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# Profiling the Competence of Chemistry Education Students at FKIP UNTAN in Designing Technology-Based Instruction

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**Abstract**
In the modern era and with the implementation of the *Merdeka Curriculum*, teachers are expected to adopt a different approach to learning by designing IT-based instruction. Education students, as prospective teachers, are expected to utilize technology to design and develop active and engaging learning experiences. This study aims to examine the competency profile of Chemistry Education students from the Faculty of Teacher Training and Education at Tanjungpura University, specifically the 2021 cohort, with a total of 45 respondents. The research method used is quantitative descriptive, with participants selected using a saturated sampling technique. Data collection techniques include a student competency profile questionnaire on IT-based learning design, a 21st-century skills implementation questionnaire, observation sheets of learning module designs, and unstructured interviews. Data were analyzed using descriptive quantitative methods. The results show the percentage scores for each aspect as follows: critical thinking and evaluation – 84%, e-safety – 85%, information, media, and technology skills – 84%, communication and collaboration skills – 89%, and creativity – 88%. Each of these aspects falls into the "Excellent" category, with an average score across all aspects of 86%. Therefore, it can be concluded that the competency profile of Chemistry Education students at the Faculty of Teacher Training and Education, Tanjungpura University, in designing IT-based learning as prospective teachers is in the “Excellent” category (86%).

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## INTRODUCTION

Information has become a highly valuable commodity for human needs in this era, serving as a means to gain power through access to crucial data. Information Technology (IT) plays a significant role in the dissemination of information in the form of content. IT is also considered a major globalizing force in today’s modern era. One of the vital instruments in triggering time-space compression can be seen from the nature of its interactions, which are not physical or individual, but rather mass in nature and involving many people (Simaremare, 2022).

In today's modern era, with the implementation of the *Merdeka Curriculum*, teachers are required to apply learning methods that differ from traditional approaches such as the lecture method. The *Merdeka Curriculum* provides educators with the flexibility to create high-quality learning experiences tailored to the students' environment and needs, thereby encouraging greater motivation to learn (Kemendikbud, 2023). Technology is closely linked to 21st-century learning, making it essential for future educators to possess technological competencies. The integration of technology into the teaching and learning process is referred to as Technological Pedagogical Content Knowledge (TPACK) (Ulfah & Erlina, 2022).

TPACK consists of seven interconnected components, formed from a combination of three core types of knowledge: Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). These three foundational types of knowledge give rise to four additional knowledge domains: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK) itself (Rahmadi, 2019). These seven domains of knowledge are essential for pre-service educators or future teachers, who will be teaching in learning environments filled with various technological tools. As a result, teachers will be able to effectively utilize appropriate technology within suitable pedagogical approaches for specific content.

According to Hague & Payton, as cited in Nasionalita and Nugroho (2020), there are five essential aspects that must be possessed by teachers and prospective teachers: critical thinking and evaluation, which refers to the ability to think critically when receiving information from the internet; e-safety, which is the ability to ensure safety when searching for information online, referring to policies, practices, and procedures that reduce harm from individuals who misuse information technology; information, media, and technology skills, which involve the ability to identify and utilize appropriate information and media technology in the learning process; effective communication and collaboration skills, which enable teachers to express ideas, understanding, and thoughts in discussions, thereby creating shared understanding and common goals; and creativity, which is the ability to share knowledge and develop it into a variety of ideas using technology.

Hence, it is imperative for pre-service teachers to develop proficiency in integrating technology into the design of IT-based learning. This necessity arises from the ongoing curricular reforms that emphasize the strategic use of educational technology to enhance learning outcomes. The current curriculum framework outlines four essential competencies: professional competence, referring to a comprehensive and in-depth mastery of subject matter; pedagogical competence, which encompasses the ability to effectively manage and facilitate student learning; social competence, involving the capacity to establish and maintain constructive social relationships through various interpersonal skills; and personal competence, characterized by moral integrity, wisdom, authority, and the ability to serve as a role model for students.

Technological literacy among pre-service chemistry teachers at the Faculty of Teacher Training and Education (FKIP) of Tanjungpura University (UNTAN) is essential and must be developed. The Chemistry Education Study Program has made efforts to equip students with technological knowledge by offering courses that cover various aspects of information technology, including media development, computer literacy, and the application of ICT (Information and Communication Technology), which encompasses both information and communication technologies. Through these courses, it is expected that pre-service chemistry teachers at FKIP UNTAN will be capable of utilizing IT in the design of instructional activities.

One of the core graduate profiles of the Chemistry Education Study Program at FKIP UNTAN is to produce competent and professional educators in the field of chemistry. Students are expected to master both content knowledge and theoretical foundations, as well as stay informed about the latest developments in their respective fields. In addition, pedagogical knowledge is emphasized, which includes four main components: understanding student characteristics, mastering learning theories, selecting appropriate instructional methods and strategies, and managing classrooms effectively. Of these four pedagogical domains, this study focuses on the ability of pre-service chemistry teachers to select and apply appropriate teaching methods and strategies, specifically within the context of IT-based learning module design.

As future educators, pre-service teachers must acquire proficiency in educational technology, as teachers are expected to utilize information technology not only to enhance the quality of

learning experiences but also to support their own professional development and the broader goals of educational advancement (Ministry of National Education Regulation No. 16 of 2007).

Based on the aforementioned issues, this study seeks to investigate the competency profile of Chemistry Education students at FKIP UNTAN in designing IT-based instruction.

## METHOD

The method employed in this study is quantitative descriptive. Quantitative descriptive research is a method used to analyze data by describing or illustrating research findings using numerical values and percentages, processed descriptively without conducting inferential analysis or drawing general conclusions (Sugiyono, 2019). The research subjects were determined using a saturated sampling technique (Nurdiani, 2014). The subjects of this study consisted of 45 students from the 2021 cohort of the Chemistry Education Study Program at the Faculty of Teacher Training and Education (FKIP), Tanjungpura University.

Data collection techniques included indirect communication through questionnaires. Two sets of questionnaires were used in this study: the first consisting of 25 items and the second comprising 9 items. In addition, an observation sheet was used to assess the design of instructional modules. Direct communication was also employed through unstructured interviews. Interview participants were selected based on Likert-scale questionnaire results, representing a range of scores from low, medium, to high.

The research instrument used was a questionnaire assessing students' competency profiles in designing IT-based instruction, which was developed based on five aspects adapted from Hague & Payton (2011). The scoring of the first questionnaire used a 4-point Likert scale, with the following response options: *Strongly Agree (SA)*, *Agree (A)*, *Disagree (D)*, and *Strongly Disagree (SD)*. The research subjects were selected using purposive saturated sampling. The principle behind this technique involves selecting samples based on specific criteria aligned with the research objectives (Nurdiani, 2014).

Table 1. Blueprint of the Questionnaire on the Ability to Utilize/Use IT

| Aspect | Indicator |
|---|---|
| Critical Thinking and Evaluation | Able to think critically when receiving information on the internet |
| E-safety | The ability to ensure security when conducting searches with information technology |
| Information, Media and Technology Skills | Ability to use a computer<br>Ability to utilize the internet<br>The ability to find and search for information<br>The ability to select information received in digital space<br>The ability to understand, be aware of, and be able to apply the importance of media literacy |
| Communication and Collaboration Skills | Able to communicate through technological media<br>The ability to work together in digital spaces to create understanding |
| Creativity | Ability to share knowledge with a variety of ideas that utilize digital technology |

Conducting data analysis on each aspect of the ability to design IT-based learning. The maximum score for each statement is 4 and each aspect of the ability to design IT-based

learning has a different number of statements, so the mean formula is used like formula (1) to obtain the average score for each aspect (Sudjana, 2005).

$$\bar{x}=\frac{\sum x}{n}$$

Information :
X : average score for each aspect
$\sum x$ : the number of each statement item in each aspect
n : number of statement items in each aspect

Determining the value in the interval 1-100 by calculating the average score for each aspect, as in formula (2) (Sudjana, 2005).

$$\text{Value} =\frac{\bar{x}}{n} \times 100$$

Namely $\bar{x}$: the average score for each aspect.

The assessment categories for each aspect of the ability to design IT-based learning use the criteria as in table 2 (Riduwan, 2007, p. 15).

Table 2. Categories of Aspects of Ability to Design IT-Based Learning

| Value Interval | Assessment Category |
|---|---|
| 81-100 | Very good |
| 61-80 | Good |
| 41-60 | Pretty good |
| 21-40 | Not good |
| 0-20 | Very good |

(Riduwan, 2007, p. 15).

Determination of the average value of the IT-based learning design ability aspect is calculated based on formula (3)

$$\text{Value} =\frac{1}{100}\frac{\sum Y}{n} \times 100$$

While $\sum Y$: is amount score respondents .

Table 3. Questionnaire Grid for the Implementation of 21st-Century Skills

| Aspect | Indicator |
|---|---|
| Comprehension of 21st-Century Skills | Knowing 21st-Century Skills<br>Understanding 21st-Century Skills<br>Recognizing the Importance of 21st-Century Skills |
| Implementation of 21st-Century Skills | Applying 21st-Century Skills<br>Applying Learning Skills<br>Applying Information, Media, and Technology Skills |

Table 4. Observation Sheet Framework for Learning Module Design

| Aspect | Indicator |
|---|---|
| Learning Objectives | Alignment with Competencies |
| Learning Materials | Content Relevance<br>Utilization of Digital Resources<br>Learning Video |
| Teaching Methods | Interactivity<br>Variety of Media |
| Technology Usage | Appropriateness of Tools and Applications |

| Aspect | Indicator |
|---|---|
| | Ease of Access |
| Learning Activities | Alignment with IT-Based Methods<br>Applying the 21st-Century Learning Model<br>Creativity |
| Assessment and Evaluation | IT-Based Assessment |

## RESULTS AND DISCUSSION

The use of technology in education today serves as a medium for delivering knowledge to students. Both software and hardware can be utilized in the teaching and learning process to make it more engaging and to enhance students' motivation to learn. This study examines the competency profile of Chemistry Education students at FKIP UNTAN in designing IT-based instruction, focusing on the 2021 cohort, with a total of 45 respondents.

Two indicators were used to assess the students' competencies in designing IT-based learning: The ability to utilize and operate IT, This indicator was used to evaluate the initial technological proficiency of pre-service teachers. It is assumed that with sufficient knowledge and conceptual understanding, students are capable of designing IT-based learning.The ability to implement 21st-century skills, This indicator aims to assess the integration of 21st-century skills in students' IT-based instructional design, as reflected in their teaching modules. Prior to distributing the questionnaires to the students, the instrument was validated by two expert judgments specializing in cognitive learning. The result of the validity test yielded a coefficient of 1.00. The findings for both indicators are presented in the following section.

The aspects of both indicators are outlined as follows. The first indicator, the ability to utilize and operate IT, consists of five aspects: (1) Critical Thinking and Evaluation, (2) E-safety, (3) Information, Media, and Technology Skills, (4) Communication and Collaboration Skills, and (5) Creativity. The second indicator, students' ability to implement 21st-century skills, comprises two aspects: (1) Understanding of 21st-Century Skills and (2) Application of 21st-Century Skills. The second aspect is further supported by an observation sheet assessing the design of instructional modules, which serves as supporting evidence for the responses provided by students in the first indicator. The following section presents a graph illustrating the results of the first indicator: the ability to design IT-based instruction.

### Competence in Utilizing and Applying Information Technology

The ability of Chemistry Education students to design IT-based learning can be categorized as good, with an average achievement score of 86%, indicating a "Good" level of competency. A detailed breakdown of each assessed aspect is presented below.

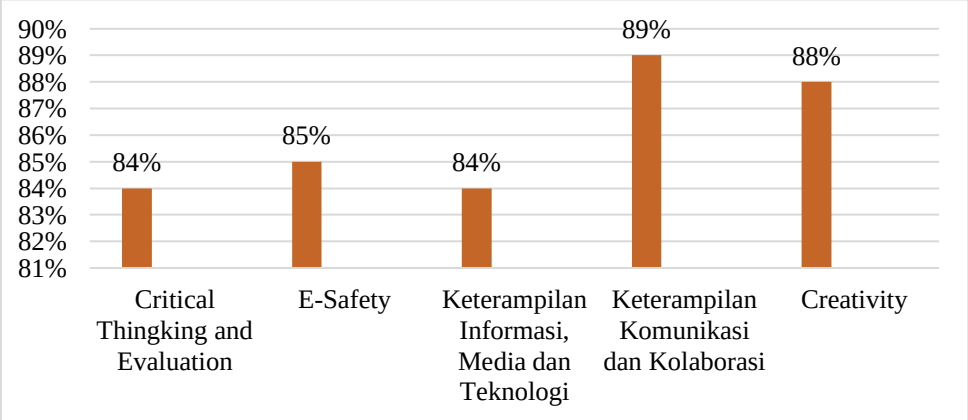


Figure 1. Percentage of Students' Ability in Designing IT-Based Learning

### *Critikal Thingking and Evaluation Aspect*

Based on Figure 1, the percentage score for the aspect of *critical thinking and evaluation* is 84%, which falls into the "Very Good" category. This indicates that students possess the ability to think critically and evaluate information received from the internet. Critical thinking is an essential skill for pre-service teachers to master in utilizing technology for learning purposes, as it is also a competency that needs to be taught to students in order to help them succeed in an increasingly complex world and to shape their thinking patterns (Nugroho & Nasionalita, 2020). The following are the respondents' answers regarding the aspect of *critical thinking and evaluation*:

Table 5. Respondents' Answers on Aspect 1

| No | Statement | SA | A | NA | SNA |
|---|---|---|---|---|---|
| 1. | I am unable to construct material obtained from the internet. (-) | 0 | 0 | 22 | 23 |
| 2. | I am able to check the credibility of information sources such as being able to find out who wrote or published the information and what their background and motives are regarding the source. (+) | 14 | 24 | 6 | 0 |
| 3. | I am able to think critically about information obtained from the internet by digging and comparing several pieces of information. (+) | 19 | 23 | 3 | 0 |

The responses provided by the participants to the three statements under the aspect of *Critical Thinking and Evaluation* are presented in Table 5. For the first statement, which was negatively worded, all respondents answered *disagree* or *strongly disagree*. This indicates that students possess the ability to construct learning materials derived from the internet. Constructing materials is a process of synthesizing content from various online sources such as websites, articles, videos, and other digital platforms, which can assist teachers in both instructional and educational purposes (Riyana, 2010). For the second statement, nearly all students responded with *strongly agree* or *agree*, indicating their ability to assess the credibility of information sources. This may be attributed to their prior knowledge of chemical concepts gained through coursework, enabling them to evaluate the accuracy of information effectively.

Functionally, the ability to verify the credibility of information sources supports pre-service teachers in validating and analyzing data accuracy within both instructional and research contexts. This ability is essential for producing valid and accountable conclusions (Saputra et al., 2024). Regarding the third statement, nearly all students responded with *strongly agree*, suggesting that they are capable of critically analyzing information obtained from the internet, supported by their understanding of chemistry concepts acquired throughout their studies. However, for the second and third statements, a small number of students responded with *disagree*. Based on unstructured interviews, these students—nine in total—revealed that they lacked the curiosity to further explore the information they encountered, indicating a limited intrinsic motivation to deepen their understanding.

Critical thinking involves not accepting information at face value, but rather engaging in analysis, evaluation, and verification of its truth and relevance. It also includes the element of self-regulation in responding to the information received (Facione, 2015). Based on this understanding, it can be concluded that students demonstrate an *excellent* level of critical thinking and evaluation skills. With such critical thinking abilities, students—as prospective teachers—are expected to become responsible educators who ensure that the knowledge they impart is accurate, relevant, and beneficial to their learners.

### *E-Safety Aspect*

The research findings for the *e-safety* aspect indicate a percentage score of 85%, which falls into the "Excellent" category. This suggests that students possess a high level of skill in exploring, collaborating, and ensuring safety when accessing information through technology.

These results are supported by interview findings, which revealed that students apply a cautious perspective to ensure information security—such as refraining from sharing personal data with unknown individuals without a clear purpose, and avoiding the random opening of website links that may risk exposing personal information. The following table presents the respondents' answers related to this aspect.

Table 6. Respondents' Answers on Aspect 2

| No | Statement | SA | A | NA | SNA |
|---|---|---|---|---|---|
| 4. | I can guarantee security when opening a website on the internet. (+) | 20 | 16 | 9 | 0 |
| 5. | I can maintain the confidentiality of personal data on social media. (+) | 26 | 15 | 4 | 0 |
| 6. | I can block people who send malicious messages and hoaxes by not opening unknown links and attachments. (+) | 25 | 18 | 1 | 1 |

Based on the respondents' answers presented in Table 6, the majority of students agreed with the statements, indicating that they are able to ensure safety while browsing websites on the internet, protect the confidentiality of personal data, and anticipate potential cybercrimes. Interview results support this finding, showing that students apply safety measures such as using secure browsers like Google Chrome and Mozilla Firefox. With tools like the Firefox Security Dashboard, students are able to recognize and heed warnings about unsafe websites, which they avoid accessing. Additionally, they strengthen account security by using complex passwords that combine letters and numbers and by enabling two-factor authentication (2FA) on their devices. However, for those students who responded with uncertainty or disagreement, unstructured interviews revealed that they still lack sufficient understanding and awareness of digital safety practices, which limits their ability to effectively anticipate and mitigate online security threats.

Therefore, students must first develop awareness of e-safety and recognize the potential negative impacts that may arise. The use of the internet offers convenience in various activities; however, easy access to the digital world has become increasingly intensive, particularly as it becomes a requirement in the teaching and learning process, especially in online settings (Niyu & Purba, 2021). Since students' thinking still requires guidance in this area, the role of parents at home is crucial, while the role of teachers as educators in schools is equally important in ensuring the e-safety of students in Indonesia (Manik, 2022).

### *Information, Media, and Technology Skills Aspect*

The research results for the aspect of information, media, and technology skills show a percentage score of 84%, which falls into the "Excellent" category. This indicates that students possess the ability to use the internet and computers effectively, as well as the competence to find, search for, and critically select information received in digital spaces, demonstrating an understanding of and awareness about the importance of applying media literacy appropriately. This aspect includes 11 statements, as it covers three areas of skills: information, media, and technology. The following data present the respondents' answers related to this aspect.

Table 7. Respondents' Answers on Aspect 3

| No | Statement | SA | A | NA | SNA |
|---|---|---|---|---|---|
| 7. | I have the ability to operate a computer. (+) | 28 | 15 | 2 | 0 |
| 8. | I can use ICT (*Information and Comunication Technology*) and the internet in terms of web development, such as creating and updating websites that contain educational learning materials. (+) | 10 | 17 | 14 | 4 |
| 9. | I realize the importance of ICT in chemistry learning. (+) | 28 | 15 | 2 | 0 |
| 10. | I use flash media in learning chemistry. (+) | 1 | 18 | 14 | 12 |
| 11. | I ignored the importance of ICT in learning chemistry. (-) | 2 | 7 | 16 | 20 |

| No | Statement | SA | A | NA | SNA |
|---|---|---|---|---|---|
| 12. | I am able to find valid information from the internet. (+) | 27 | 18 | 0 | 0 |
| 13. | I am unable to differentiate between hoax information and real information. (-) | 3 | 5 | 12 | 25 |
| 14. | I use journals in chemistry learning. (+) | 19 | 22 | 3 | 1 |
| 15. | I can access analyze and evaluate media literacy well enough to find information spontaneously through any media and be a responsible media consumer. (+) | 19 | 25 | 1 | 0 |
| 16. | In my opinion, the use of interactive media is needed in chemistry learning. (+) | 31 | 13 | 1 | 0 |
| 17. | In my opinion, the use of media complicates the learning process (-) | 4 | 1 | 10 | 30 |

Based on the respondents' answers presented in Table 7, it can be observed how the students responded in various areas. Regarding computer operation, almost all students agreed, indicating that they are capable of operating hardware technology such as computers. However, in terms of website usage, some students agreed while others disagreed, suggesting that not all students possess the skills to develop or update websites using ICT or the internet. Despite this, students recognize the importance of utilizing ICT (Information and Communication Technology).

Regarding the use of interactive media, some students agreed and others disagreed on the use of flashcards—learning cards containing images, text, or symbols that assist classroom learning. Interviews revealed that not all students understand how to use this type of media. Nevertheless, students are able to gather information from the internet as they already possess a foundational understanding of the subject matter they seek, whether from journals or articles for teaching purposes. Furthermore, students acknowledge the importance of using interactive media in chemistry learning to make the learning process more engaging and innovative.

In this regard, Rahmadani (2020) concurs that all students own smartphones or laptops and routinely spend time using the internet, which enables them to develop various skills in operating online applications. With the proficiency possessed by students in operating technological hardware such as computers or laptops, they are able to keep pace with technological advancements and utilize a range of available applications effectively (Akbar & Anggraeni, 2017). Information technology literacy refers to the ability to use media, such as the internet, to access, disseminate, and communicate information efficiently. This literacy is understood as media literacy, which enables individuals to comprehend, master, and utilize mass media content (Helaluddin, 2019).

### *Communication and Collaboration Skills Aspect*

Based on Figure 1, the research results for the aspect of communication and collaboration skills show a percentage score of 89%, which falls into the "Excellent" category. This indicates that students are capable of communicating through technological media and collaborating effectively in digital spaces to create shared understanding during the teaching and learning process. Communication and collaboration skills refer to an individual's ability to work effectively with others to achieve common goals, and students are expected to develop these skills as essential competencies for future educators (Thahir et al., 2024). This aspect consists of six statements, covering two main areas: communication and collaboration. The following data present the respondents' answers related to this aspect.

Table 8. Respondents' Answers on Aspect 4

| No | Statement | SA | A | NA | SNA |
|---|---|---|---|---|---|
| 18. | I am able to communicate using the right application during presentations, both visual and non-visual. (+) | 16 | 27 | 2 | 0 |

| No | Statement | SA | A | NA | SNA |
|---|---|---|---|---|---|
| 19. | I can use google classroom, google drive, youtube, to discuss and send assignments. (+) | 35 | 10 | 0 | 0 |
| 20. | I can't edit videos well to complete the task. (-) | 5 | 4 | 16 | 20 |
| 21. | I don't have the ability to express my opinion in the digital space (zoom, google meet, and other applications). (-) | 0 | 3 | 13 | 29 |
| 22. | I am unable to collaborate in editing materials in google docs, google sheet, google form, and other applications. (-) | 0 | 3 | 9 | 33 |
| 23. | I am able to receive and respond to other people's ideas in groups in digital spaces. (+) | 22 | 20 | 3 | 0 |

Based on the respondents' answers presented in Table 8, various responses can be observed. Regarding communication through appropriate applications for presentations, both visual and non-visual, nearly all students agreed. This is further supported by the teaching modules designed and used by the students, which incorporate PowerPoint, images, and instructional videos as learning stimuli. Next, students' ability to use Google Classroom, Google Drive, and YouTube for discussions and submitting assignments is reflected in their responses, with all students indicating agreement. This suggests that students possess strong proficiency in using these applications, which is supported by the fact that coursework frequently employs Google Classroom, Google Drive, and YouTube for collaborative discussions and assignment submissions.

As a result, students are well-trained and familiar with these tools. Regarding video editing and design/concept development for completing assignments, Table 8 shows that nearly all students disagreed with the negatively worded statement, indicating they are capable of producing video assignments. This skill is also cultivated through coursework that includes video-making tasks. However, some students agreed with the negative statement. Based on interviews with these students, it was concluded that some are less active in discussions due to fear of making mistakes when expressing opinions, preferring to remain silent and listen. Additionally, they are not yet proficient in video editing or related applications. In summary, based on the students' responses, it can be concluded that they are capable of expressing opinions in digital platforms such as Zoom and Google Meet, and they are proficient in editing materials using Google Docs, Google Sheets, and Google Forms. Therefore, in terms of communication and collaboration, students demonstrate strong competencies.

The ability to communicate effectively is supported by respondents' habitual use of communication devices such as laptops, smartphones, and other tools. This familiarity influences their comfort in expressing and receiving ideas through digital media (Nasionalita & Nugroho, 2020). The research findings on the aspect of communication and collaboration skills indicate that students are capable of cooperating in digital environments such as Zoom, Google Meet, Google Docs, and other platforms, which facilitate effective interaction among peers. Consequently, students are able to share ideas digitally with one another (Sianipar, 2020).

### Aspect Creativity

The research results for the creativity aspect, as shown in Figure 1, indicate a percentage score of 88%, which falls into the "Excellent" category. This demonstrates that students possess a very good ability to share knowledge through diverse ideas utilizing digital technology. The following data present the respondents' answers related to this aspect. Based on the respondents' answers presented in Table 9, it can be observed that in terms of utilizing various applications commonly used in learning, such as PowerPoint, Google Slides, and other presentation tools, all students agreed that they are capable of organizing and delivering material in a more engaging and structured manner. This is evidenced by the teaching modules

that have been observed. Students demonstrate a very good level of creative thinking. This is further supported by interview results, which revealed that students frequently use applications like PowerPoint, Mentimeter, and Google Slides because of their accessibility.

Table 9. Respondents' Answers on Aspect 5

| No | Statement | SA | A | NA | SNA |
|---|---|---|---|---|---|
| 24. | I can utilize various applications such as Power Point, Google Slides, and other presentation applications to organize and present material in a more interesting and structured way. (+) | 30 | 15 | 0 | 0 |
| 25. | I am able to draw chemical structures using the chemdraw application and virtual experiment videos. (+) | 17 | 26 | 2 | 0 |

Furthermore, students also agreed that they are able to depict chemical structures using the ChemDraw application, which has been used since their coursework. They can view structures clearly thanks to the 3D features in the application and are also able to create visual experiment videos. Additionally, students employ a variety of applications such as ChemDraw, Quizizz, Wordwall, and others that enhance their creativity, enabling them to apply these tools effectively in the classroom learning process. Creative thinking is the ability to explore various techniques to generate ideas, whether by broadening perspectives, combining existing concepts, or creating new ideas (Wibowo, 2014).

It can be concluded that the average ability of Chemistry Education students from the 2021 cohort in utilizing and applying Information Technology (IT) falls into the "Excellent" category, with a score of 86%. This competence is highly important for students as they prepare to enter the professional field. With these skills, students are able to understand one another, convey ideas effectively, and engage in meaningful communication. Starting from the individual, a teacher must strive to introduce IT to their students and integrate it into the teaching and learning process. This approach is commonly referred to as computer-based or IT-based learning (Anantiwi, 2021).

**The Competency in Implementing 21st-Century Skills**

The implementation of 21st-century skills refers to the ability to understand and apply these skills in the learning process, which includes the use of learning models, media, learning resources, and educational technology. The ability to implement 21st-century skills encompasses two key aspects: (1) initial understanding of 21st-century skills, and (2) application of these skills to design IT-based learning. In terms of 21st-century skills implementation, students demonstrate strong abilities and knowledge in understanding these skills and have already applied them in the chemistry learning process in the classroom, as evidenced by the teaching modules they have developed.

***Understanding 21st-Century Skills***

This aspect includes the ability to recognize, comprehend, and be aware of the importance of 21st-century learning. Students gain knowledge about 21st-century skills from various sources such as the internet, talk shows/seminars, workshops, and academic journals that provide definitions and explanations of these skills. The development of these skills is cultivated through habitual practices and the fulfillment of life needs based on knowledge. In the 21st century, learning is not solely reliant on knowledge, but also emphasizes the importance of skills within the learning process (Mardhiyah et al., 2021).

Students then study and understand the components that constitute 21st-century skills. Based on the questionnaire responses, nearly all students answered correctly, identifying skills such as creative thinking, critical thinking and problem solving, communication and collaboration, innovation, as well as media, information, and technology literacy. The importance of 21st-

century skills for education program students aligns with the opinion of Asri et al. (2023), in their work titled *"21st-Century Competencies as Provisions to Face Future Challenges"*, which states that relevant 21st-century skills for overcoming future challenges are based on the four pillars of life: learning to know, learning to do, learning to be, and learning to live together. Each of these pillars encompasses essential skills such as communication, collaboration, innovation, critical and creative thinking, problem-solving, and media, information, and technology literacy. Mastery of these skills is crucial to help students face future challenges; therefore, education program students must acquire and implement these competencies in the teaching and learning process.

***21st-Century Skills Implementation***

This aspect includes several statements related to the awareness of the importance of implementing 21st-century skills in chemistry instruction, the application of 21st-century learning models, and the integration of information, media, and technology skills into chemistry teaching. These skills are further reflected in the design of IT-based instructional modules.

To assess the implementation of 21st-century skills, students were asked, *"What learning models are commonly used in the chemistry learning process?"* The research findings indicate that students have applied 21st-century skills in their chemistry teaching practices. The learning models commonly employed by students in chemistry education are illustrated in the following graph.

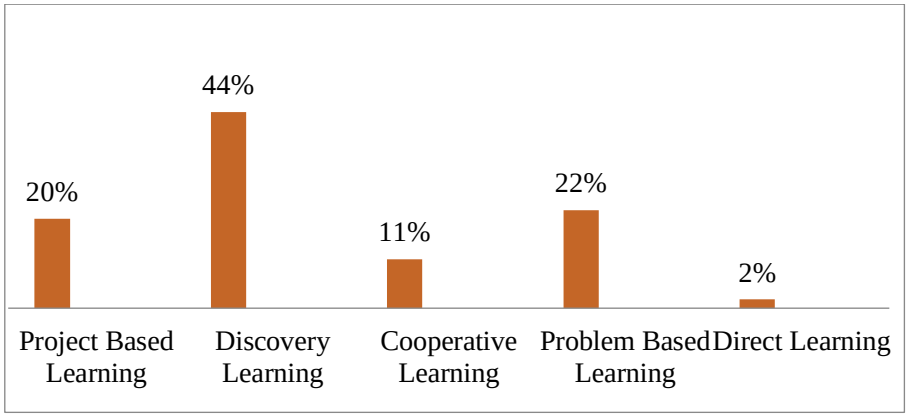


Figure 2. 21st-Century Learning Models Used by Students

The most frequently used learning model based on Figure 2 is the discovery learning model, with a percentage of 44% out of 45 student respondents. From the interview results, it was found that students frequently use the discovery learning model because they are more familiar with and confident in applying it. This model is used in several sessions within each learning module. Meanwhile, the problem-based learning model is applied to complex chemistry topics that are related to real-life issues, such as interpreting the relationship between moles and molar volume, or applying Proust's law to solve daily life problems, and other topics related to critical thinking and problem-solving. This is in line with the opinion of Nurmasita et al. (2023), who stated that problem-based learning (PBL) is a learning method that places students in real, contextual situations by presenting actual problems from daily life. This helps students construct knowledge to solve problems and explore knowledge independently.

The implementation of skill-based learning models in the learning process aims to build students' character in accordance with the needs and objectives of the curriculum, so that learning outcomes can be achieved optimally (Angga et al., 2022). A learning model is a form or framework of the learning process from beginning to end, presented by lecturers or teachers to make the learning process more effective and creative (Roza, 2018).

Then, in the aspect of 21st-century skills implementation, particularly in the statement regarding the application of information, media, and technology skills, students were asked the question: “What sources do you use to search for or obtain chemistry learning materials?” In this question, students were allowed to select more than one answer option based on the sources they use. The results of the respondents' answers regarding their skills in finding information on chemistry learning materials can be seen in the following chart.

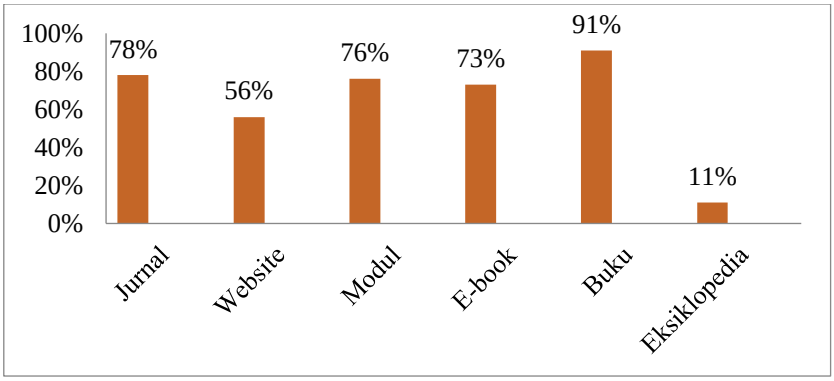


Figure 3. Sources Used by Students to Obtain Chemistry Learning Materials

The sources used by students to obtain chemistry learning materials can be seen in the chart in Figure 3. Based on responses from 45 students, the highest percentage 91% indicated that they used books. This is unsurprising, as textbooks remain one of the main learning resources in schools. However, teachers also play an important role as facilitators in developing the content found in books, since not all school textbooks contain complete or accurate information. Therefore, it is necessary to explore additional sources. This aligns with the opinion of Rahmawati (2015), who states that the rapid and widespread development of information through print and digital media presents a major challenge for information providers in ensuring the accuracy of book content. As such, we must assess whether the information in a book can serve as an appropriate reference to meet information needs or whether it may fall short. Consequently, students seek out various sources of information about the material to be studied in class, using resources such as journals, modules, trusted websites, e-books, and encyclopedias.

In the aspect of applying 21st-century skills related to media skills, students were asked the question: "Do you use instructional media in chemistry learning?" All students responded that they used learning media during the teaching and learning process in the classroom. Students utilized a variety of interactive learning media such as educational videos, educational games, web-based learning applications, and others that stimulate the learners' senses. Instructional media is very important for increasing motivation and interaction between educators and learners. This aligns with the view of Daniyati et al. (2023), who stated that learning media plays a vital role in improving the quality of education and instruction because it helps teachers explain learning materials in class more easily. It also makes the teaching and learning process more engaging, encouraging students to be more active, and making the material clearer and easier to understand. This, in turn, leads to more varied and interesting teaching methods. Using challenging learning strategies such as games can motivate students by introducing contextual interactive media that stimulates learning. Media also serves as a means of non-verbal communication, which means that as a component of the educational system, media is essential and must be utilized in every learning process (Rahmadani et al., 2020).

In the aspect of applying 21st-century skills related to technological skills, students were asked the question: “What types of technology have you used for learning chemistry?” In this question, students were provided with several answer options regarding the types of technology they have used. Students utilized various technologies such as smartphone applications,

PowerPoint, Word, Mentimeter, Spin Wheel, Canva, and Wordwall. These software tools include presentation media, interactive quizzes, and animations that allow students to create works resulting from their creativity. Educational technology software plays a crucial role in the modern teaching and learning process because it enhances student engagement and motivation. With the appropriate use of technology, teaching and learning become more effective, efficient, and engaging for everyone involved. This aligns with the opinion of Djarwo et al. (2024), who stated that the implementation of digital literacy—or the ability to use information technology (IT)—aims to improve the quality of chemistry learning and prepare students to be more competent in using technology in their daily lives and future careers. It also creates a more engaging and relevant learning experience for today's digital generation.

**Observation of IT-Based Learning Module**

An IT-based learning module is a learning resource or tool designed by utilizing information and communication technology to support the teaching and learning process. In the observation of the learning module design, there are six assessment aspects included, namely: 1)Learning objectives, 2)Learning materials, 3)Learning methods, 4)Use of technology, 5)Learning activities, 6)Assessment and evaluation.

In this study, the learning module designed by the 2021 batch of Chemistry Education students of FKIP UNTAN while participating in MBKM-IKM was said to be "Good". The following is a description of the results of observations of the learning module designed by students.

***Learning Objectives Aspect***

This aspect pertains to its alignment with the relevant competencies, assessed by examining whether the learning objectives correspond to the stipulated basic competencies and the indicators intended to be achieved in the instructional process. Observational findings were rated as "Good," indicating that all students had formulated learning objectives in accordance with the expected learning outcomes. The formulation of learning objectives constitutes a fundamental and primary step in designing the instructional process, ensuring that the intended goals can be effectively attained. This is consistent with the view of Puwarno and Naibaho (2023), who assert that a teacher's ability to formulate learning objectives encompasses the potential, knowledge, and skills required to define the expected behaviors or competencies to be demonstrated by students during the learning process. Such objectives should be articulated in a clear and operational manner, enabling them to be measured and evaluated appropriately.

***Learning Material Aspects***

In this aspect, three indicators were assessed, namely: content relevance, utilization of digital resources, and instructional video usage. Content relevance refers to whether the presented material aligns with the expected competencies. This aligns with the view of Magdalena et al. (2023), who define the principle of relevance as the relationship between the learning material and the attainment of competency standards and basic competencies. In this regard, the material presented by the students was found to be in accordance with the expected competencies.

Utilization of digital resources refers to the extent to which the material incorporates various digital sources, such as e-books, videos, online articles, and other resources that effectively support students' understanding. In their learning modules, the students utilized a range of digital resources to gather information related to the subject matter to be taught in class, including scholarly articles or journals, instructional videos, e-books, and other online literature. The use of digital resources in sourcing instructional materials is highly significant in the school context, as it provides broad access to information.

Digital resources such as e-books, journals, educational videos, and online learning platforms offer access to a variety of materials that may not be available in the school library, and they

can be accessed anytime and anywhere by both students and teachers. This is consistent with the view of Erlina and Ulfah (2022), who note that twenty-first-century learning integrates various technologies at every stage of interaction between students, teachers, and learning resources within an educational environment, with technology serving actively as a tool, a method, and even a primary source in supporting both the learning process and its implementation. The final indicator, instructional video usage, was evaluated based on the videos presented by students during the learning process. It was found that the videos primarily originated from YouTube, meaning that the students did not create or design the instructional videos themselves. From the results of informal interviews, students stated that their ability to produce their own instructional videos was hindered by limited access to adequate facilities—such as computers, laptops, or smartphones—as well as time constraints. Furthermore, some students reported lacking intrinsic motivation to develop their own instructional videos.

### *Learning Method Aspects*

This aspect comprises two assessment indicators, namely interactivity and media variety. *Interactivity* refers to the use of instructional methods that leverage technology to enhance student engagement, such as online discussions, interactive quizzes/games, and similar activities. In this regard, students utilized various easily accessible software tools for learners, including Quizizz, interactive games, Mentimeter, Spin Wheel, Wordwall, as well as platforms such as Padlet and Google Forms, alongside online discussion and question-and-answer sessions conducted via smartphones.

With respect to the *media variety* indicator, students employed a diverse range of media, including audio, video, and stimulus images, to engage learners' senses during the learning process. Notably, stimulus images were consistently used in every meeting, with the aim of providing learners with a visual representation of the subject matter to be delivered. Thus, students have applied IT-based instructional methods that integrate both interactivity and media variety. The significance of these two indicators lies in their capacity to enhance learner engagement and clarify complex concepts. This aligns with the view of Munawir et al. (2024), who state that one of the factors influencing students' learning motivation is the use of instructional media during the learning process. Alongside advances in information and communication technology, various new innovations have been developed to create interactive learning media capable of capturing students' interest. The numerous benefits of instructional media necessitate that teachers possess the ability to develop such media in the digital era to achieve educational goals (Lillihata et al., 2022).

### *Aspects of Technology Use*

This aspect comprises two assessment indicators, namely appropriateness of tools and applications and ease of access. The tools or applications employed are intended to support the attainment of learning objectives and ensure accessibility for learners, such as presentation software, interactive quizzes, and simulations. In this regard, the students utilized PowerPoint, Canva, Mentimeter, and Wordwall to create interactive games, quizzes, and crossword puzzles. They also consistently implemented simulations at the beginning of lessons to engage learners' visual and auditory senses through educational audio or video materials related to the subject matter. The technological hardware used included laptops, projectors, and smartphones, while the aforementioned applications were easily accessible to learners. Within this aspect, the students demonstrated proficient mastery in the use of technological tools and applications, aligning with twenty-first-century skill requirements.

### *Aspects of Learning Activities*

This aspect consists of three assessment indicators: alignment with IT-based methods, application of twenty-first-century learning models, and creativity. *Alignment with IT-based*

*methods* refers to the effective utilization of IT features in learning activities, such as online collaboration, discussion forums, and online assessments. In this context, some students employed discussion forums via platforms such as Google Classroom and WhatsApp; however, several others did not make use of online discussion forums. Based on interview findings, some students reported that not all learners possessed smartphones, and the number of available devices was limited, leading them to conduct discussion forums offline in the classroom.

For online assessments, students utilized Google Forms and Quizizz to evaluate learners' final knowledge outcomes. Nevertheless, similar to the discussion forum case, not all students implemented IT-based assessment methods, citing limitations on the part of both learners and schools, particularly due to unstable internet connectivity.

Table 10. Data on learning models applied by students in the teaching module.

| No. | Learning Model | Number of students |
|---|---|---|
| 1. | Problem Based Learning | 19 People |
| 2. | Discovery Learning | 21 People |
| 3. | Project Based Learning | 1 People |
| 4. | Inquiry Learning | 4 People |

Based on the data, the results of the observation of students' learning modules and the findings from informal interviews indicate that the majority of students employed the *discovery learning* and *problem-based learning* models. This preference is due to their greater familiarity and mastery of these models. In contrast, the *project-based learning* model was implemented by only one student, as it aligned with the intended learning objective of producing a tangible project, such as the creation of instructional videos, practical experiment videos, or posters designed by learners. The *inquiry learning* model was adopted by only a few students. Overall, all students demonstrated the application of twenty-first-century learning models during the teaching and learning process.

The subsequent assessment indicator under the learning activity aspect is creativity. Observations of the students' learning modules revealed that they effectively utilized various IT software features, including Mentimeter, Wordwall, PowerPoint, and many others, which were integrated into the design of their modules. Informal interviews further showed that Quizizz and Google Forms were the most frequently used applications due to their accessibility for learners and suitability for time constraints. For offline interactive games, students reported opting for online interactive games instead, as limited class time restricted their ability to implement offline versions.

From these findings, it can be concluded that students possess the capability to design IT-based learning activities that incorporate creative and innovative thinking. This is consistent with the assertion of Junanto and Sartika (2023) that creative thinking is an essential skill and competency to be cultivated among learners, students, teachers, lecturers, and the general public to develop a strong competitive edge in the twenty-first century.

### *Assessment and Evaluation*

This aspect contains a single assessment indicator for the learning module, namely IT-based assessment. The related statement refers to the conduct of assessments utilizing technology, such as online quizzes, digitally based assignments, and similar activities. Based on observations of the designed learning modules, it was found that nearly all students employed Quizizz as a tool for final evaluation in class and assigned projects to learners, such as creating posters and simple practical experiment videos. However, the observations also revealed that some students still conducted summative assessments through written tests.

Nevertheless, in terms of IT-based assessment and evaluation, the students were generally categorized as "Good" in their ability to effectively utilize IT, consistently making efforts to explore and maximize their own potential.

## CONCLUSION

The study findings indicate that students have demonstrated good competence in integrating information technology into the learning process. They effectively applied various IT tools and applications, such as Quizizz, Google Forms, Mentimeter, Wordwall, Canva, and PowerPoint, for instructional delivery, media integration, collaboration, and assessment. Commonly used models included discovery learning and problem-based learning, with some application of project-based and inquiry learning. Despite challenges such as limited devices, unstable internet, and minimal original video production, students consistently utilized IT to enhance engagement, support learning objectives, and foster creativity. Overall, they met the criteria for effective twenty-first-century, technology-enhanced teaching. The profile of IT-based lesson design competence among Chemistry Education students of FKIP UNTAN, as prospective teachers, falls within the "Good" category. In terms of the overall profile of IT-based lesson design skills, the average score across all assessed aspects was 86% ("Very Good"). From the perspective of implementing twenty-first-century skills, the students demonstrated a sound understanding of these skills and were able to apply them effectively in designing IT-based learning within their lesson modules. This is further supported by observation results, which showed that the lesson modules developed by the students were in accordance with the criteria for IT-based lesson design.

## RECOMMENDATIONS

Based on the results of the study, the researcher hopes to always maintain what is already good so that in the future it will be even better, because the research conducted only shows how the profile of students' abilities in designing IT-based learning and has not reached the stage of how to improve the ability to design IT-based learning in students. As well as the limitations of the author in writing each existing writing. The ability to design IT-based learning can be improved by increasing digital literacy, integrating IT into the curriculum, and practicing IT-based learning and understanding the positive and negative impacts in the world of technology and information.

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