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Impact of Career Integrated STEM Topic "Biomedical Research and Product Development" Grade 10 Students' Career Interests and Academic Performance

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Abstract. Career orientation is a crucial objective of STEM education activities. In this research, a STEM topic was organized following the scientific research process, where students assumed the roles of researchers developing biomedical products. They formulated an experimental plan to evaluate the antibacterial efficacy of alcohol and silver nanoparticles on bacteria sourced from hands. The STEM Career Interest Survey tool by Kier et al. (2014) was adapted and administered before and after the STEM experiential activity to assess changes in students' career interests. Additionally, students' career orientation competency was recorded based on the results of Q&A sessions, written tests, and their learning products. The level of achievement in biology competency through the STEM topic was evaluated based on the results of competency assessments and the students' learning products. A pedagogical experiment involving 44 tenth-grade students demonstrated that they had developed competencies in understanding the living world, an essential aspect of career orientation related to scientific research. Moreover, a t-test validation of the career interest survey results before and after the pedagogical experiment indicated significant increases in personal goals, student preferences, and interest in Technology and Engineering fields. Through the written test conducted after the STEM topic, students also clearly articulated their thoughts on the prospects, qualities, and essential competencies needed as biomedical product research specialists and self-assessed their suitability for this career.

INTRODUCTION

Contemporary educational researchers have been increasingly focusing on the integration of vocational education for students through subject-specific instruction (Schmidt, 2003) (Yoto, 2016). According to Social Cognitive Career Theory, interest, self-efficacy beliefs, and outcome expectations are factors that influence an individual's career choice and pursuit tendencies học (Lent, 1994). Among these, interest plays a crucial role; in other words, an individual interested in a particular field or profession is more likely to establish specific goals and actions to attain that professional position in the future. Organizing subject teaching with close professional relevance creates numerous opportunities for students to develop awareness and interest in specific related professions during the learning process. Research (Hutchinson & Bentley, 2011) indicates that students tend to approach subject teachers to clarify career-related queries rather than seek advice from school counselors.

STEM education is a teaching model that has garnered attention and promotion in many countries due to its alignment with contemporary trends, aiming to enhance the workforce in STEM fields. According to Shahali, to attract young people to natural science and engineering professions, it is necessary to improve their awareness of these fields by developing appropriate programs or activities (Shahali, 2017). Designing STEM activities that promote practical engagement linked to real-world occupations will help students gradually form career awareness and develop relevant competencies. Secondary school students need accurate information and appropriate guidance on STEM careers to make effective career choices and pathway decisions. Therefore, enhancing students' attitudes and awareness of STEM professions is crucial to lead to career aspirations in these fields (Wyss, 2012). To this end, STEM subject teachers, including those in science, mathematics, engineering, and technology, play a vital role in providing learning experiences and supporting students' interest in STEM learning and career orientation. According

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to (Wiebe, 2018), students' attitudes toward STEM careers remain stable and balanced during their high school years. Consequently, integrating career guidance in STEM education for science subjects in secondary schools is essential.

Cohen & Patterson (2012) posited that to ensure practical career orientation in STEM-related subject teaching, learning activities should encompass four cognitive-behavioral career development blocks: (1) Awareness - understanding of the profession; (2) Relevance - the connection between the profession and daily life; (3) Engagement - participation in activities related to STEM professions; and (4) Self-Efficacy - confidence in performing profession-related tasks (Cohen, Carolyn, & Davis G. Patterson, 2012). To develop self-efficacy, students require a nurturing process to form career-related competencies, specifically through experiencing career-related content during their learning process. Cohen asserts that career awareness and understanding are crucial components students need for career orientation. Opportunities to participate in appropriate career experience activities contribute to enhancing career awareness. Motivation towards STEM careers depends on the level of engagement in STEM activities and the presence of role models in STEM fields (Dökme, 2022). With its dual approaches to scientific research and engineering design, STEM education initially facilitates students' career orientation. STEM topics integrating career guidance create an environment for students to perform tasks in specific professional contexts, based on the work processes of scientists or engineers. The combination of specific contexts, professional positions, and appropriate activity processes forms the crucial foundation of STEM education integrated with career guidance, fully meeting the characteristics of STEM education and the career development blocks of school-based career guidance.

In Vietnam, the 2018 General Education Curriculum emphasizes the importance of career orientation for students and also promotes STEM education to create an environment for students to apply knowledge and skills in science, technology, engineering, and mathematics to solve practical problems (Ministry of Education and Training, 2018)). The integration of STEM education into career guidance activities enables students to access new professions (Nguyen, Tuong, & Tran, 2020). As an experimental science subject, biology has close connections with real-life practices and STEM professional fields. The content of Microorganisms and Viruses in the 10th-grade Biology curriculum is closely linked to scientific research activities aimed at developing technological product manufacturing processes based on applying microbiological knowledge to practice. This content has the potential to develop STEM education and contribute to career education for students (Adkins, 2018) (Nguyen P. L., 2024) (Teresa, Girón-Gambero, & García-Ruiz, 2022)

The research aims to develop a STEM experience activity integrating career education titled "I am a Biomedical Researcher and Product Developer" in teaching Microbiology and Virology content. This activity is designed to increase students' career interests, enhance learning effectiveness, and improve their career orientation competencies.

Research methods

STEM topic implementation

The STEM topic "I am a Biomedical Researcher and Product Developer" is structured according to the scientific research process, comprising a series of five learning activities that closely align with the professional activities of a biomedical researcher and product developer. This STEM topic is experimentally implemented over three classroom periods and one laboratory period, each lasting 45 minutes, supplemented by home-based work. The teacher conducts the initial direct instruction session, encompassing Activity 1 - Formulating Research Questions and Activity 2.1 - Investigating Background Knowledge. Subsequently, the teacher assigns specific guidelines for students to execute Activity 2.2 - Developing an Experimental Plan, as a home-based task. The teacher then facilitates one session dedicated to Activity 3 - Defending the Experimental Plan, followed by another session for Activity 4.1 - Conducting the Experiment. Afterward, the educator provides detailed instructions for students to complete Activity 4.2 - Observation, Analysis, and Conclusion Drawing, as an independent home assignment. Finally, Activity 5 - Sharing, Discussion, and Refinement is conducted directly in class.

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Participants

An experimental study was conducted with 44 10th-grade students in Ho Chi Minh City, including 20 female students (45.5%) and 24 male students (54.5%). All students are learning in the form of STEM experiential activities for the first time, so they have absolutely no experience with the scientific research process. Facilities for experiments ensure adequate equipment, creating favorable learning conditions for students.

Data Collection

We employed a multi-faceted data collection approach to assess the efficacy of STEM experiential activities on students' STEM career interests, career orientation competencies, and academic performance. This methodology encompassed video recordings, observational note-taking, analysis of students' learning outputs, and survey questionnaires. The data collection instruments corresponding to each evaluation criterion are systematically presented in Table 1.

TABLE 1. *The assessment tools utilized in pedagogical experimentation.*

	Assessment objectives	Assessment tools
1	STEM career interest	STEM-CIS survey
2	Career orientation	Written test Learning products
3	Study effectiveness	Observation; Q&A Learning products

In this study, we employed the translated version of the STEM Career Interest Survey (STEM-CIS) (Le, Quan, & Le, 2024). The questionnaire comprises 30 items addressing four primary factors: self-assessment of personal competence, personal goals, outcome expectations, and STEM career interest. Responses were collected using a 10-point Likert scale, where 1 indicates strong disagreement, and 10 signifies strong agreement.

Career orientation competency manifestations were evaluated based on oral questioning results, written tests, and students' learning outputs. Through career guidance activities integrated into the instructional process, the STEM topic "I am a Biomedical Researcher and Product Developer" addresses three essential requirements of career orientation competency: (1) Articulating societal needs for various professions and their development within society; (2) Analyzing the requisite qualities and competencies of professionals in the field; (3) Demonstrating interest in the profession or career field and regularly engaging in activities within that professional domain. The oral questioning and written tests included essay questions requiring students to present their understanding of the biomedical research and product development profession and self-identify their personal qualities and competencies aligned with the profession.

Results and discussion

STEM Experiential Activity Topic Integrated with Career Education: "I'm a Biomedical Product Research and Development Specialist

Context and Career Description

Biomedical science is an applied scientific discipline that integrates fundamental biological principles (such as cellular and molecular biology) with scientific and engineering principles (including mechatronics, information technology, artificial intelligence, etc) to develop medical devices and solutions in medicine and biology. These innovations aim to enhance healthcare services, prevention, diagnosis, and treatment of diseases. Biomedical science forms the foundation of the healthcare technology industry, valued at hundreds of billions of dollars annually,

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encompassing medicine, pharmaceuticals, cosmetics, and functional foods. New product development involves creating or improving existing products with features that meet target demographics' needs.

Biomedical product research and development experts/specialists work in research departments of pharmaceutical and cosmetic companies or in market development roles at pharmaceutical and cosmetic manufacturing and distribution companies. They belong to the Scientific Research and Technological Development sector in medical engineering. Their responsibilities include developing proposals, plans, and implementing new product research projects; Researching production formulas, manufacturing processes, and raw material standards; Evaluating and monitoring product stability; Conducting laboratory-scale product trials and cost calculations; and Scaling up production from research to industrial levels.

Lesson topic objectives

The content of Microbiology and Virology in the 10th-grade Biology curriculum is closely linked with scientific research activities aimed at developing technological products based on the practical application of microbiological knowledge. Specifically, theories on microbial metabolism, growth, and reproduction serve as the foundation for establishing production processes for fermented foods and beverages, agricultural and environmental treatment preparations, and medical products for infectious disease prevention.

Certain cleaning products and hand sanitizers incorporate silver nanoparticles into everyday life to enhance long-term antibacterial efficacy. The question arises: How can we verify that products containing silver nanoparticles exhibit prolonged antibacterial effects as advertised? Based on the responsibilities of biomedical product research and development specialists, which include planning and implementing new product research projects, studying production formulas, manufacturing processes, raw material standards, and evaluating product stability, students in this STEM topic will assume the role of biomedical product research and development specialists. Their task is to investigate the duration and effectiveness of antibacterial properties in alcohol (conventional hand sanitizer) and silver nanoparticles (hand sanitizer containing silver nanoparticles) to assess the quality of the company's nanosilver products. The specific requirements are as follows:

(1) Design an experiment to investigate the antibacterial properties of silver nanoparticles and alcohol (ensuring accuracy, repeatability, and objectivity in the experimental setup…).

(2) Observe and collect experimental results.

(3) Compare experimental results with hypotheses, explain findings, and draw conclusions from the experimental results.

In order to accomplish this task, students need to explore various microbiological research methods and factors affecting microbial growth. They will also need to implement specific microbiological research techniques, such as microbial cultivation and investigation of factors influencing microbial growth.

TABLE 2. *Objectives of the STEM topic*

Competencies	Requirements to be achieved in the National General Education Program	Lesson objectives
Biological Competence	- Be able to describe some methods of studying microorganisms (NTSH_1.2). - Be able to practice some common methods of studying microorganisms (THTGS_3). - Be able to describe the factors affecting the growth of microorganisms (NTSH_1.2).	[SH1] Be able to describe some methods of studying microorganisms. [SH2] Be able to explain the method of culturing microorganisms on an agar plate using an inoculation loop. [SH3] Be able to propose an experiment to examine the bactericidal effect of alcohol and silver nanoparticles. [SH4] Be able to set up an experiment to examine the bactericidal effect of alcohol and silver nanoparticles. [SH5] Be able to practice some methods of studying microorganisms. [SH6] Be able to explain and draw conclusions

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		from the experimental results (propose improvements to the experiment setup if necessary). [SH7] Be able to apply the factors affecting the growth of microorganisms to explain the bactericidal mechanism of alcohol and silver nanoparticles. [SH8] Be able to describe the factors affecting the growth of microorganisms.
Career orientation	- Be able to describe the societal demand for various professions and their development in society (DHNN_1.3). - Be able to analyze the required qualities and competencies of professionals (DHNN_1.2). - Be able to demonstrate an interest in a profession or field of work and regularly engage in activities related to that profession (DHNN_2.1).	[NN1] Be able to describe the profession, societal demand for the profession, and the development of the profession of biomedical research and development specialists in society. [NN2] Be able to identify the qualities and competencies of oneself that are suitable or unsuitable for the requirements of a biomedical research and development specialist. [NN3] Be able to carry out the steps in the research process to examine the bactericidal effect of alcohol and silver nanoparticles.

Overall teaching organization process

According to the scientific research process, the topic is designed to include 5 activities, as shown in the following table:

Activity	Content of the activity	Integrated career education content
Activity 1. Posing Research Questions	- Students receive information about the COVID-19 pandemic and observe images of microbial growth on hands with and without hand sanitizer. - Students answer teacher questions to understand the importance of hand sanitizer products in controlling the pandemic. - Students answer teacher questions to learn about the profession of biomedical product research and development specialists. - Students will be asked to examine the bactericidal effectiveness of alcohol and silver nanoparticles, along with specific task requirements.	- Learning about the job, societal needs, the development of the profession of biomedical research and development specialists, and related subjects at the high school level.
Activity 2. Researching Background Knowledge and Planning Experiments	- Students discuss and present characteristics of methods for studying microorganisms. - Students read reference materials to learn about basic concepts in scientific research and the process of culturing microorganisms on an agar plate using an inoculation loop. - Students propose methods for culturing microorganisms and experimental setups to investigate the bactericidal capacity of alcohol and silver nanoparticles.	- Learning knowledge related to career activities. - Practicing career activities: planning research.
Activity 3. Defending the Experimental Plan	- Students present a summary report of the experimental steps and the proposed experimental setup. - Students answer feedback questions and defend their plans. - Students finalize the experimental setup.	- Practicing career activities: presenting and defending a research plan.

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	- Students learn about laboratory safety and refine their experimental setup.	
Activity 4. Conducting the Experiment, Observing, Analyzing, and Drawing Conclusions	- Students divide tasks and experiment under the teacher's supervision. - Students observe, record experimental data, and collect evidence through images.	- Practicing career activities: implementing the research plan.
Activity 5. Sharing, Discussing, and Adjusting	- Students report results and explain the experiment's findings. - Students listen to feedback, propose improvements, discuss the research development direction, and reflect on the practice process. - Students take a test on the profession of biomedical product research and development specialists.	- Practicing career activities: presenting and defending research results. - Evaluating whether the profession is suitable or not suitable for one's abilities.

Pedagogical Experimental Results

Evaluation of Students' Interest in STEM Careers

The t-test results comparing students' interest in STEM careers before and after the pedagogical experiment, as shown in Table 3, indicate statistically significant changes in students' attitudes across all components. Notably, substantial changes were observed in components related to personal goals, student interests, enthusiasm for Technology subjects, and the Engineering field, with mean differences exceeding 0.5 points. This demonstrates that integrating career education into the STEM theme contributed to altering students' perspectives and interest in STEM careers.

The decrease in standard deviation for all surveyed content after the pedagogical experiment indicates a convergence of results, suggesting an improvement in students' awareness and attitudes following the learning process. However, the effect size (ES) indicates that the impact of the STEM theme on students' interest in STEM careers is small (ES approximately 0.2). This suggests that additional measures may be necessary to emphasize career education integration more prominently as students engage with the topic.

TABLE 3. *T-test results of STEM career interest survey before and after the pedagogical experiment.*

Component	Before Experiment		After Experiment		X`	Mean Difference	Effect Size (ES)
	Mean	Standard Deviation	Mean	Standard Deviation			
Self-competence	6.64	2.083	6.90	2.073	0.008	0.257	0.13
Personal Goals	6.52	2.234	7.07	2.075	**0.000**	**0.547**	**0.26**
Expected Results	6.97	2.419	7.30	2.261	0.003	0.329	0.14
Interests	6.36	2.566	7.00	2.233	**0.000**	**0.633**	**0.27**
Science Subject	6.34	2.400	6.69	2.241	0.001	0.353	0.15
Math Subject	6.81	2.263	7.23	2.240	0.000	0.418	0.19
Technology Subject	6.94	2.250	7.47	1.931	**0.000**	**0.527**	**0.25**

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Technical Field	6.32	2.350	6.78	2.115	**0.000**	**0.463**	**0.21**

Total number of students surveyed = 43.

According to Cohen (1988), an ES value near 0.2 indicates a small effect, an ES near 0.5 indicates a medium effect, and an ES near 0.8 indicates a significant impact.

Career Orientation Manifestations of Students

Through observation of the project implementation process and evaluation of students' learning outcomes, it is evident that all student groups have maintained progress in accordance with the guidelines provided for each session. Specifically, *students proposed microbial cultivation methods through a design plan (Fig 1a) that comprehensively delineated the experimental procedures in a logical sequence. They demonstrated an understanding of critical operational considerations, ensuring scientific validity and accuracy in conducting the experiment, such as (step 2) Methodology for sampling microorganisms from the hand surface; (step 3) Establishment of a sterile environment to mitigate the influence of airborne and hand-surface microorganisms on experimental outcomes; (step 4) Ensuring uniform microbial distribution across cultivation media in various treatments; (step 5) Investigation of the antibacterial properties of alcohol and silver nanoparticles; (step 6) Labeling of treatments to facilitate result monitoring in step 8; Sealing of petri dishes with food-grade film post-inoculation to prevent incomplete closure of the two Petri dish lids (step 7).*

Besides, students proposed an experimental layout to investigate the antibacterial capabilities of alcohol and silver nanoparticles (Fig 1b). The experiment was designed with the following considerations: minimum of three replications per treatment; minimization of factors influencing experimental results; ensuring uniform impact of random factors across treatments; arrangement of treatments to demonstrate the prolonged antibacterial effect of silver nanoparticles compared to alcohol. The specific treatments were as follows:

Treatment 1: Culture medium containing only hand surface microorganisms.

Treatment 2: Culture medium with hand surface microorganisms immediately after alcohol hand washing.

Treatment 3: Culture medium with hand surface microorganisms 5 minutes after alcohol hand washing.

Treatment 4: Culture medium with hand surface microorganisms immediately after silver nanoparticle hand washing.

Treatment 5: Culture medium with hand surface microorganisms 5 minutes after silver nanoparticle hand washing.

The experimental results investigating the antibacterial efficacy of alcohol and silver nanoparticles (Fig 1c) were evaluated using the Rubrics assessment tool. Students observed and analyzed the experimental results based on the quantity and size of bacterial colonies on the Petri dish culture medium; the findings aligned with the proposed hypothesis:" Comparison of bacterial colony counts in treatments II and III indicate that alcohol exhibits immediate antibacterial properties but is prone to evaporation, leading to reduced antibacterial efficacy after 5 minutes. Comparison of bacterial colony counts in treatments II and III demonstrate that silver nanoparticles persist longer in the culture medium and maintain antibacterial capabilities after 5 minutes – as explained by students in Group 6."

Observations of the project implementation process (Fig 2) and evaluation of students' learning outcomes indicate that all student groups adhered to the work schedule as per session guidelines. The experimental results demonstrated that the antibacterial properties of silver nanoparticles met the assessment criteria at satisfactory to excellent levels. This contributes to the manifestation of students' professional awareness through practical engagement in career-related activities. The STEM topic has enhanced students' understanding of the biomedical product research and development specialist profession, stimulating interest in STEM careers and providing deeper insights into the activities within this field.

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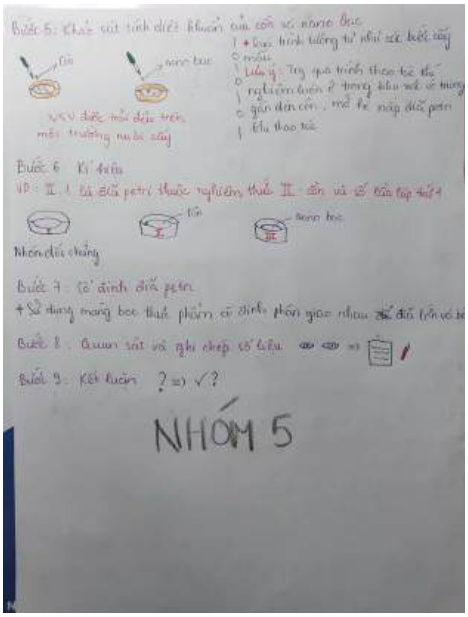
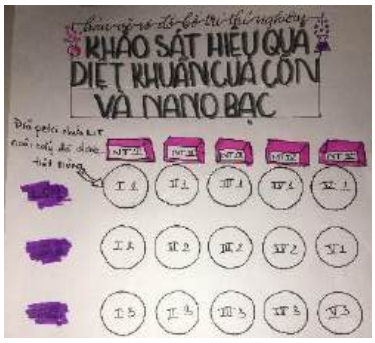
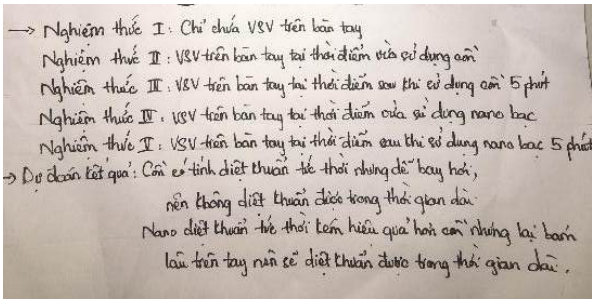


(a)





(b)

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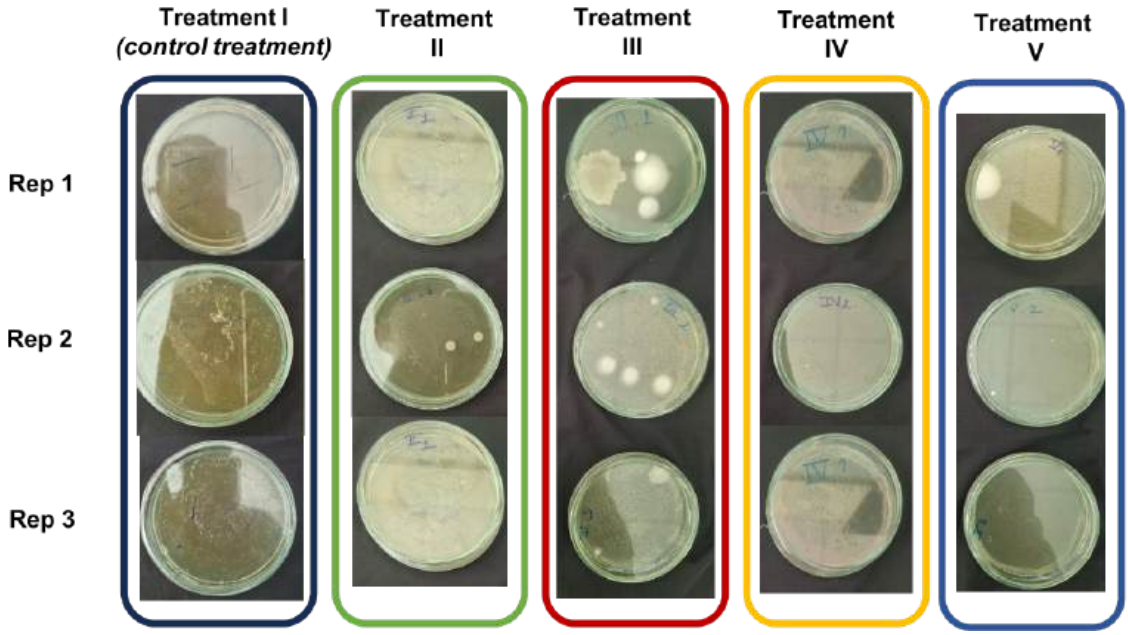

(c)

FIGURE 1. *Diagram of the Experimental Procedure and Results Demonstrating the Antibacterial Properties of Silver Nanoparticles: (a) Diagram of the experimental procedure drawn by a student group; (b) Diagram of the experimental setup proposed by a student group; (c) Results of the experiment demonstrating the antibacterial properties of alcohol and silver nanoparticles on petri dish culture medium by a student group.*

(a) (b) (c)

FIGURE 2. *Student Experimental Procedure*
(a) Students inoculate a culture medium in a petri dish with a solution containing microorganisms from their hands; (b) Students use a sterile spreader to evenly distribute the solution containing microorganisms across the entire surface of the culture medium; (c) Students label the petri dishes with experimental information in the form of numbers.

The results of the written test show that 39 out of 43 students (90.7%) believe that the profession of biomedical product research specialist has solid prospects for the future due to reasons such as "increasing societal demand," "helping society," and "meeting human needs."

S22: "The biomedical product research and development specialist profession is very promising for the future because today's society is increasingly developing effective, safe, and environmentally friendly products. Additionally, the outbreak of many diseases requires people to develop products to meet these needs."

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S39: "The biomedical product research and development specialist profession has prospects for the future because this field is currently being adopted and gradually developed. In the future, the biotechnology field will rise, so the biomedical product research and development specialist profession will be extremely promising."

S44: "In my opinion, yes, because in the future, with the development of science and technology, diseases that are difficult to treat, such as cancer, will benefit from the development of this profession. This profession will also support the country in the future."

Additionally, 14 out of 44 students (31.8%) believe that they have the qualities and competencies suitable for the profession of biomedical product research and development specialist.

S15: "Regarding the qualities of the profession, I believe I am about 60% suitable, but I still have a high ego, and I lack cooperation and the ability to listen to teammates' opinions."

S16: "Regarding the qualities and competencies of a biomedical product research and development specialist as mentioned above, I feel I am suitable with qualities such as using laboratory equipment safely and ensuring biosafety."

S22: "I feel that I am suitable with qualities and competencies such as applying knowledge, the ability to collect and process information, using equipment safely, and using English to read and understand documents."

However, 25 out of 44 students (56.8%) believe that they do not yet have the qualities and competencies suitable for the profession. These students are aware of their abilities and qualities and provide reasons why they do not feel suitable for the profession.

S20: "Regarding the qualities and competencies of a biomedical product research and development specialist mentioned above, I feel I am not suitable for the qualities and competencies such as proficiency in using information technology tools for data processing."

S40: "I feel that I have not yet met the skills in information technology and English, as well as the skills in using laboratory equipment and applying biological knowledge in research."

S44: "I feel unsuitable for this profession because, with my current abilities, I lack the necessary knowledge in this field, and it does not align with my dream job."

Moreover, despite recognizing that they do not yet have the qualities and competencies suitable for the biomedical product research and development specialist profession, some students express determination to change themselves to fit the profession.

S15: "I feel I still lack many aspects in the field of research. My classmates and I will strive to improve."

S31: "I feel that I am not yet fully suitable for this profession, but I will work hard to develop the necessary abilities."

Student Learning Outcomes

The results of the biological competence assessment test in Fig 3 indicate the following:

For the competency "ability to use charts and tables to present research results" (part of the competency in exploring the living world), 16 out of 39 students (41.03%) scored 50% or higher. However, 58.97% of students have not yet demonstrated this competency.

For the competency "ability to explain and draw conclusions" (Fig 3b, part of the competency in Exploring the living world), 35 out of 39 students (89.74%) scored 50% or higher. Among them, 22 students (56.41%) achieved the maximum score in this competency.

For the competency "ability to select appropriate methods" (Figure 3c, part of the competency in Exploring the living world), 27 out of 39 students (69.23%) scored 50% or higher. Most students (41.02%) achieved 2 out of 3 points.

For the competency "ability to propose recommendations for applying research results or further research topics" (Fig 3d, part of the competency in exploring the living world 4.4), 30 out of 39 students (76.92%) scored 50% or higher. Among them, 19 students (48.72%) achieved the maximum score in this competency.

Thus, the learning activities implemented in the STEM experiential activity have effectively supported the development of students' competency to explore the living world. This is an important competency component closely associated with the profession of biomedical product research and development, as well as other scientific research-related careers. However, the competency "Writing, presenting reports, and discussing: using language, drawings, diagrams, and tables to express the research process and results" (Fig 3a) still requires further development through other topics.

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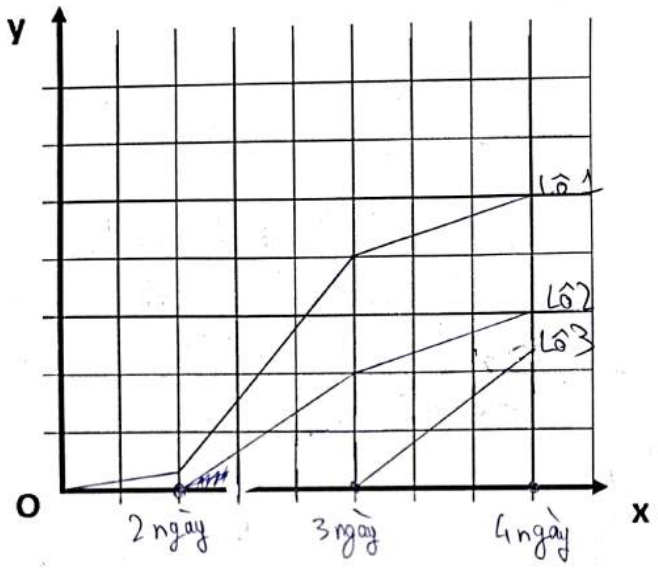
a) Em hãy vẽ sơ đồ biểu diễn số liệu tổng diện tích khuẩn lạc của 3 lô thí nghiệm qua các ngày quan sát.



1,5

b) Em kết luận được gì về tính diệt khuẩn của sản phẩm A? Giải thích?

Tính diệt khuẩn của sản phẩm A có hiệu quả cao, diệt được nhiều và kì vi khuẩn và để lại ít khuẩn lạc

c) Ở bước thí nghiệm số 3, bạn HS nhỏ đồng đều 1 giọt dung dịch chứa các VSV lên các đĩa petri. Em hãy giải thích lí do hành động của bạn HS đó.

Hành động nhỏ đồng đều 1 giọt VSV lên các đĩa petri để tạo ra môi trường sống 1 lượng VSV giống nhau để có thể so sánh độ diệt khuẩn của sản phẩm 1 so với nước cất và cồn

3

d) Trong thí nghiệm của bạn HS, em hãy tìm ra 1 lỗi làm ảnh hưởng đến độ tin cậy của kết quả thí nghiệm và đề xuất hướng giải quyết vấn đề đó.

Lỗi làm ảnh hưởng là không bọc kín đĩa petri

Hướng giải quyết là bọc kín đĩa petri

FIGURE 3. *Results of the Student Competency Assessment Test*
(a) Draw a diagram representing the total area of bacterial colonies in the three experimental batches over the observation days; (b) What conclusion can you draw about the antibacterial effect of Product A? Explain; (c) In experimental step 3, the student evenly dropped one drop of a solution containing microorganisms onto the petri dishes. Explain the reason for this action; (d) In the student's experiment, identify one error affecting the experimental results' reliability and propose a solution to address it.

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Conclusion

Developing STEM experiential learning activities integrated with career education when teaching Microorganisms and Viruses content in 10th-grade Biology is necessary. It aligns with the requirements and orientation of the 2018 General Education Program for high schools. The pedagogical experimental results demonstrate that teaching STEM experiential activities integrated with career education for "biomedical product research and development specialists" increases learning interest and enables students to assess their suitability for the career requirements. This indicates that developing STEM themes based on specific tasks can contribute to career guidance for students.

References

1. Adkins, S. J. (2018). Interdisciplinary STEM education reform: dishing out art in a microbiology laboratory. *FEMS Microbiology Letters, 365*(1). doi:https://doi.org/10.1093/femsle/fnx245
2. Cohen, Carolyn, & Davis G. Patterson. (2012). *Teaching Strategies that Promote Science Career Awareness.* Northwest Association for Biomedical Research Bio-ITEST: New Frontiers in Bioinformatics and Computational Biology Project.
3. Dökme, İ. A. (2022). *Investigation of STEM fields motivation among female students in science education colleges.* International Journal of STEM Education. doi:https://doi.org/10.1186/s40594-022-00326-2
4. Hutchinson, J., & Bentley, K. (2011). STEM subjects and jobs: A longitudinal perspective of attitudes among key stage 3 students. *Derby: International Centre for Guidance Studies, University of Derby.*, 2008–2010.
5. Le, N. H., Quan, H. M., & Le, Q. N. (2024). Integrated career-based STEM lesson "Roller coaster engineer" in teaching Kinetic and potential energy - Physics 10. *HCMUE journal of Science*, 476-489. doi:https://doi.org/10.54607/hcmue.js.21.3.4022(2024)
6. Lent, R. W. (1994). Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance. *Journal of vocational behavior*, 45(1), 79-122.
7. Ministry of Education and Training. (2018). *Genaral education curriculum.* Ha Noi.
8. Nguyen, B. V., Tuong, H. D., & Tran, D. M. (2020). *STEM Education in High School.* Ha Noi: Vietnam Education Publishing House.
9. Nguyen, P. L. (2024). Modernizing education in Research4life countries: Integrating STEM and developing the model design process for secondary education in VietNam. *VIETNAM JOURNAL OF EDUCATIONAL SCIENCES*, 70-80. doi:https://doi.org/10.15625/2615-8965/22410206
10. Schmidt, J. J. (2003). *Counseling in schools: Essential services and comprehensive programs.* Allyn & Bacon.
11. Shahali, E. H. (2017). STEM learning through engineering design: Impact on middle secondary students' interest towards STEM. *Eurasia Journal of Mathematics, Science and Technology Education*, 1189–1211. doi:https://doi.org/10.12973/eurasia.2017.00667a
12. Teresa, L.-C., Girón-Gambero, J. R., & García-Ruiz, C. (2022). Building STEM inquiry-based teaching proposal through collaborations between schools and research centres: students' and teachers' perceptions. *European Journal of Educational Research*, 899-915. doi:https://dx.doi.org/10.12973/eu-jer.11.2.899

QRCBN 62-6861-0508-697
https://proceeding.unnes.ac.id/icmse

13. Wiebe, E. U. (2018). The Relationship of STEM Attitudes and Career Interest. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(10). doi:https://doi.org/10.29333/ejmste/92286
14. Wyss, V. L. (2012). Increasing middle school student interest in STEM careers with videos of scientists. *International Journal of Environmental and Science Education, 7*(4), 501–522.
15. Yoto, Y. (2016). Vocational education development strategy to improve quality of human resources in dealing with Asean Economic Community. *AIP Conference Proceedings, 1778*(1). doi:https://doi.org/https://doi.org/10.1063/1.496578