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Profile of Students' Needs Analysis for the E-Module of Statistical Physics on the Topic of Quantum Statistics Applications to Other Systems

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Abstract. *Lecturers, as facilitators, must effectively fulfill their role in providing instructional materials that enhance students' understanding of the course content. This study aims to analyze students' needs for teaching materials in Statistical Physics, specifically focusing on the application of quantum statistics to other systems. A quantitative survey method was employed for this research. The participants were 50 Physics education students at Jambi University, all of whom had enrolled in the Statistical Physics course. Data were collected through a questionnaire designed to assess students' preferences for the teaching materials they require. The findings reveal that the majority of instructional resources and materials used by instructors are printed textbooks. Furthermore, 94% of students indicated a preference for digital teaching materials, such as e-modules, to facilitate learning. Based on these results, there is a clear need for the development of e-modules as a practical and mathematical resource to address the challenges students face in comprehending Statistical Physics content.*

Keywords*: digital teaching materials, e-module, physics statistics, student needs, teaching materials*

INTRODUCTION

The advancement of technology and information has had a significant impact on various aspects of life, including education. The positive effects of technological development influence future learning processes, requiring adaptations in teaching methods and learning media (Nurdin, 2016;suci rahayu rais et al., 2018). One of the factors that influences the learning process is the use of appropriate and effective teaching materials.

Teaching materials play a crucial role in the learning process as tools that assist educators in transferring knowledge and values effectively while engaging students (Raharjo & Ringga Persada, 2020; Imswatama & Lukman, 2018). Teaching materials are a set of learning tools that contain the learning content, methods, limitations, and evaluation techniques, systematically and engagingly designed to achieve the expected goals, namely to attain competencies or sub-competencies with all their complexities (Fajriah & Churiyah, 2016). Teaching materials are any form of resources used to assist teachers/instructors in conducting teaching and learning activities in the classroom (Aditia &Muspiroh, 2013; Zulmaulida et al., 2014). Engaging teaching materials will make students feel comfortable during the learning process and can certainly assist them in understanding the material, thereby improving learning outcomes. The use of teaching materials in learning activities benefits students in several ways, including sparking motivation, fostering creativity, providing initial knowledge, reinforcing concepts, contributing to the development of various skills and the

acquisition of values, as well as enhancing retention of knowledge, skills, and attitudes. Teaching materials can be categorized into three types: audio, visual, and audiovisual (Sumiati et al., 2017), which are essential for enhancing modern learning experiences. Teaching materials can be categorized into printed and non-printed materials. Printed teaching materials are those that present content in physical form, using printed media such as paper, with a simple creation process that requires minimal technological assistance. On the other hand, non-printed teaching materials are those that present content in digital and visual formats, offering attractive and interactive designs that require technology for their creation (Rijalul et al., 2022 ; Kurniawati, 2015).

21st-century learning emphasizes the use of information and communication technology-based learning, such as the use of digital teaching materials. The use of digital teaching materials is a selection of resources that align with current advancements and can make the learning process more effective and efficient, ultimately enhancing students' abilities (Handoyo et al., 2022 ; Asrowi et al., 2019). One of the teaching materials that support effective and interactive teaching and learning in the classroom is the e-module. An e-module is a digital teaching material that is practical, interactive, and flexible, serving as an independent learning resource that can be used anytime and anywhere (Adie Perdana, 2017; Triwahyuningtyas et al., 2020). This is in line with the research Wahyu Pinilih & Masykuri, (2016) That e-modules can enhance students' understanding, which can be retained in the long term. E-modules present material that is easy to learn independently, accessible, and user-friendly for communication and collaboration between students and teachers, with various content in the form of text, images, videos, and audio.

Statistical Physics is a course at the undergraduate level of the Physics Education Study Program at Jambi University. Statistical physics connects the microscopic scale (individual particles) with the macroscopic scale (overall system properties). For example, the temperature of a gas is not a property of a single particle but rather the result of the average kinetic energy of the particles in the system. Statistical physics aims to explain how macroscopic properties of a system emerge from the microscopic behavior of its particles, either through classical mechanics or quantum mechanics, to study macroscopic properties of systems, such as ideal gases, from the perspective of microscopic behavior. The learning objectives in the Statistical Physics course require students to systematically, structurally, and deeply understand the concepts of physics related to the macroscopic properties of a system from a microscopic perspective. Therefore, the teaching materials used in the course play a crucial role in determining the success of the course. However, printed textbooks often have limitations in their presentation, which are theoretical and lack real-life application examples of the concepts being studied, making it difficult for students to construct their understanding. Concepts are fundamental elements that students must possess in the course. Designing teaching materials requires a comprehensive and well-structured approach to ensure educators can use them as effective tools that fully support the learning process (Ardiansyah et al., 2016). In terms of visualization and ease of understanding concepts, students need engaging, modern, flexible, and well-structured teaching materials that can be studied independently and are interactive to enhance their understanding of Statistical Physics.

This study aims to identify the specific teaching materials required by students and propose the development of e-modules to support independent and effective learning in Statistical Physics at Universitas Jambi. Through a questionnaire, the results of this research are expected to provide insights into the types of teaching materials that students can use in class for independent learning, thereby enhancing their ability to understand Statistical Physics, specifically in the topic of applying quantum statistics to other systems.

METHOD

This study is a quantitative research applying a survey method. The research was conducted at the Physics Education Study Program, Faculty of Teacher Training and Education, Universitas Jambi. The research subjects consisted of 50 students who had enrolled in the Statistical Physics course.

This sample represents the entire population of eligible students for the study. The sampling technique used was total sampling, where the researcher conducted the study on the entire sample population (McFadden, 2015; Mueller, 2008). Data for this study were collected through questionnaires completed by the research subjects to identify the teaching materials needed. This study aims to address students' challenges in understanding Statistical Physics, particularly in applying quantum statistics to different systems, by providing targeted teaching materials. The data collection instrument employed a Likert scale approach, specifically a 5-point Likert scale. The data analysis technique involved analyzing the quantitative data descriptively, categorizing the data, and then compiling the conclusions narratively. According to Agustina et al. (2017), the response scale for the observation and needs analysis questionnaire used a 1-5 Likert scale.

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Table 1. Scale Category

Scale	Category
1	Strongly Disagree
2	Disagree
3	Slightly Agree
4	Agree
5	Strongly Agree

To calculate the percentage of each student's response, the following formula is used :

$$Y = \frac{\sum P}{\sum Q}\ x\ 100\%$$

Explanation:
Y = Calculation result/Percentage of student responses
P = Score
Q = Maximum score

To ensure that the calculation results can be translated back into the response scale, an interpretation scale is required, as shown in Table 2

Tabel 2. Total percentage

Percentage (%)	**Category**
80 - 100	Strongly Agree
60 - 80	Agree
40 - 60	Slightly Agree
20 - 40	Disagree
0 - 20	Strongly Disagree

FINDING

The data was obtained through the analysis of a questionnaire distributed regarding Statistical Physics learning and the teaching materials needed by students. The questionnaire consisted of 11 statements. Table 3 provides in-depth information about the student's perceptions regarding Statistical Physics learning.

Table 3. Results of Students' Perceptions Regarding Statistical Physics Learning

Item	**Percentage (%)**
Students enjoy the Statistical Physics course.	Strongly Disagree (0) Disagree (0) Slightly Agree (10) Agree (68) Strongly Agree (22)

For students, the Statistical Physics course is difficult and boring.	Strongly Disagree (0) Disagree (4) Slightly Agree (78) Agree (18) Strongly Agree (0)
Students face difficulties in learning Statistical Physics, particularly in the topic of quantum statistics applications to other systems.	Strongly Disagree (0) Disagree (0) Slightly Agree (18) Agree (74) Strongly Agree (8)
Students review the Statistical Physics material at home.	Strongly Disagree (0) Disagree (12) Slightly Agree (66) Agree (22) Strongly Agree (0)
Students have a reference book for the Statistical Physics course.	Strongly Disagree (0) Disagree (14) Slightly Agree (16) Agree (80) Strongly Agree (0)
The majority of teaching materials used in Statistical Physics are printed books.	Strongly Disagree (0) Disagree (0) Slightly Agree (0) Agree (40) Strongly Agree (60)
Students seek additional learning materials to help them understand Statistical Physics independently.	Strongly Disagree (0) Disagree (0) Slightly Agree (0) Agree (88) Strongly Agree (12)
Students enjoy technology-based teaching materials (digital materials).	Strongly Disagree (0) Disagree (0) Slightly Agree (6) Agree (68) Strongly Agree (26)
Students have not used e-module teaching materials before.	Strongly Disagree (0) Disagree (0) Slightly Agree (20) Agree (72) Strongly Agree (8)
Students need digital teaching materials that contain concepts related to everyday life phenomena, such as e-modules.	Strongly Disagree (0) Disagree (0) Slightly Agree (0) Agree (60) Strongly Agree (40)
Students agree that e-modules should be developed as an alternative teaching material that can be understood independently for the Statistical Physics course, particularly in the topic of quantum statistics applications to other systems.	Strongly Disagree (0) Disagree (0) Slightly Agree (0) Agree (90) Strongly Agree (10)

The results presented in Table 3 are classified into several categories, including students' responses to course material, the need for varied teaching materials, responses to e-modules, and requests for

the development of digital teaching materials. The findings from each of these categories are outlined as follows.

Students' Responses to Course Material

The study investigated students' responses to the Statistical Physics course material using four survey statements, which highlighted mixed perceptions regarding engagement, difficulty, and study habits. For Statement 1, 90% of students expressed interest in studying Statistical Physics, with 28% strongly agreeing and 68% agreeing. This overwhelmingly positive response suggests that students find the subject matter appealing, potentially due to its intellectual challenge and relevance to their academic goals. However, this enthusiasm is juxtaposed with the results of Statement 2, where 78% of students slightly agreed that the course content was both difficult and uninteresting. This divergence implies that while students recognize the importance of the subject, they struggle to remain engaged due to the complexity of the material or the methods used in its presentation.

Statement 3 delved deeper into these challenges, revealing that 82% of students agreed that they faced significant obstacles in understanding quantum statistics applications to other systems. This is a particularly advanced topic in Statistical Physics, which may require more innovative instructional approaches, such as visual aids, real-world problem-solving exercises, or interactive simulations, to bridge the gap between theoretical understanding and practical application. Finally, Statement 4 examined students' study habits, with 66% slightly agreeing and 22% agreeing that they reviewed course material at home. This lukewarm response suggests a need to foster a more engaging and supportive learning environment that motivates students to explore and revisit complex concepts outside of lectures independently. The low inclination to study independently may be attributed to the perceived difficulty of the course and the lack of accessible learning resources tailored to students' needs. In conclusion, while students exhibit a strong interest in Statistical Physics, their challenges in comprehending and engaging with the material underscore the importance of revisiting instructional design. Providing simplified explanations, incorporating diverse teaching methodologies, and enhancing the availability of supporting resources can significantly enhance the overall learning experience.

Need for Varied Teaching Materials

Statements 5 through 8 shed light on students' perspectives and preferences regarding the learning materials available for the Statistical Physics course. Statement 5 revealed that 80% of students agreed on the necessity of having a dedicated reference book for the course. This underscores the importance of core materials to provide foundational knowledge and structure for students' learning. However, Statement 6 highlighted a notable limitation: all students (100%) reported that the primary learning resources currently available are traditional printed textbooks. While these resources have long been a cornerstone of academic instruction, they may not align with the evolving needs of students in the digital era. Printed textbooks, though reliable, lack the interactivity and flexibility that digital resources can offer, potentially limiting engagement and accessibility for students accustomed to technology-driven learning environments. Further emphasizing the need for more dynamic materials, Statement 7 demonstrated that 100% of students (12% strongly agree, 88% agree) actively sought additional resources to enhance their independent understanding of Statistical Physics. This proactive approach by students suggests gaps in the comprehensiveness or appeal of the current materials. Additionally, Statement 8 revealed that 94% of students expressed a strong preference for technology-based resources, such as digital learning aids or interactive

content. This trend reflects a broader shift in educational preferences, as students increasingly gravitate toward materials that integrate multimedia elements, provide immediate feedback, and offer accessibility across various devices.

The combined findings of Statements 5 to 8 present a compelling case for the integration of modern, technology-enhanced teaching materials in the Statistical Physics curriculum. Digital learning tools, such as e-books enriched with animations, interactive problem-solving platforms, or video-based tutorials, can bridge the gap between theoretical knowledge and practical understanding. Such resources not only accommodate diverse learning styles but also empower students to engage with complex concepts more effectively and independently. By addressing these needs, educators can foster a more inclusive and adaptive learning environment that aligns with students' expectations and the demands of contemporary education.

Request for Developed Teaching Materials

The final three statements (Statements 9, 10, and 11) emphasize a strong demand for learning resources that are engaging, flexible, and conducive to independent study. Statement 9 revealed that 80% of students reported never having used e-modules as a form of digital learning material in their studies. This indicates a significant gap in the integration of technology-based learning tools within the Statistical Physics curriculum. Despite this lack of exposure, Statement 10 demonstrated unanimous agreement (100%, with 60% strongly agreeing and 40% agreeing) on the need for digital learning materials, such as e-modules, that connect theoretical concepts with real-world phenomena. Such resources not only help contextualize abstract topics but also make the learning process more relatable and engaging for students.

Statement 11 provided further insights, with all students (100%) expressing strong support for the development of digital learning materials in the form of e-modules specifically tailored to the Statistical Physics course. These e-modules would focus on the quantum statistical applications to other systems, enabling students to understand complex materials better independently. This overwhelming support underscores a clear student preference for innovative resources that enhance autonomy in learning and foster a deeper understanding of challenging topics.

The findings from Statements 9, 10, and 11 collectively highlight critical areas for improvement in the current learning environment. The lack of exposure to e-modules (Statement 9) suggests a missed opportunity to utilize digital tools that cater to contemporary learning preferences. E-modules, which integrate multimedia elements such as animations, simulations, and interactive assessments, have been shown to increase student engagement and improve knowledge retention.

The strong endorsement for e-modules that connect theoretical concepts to everyday phenomena (Statement 10) aligns with pedagogical best practices. Contextualizing abstract ideas, particularly in subjects like Statistical Physics, helps bridge the gap between theory and application, making the subject matter more tangible and meaningful for students. Furthermore, the unanimous support for independently understandable e-modules (Statement 11) reinforces the need for materials that support self-paced learning, an essential feature for accommodating diverse learning speeds and styles.

DISCUSSION

The analysis results presented in Table 3 provide an opportunity to observe trends, challenges, obstacles, and needs within the context of the Statistical Physics course. One of the main challenges faced by students in the learning process is the effort required to understand the course material with the available teaching materials. Despite their interest in the subject, students struggle to grasp complex topics due to the limited accessibility and interactivity of traditional printed materials. This highlights the need for more engaging, accessible, and interactive teaching resources that can better support students in comprehending the course content, particularly when dealing with abstract and challenging concepts in Statistical Physics (Matcha et al., 2020; Ulzheimer et al., 2021).

There is a tendency to choose technology-based teaching materials in the form of digital learning resources. The 21st-century generation is more interested in technology-based (digital) teaching materials because they make the learning process more engaging, offering the convenience of delivering content (theory in articles through digital e-modules). Digital materials not only enhance student engagement but also provide flexibility in how and when they can access the content, supporting self-directed learning and making complex concepts more accessible. This shift aligns with the growing demand for innovative, interactive, and easily accessible learning tools (Esteve-Mon et al., 2023; Ma, 2021; Rice & Ortiz, 2021; Ulzheimer et al., 2021).

The flexibility and interactivity offered by digital teaching materials help students learn more independently and stay motivated. In challenging learning situations, interactive features provide opportunities for active student engagement, reducing the boredom often associated with conventional, print-based learning. The limitations of print media, such as textbooks, in being used effectively open up opportunities for integrating additional teaching materials with current information technology. This integration supports the achievement of 21st-century skills by enhancing learning experiences and enabling students to interact with content in dynamic and personalized ways (Kimianti & Prasetyo, 2019).

One type of teaching material that can facilitate the characteristics of learning for the digital native generation is interactive multimedia-based teaching materials, such as e-modules. An e-module is a form of self-learning material that is systematically organized in the learning sections and presented in an electronic format (Chang et al., 2014; Hung & Young, 2021; Kamisah Osman et al., 2012; Kannan et al., 2022; Saputra & Razak, 2020). E-modules can be designed interactively to strengthen learning, one of which is by providing reflective tasks that stimulate students' curiosity (Dunleavy et al., 2022; Fadieny & Fauzi, 2021; Kwant et al., 2015; Sanders et al., 2014; Wang, C., Zhang, Y., Ding, H., 2023). Given the support for the development of technology-based teaching materials, the development of an interactive e-module for Statistical Physics on Statistical Physics material should be carried out to address the difficulties students face in understanding the topics presented. Student's difficulties in the Statistical Physics course so far include insufficient explanations of formulas and example problems, which have not been linked to contextual physics phenomena (Laufer et al., 2021; Paniagua & Simpson, 2018; Suppan et al., 2020; Wojniusz et al., 2022). The limitations of this study have not fully provided information on the specific specifications of the e-module that need to be developed. For example, it has not been determined whether the e-module should be integrated with a learning model that aligns with the students' conditions. Therefore, further in-depth analysis is required, such as an analysis of the content and learning objectives.

CONCLUSION

Based on the needs analysis conducted, the results indicate that students face difficulties in understanding the content of the Statistical Physics course, particularly regarding the application of quantum statistics. The most commonly used learning resource by both lecturers and students in the teaching process is printed textbooks. There is a clear tendency among students for a diverse range of learning materials, with 94% of students expressing the need for technology-based learning

resources (digital learning materials) that are practical and systematic. Therefore, the development of e-modules is crucial as a solution to address the challenges students face in comprehending the course content of Statistical Physics and to enhance the learning experience. The e-modules should be designed systematically and interactively to make learning more engaging and enjoyable. The development of such materials will provide students with an innovative and flexible way to study independently, thus improving their understanding of complex topics and fostering greater engagement in the learning process. By incorporating multimedia elements, interactive features, and real-world applications, e-modules can bridge the gap between theoretical concepts and practical applications, supporting students in mastering the material effectively and efficiently.

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