation of the SaLDI Biology learning model integrated with TPACK not only improves the practicality of teaching materials, but also provides a meaningful learning experience. This, in turn, familiarises students in constructing their own knowledge, which is key to achieving sustained and deep learning (Brusilovsky & Millán, 2007). Therefore, this study makes an important contribution to more effective and relevant learning in the context of biology education at the high school level.

Table 10 Student response to teaching materials

Assessment aspect	Student response	Category
Concept associations	88	Very practical
Benefits	89	Very practical
Design	88	Very practical
Language	88	Very practical
Total average	**88.3**	**Very practical**

Table 11 Student response to e-learning

Assessment aspect	Student response	Category
Display	87	Very practical
Content	88	Very practical
Functionality	89	Very practical
Accessibility	89	Very practical
Benefits	91	Very practical
Language	92	Very practical
Total average	**89.3**	**Very practical**

Table 12 Student response to PowerPoint

Assessment aspect	Student response	Category
Concept associations	88	Very practical
Benefits	84	Very practical
Design	86	Very practical
Language	85	Very practical
Total average	89	Very practical
Assessment aspects	86	Very practical

Based on Table 11, the average student response to saldi.id e-learning in the learning model is very practical, with a value of 89.3%. It can provide better learning support through a very attractive appearance that adds to students' interest in learning. Then, in terms of e-learning content provided is very suitable and can provide support to achieve student learning objectives. It also helps students to improve their understanding. The features contained in saldi.id e-learning is very good to operate, helping in material access activities, assignment work and interaction between students and students and teachers. The accessibility aspect of saldi.id e-learning can make it easier for students to access the e-learning anywhere and everywhere and provide convenience in accessing the available features. The use of language in saldi.id e-learning is very clear and can be understood by students. Student responses to saldi.id e-learning can help students in the learning process effectively, supporting active students in learning in the digital era both online and offline (Ruest et al., 2017; Pusporini, 2020).

Based on Table 12, it shows that the overall PowerPoint in the SaLDI Biology learning model integrated with TPACK is 86% in the very practical category. This indicates that PowerPoint can effectively provide learning support for students, which includes good readability, very attractive visual design, appropriate learning content and there are interaction elements that can encourage interest and motivation. The positive response to the use of PowerPoint in the learning model is very beneficial in building an interactive learning environment and attracting students to be more enthusiastic in the learning process (Clark, 2008; Wanner, 2015).

In the TPACK perspective, the use of PowerPoints that have been developed on the TPACK framework shows that technology is not only a tool that can help but can be contextualised with a TPACK-integrated SalDI biology learning model on biological concepts. This can provide support for the basic principles of TPACK which reveal that the use of technology in learning depends on how a teacher can integrate optimally and synergistically between pedagogics and content.

The TPACK-integrated biology learning model is recommended to be implemented to a wider range of schools because it can be practically proven. Teacher training is needed before the implementation of the model in various schools in order to improve skills in integrating the original learning model on the internet. More advanced research needs to be conducted in terms of measuring the long-term impact on students' learning outcomes and 21st century skills to determine how sustainable this model is to ensure it continues to evolve according to technological and pedagogical needs.

D. Conclusion

Based on the results of the study, it can be concluded that the SaLDI learning model integrated with TPACK has a teacher practicality value is included in the very practical category. The students' response has a practicality value also in the very practical category. Therefore, the practicality test of the SaLDI learning model integrated with TPACK is very practical, which facilitates teachers and students in learning. The scientific impact of this research is to contribute in optimising the use of technology, active learning, interesting learning, and meaningful. The limitation of this research is that the scope of implementation is still limited to one level of education. Obstacles faced by students' adaptation to the platform and limited time. Therefore, further research at different levels is recommended in order to provide more massive and in-depth reinforcement of this friend.

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