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# Understanding of the living world of high school students in the Mekong Delta, Vietnam

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## Abstract

Biology is an experimental science that is leading in developing students' ability to understand the living world. This research aims to assess the level of students' understanding in selected high schools in the Mekong Delta region. The study was conducted for eight months, from May 2022 to December 2022. A total of 464 students from nine regional high schools participated in the study. This research adopted a cross-sectional survey model, combining quantitative and qualitative research methods. The data were collected using Google Forms. The results from this study show that students had limited ability to understand the living world, particularly in their scientific research skills, the ability to interpret charts and statistical data, and the application of learned knowledge to practical scenarios. Factors such as the study environment, organization of activities for teaching and learning biology, skills required for scientific research, self-study ability, analytical and problem-solving skills, and the ability to apply learned knowledge in real-life situations contribute to these limitations. As a result, educators should introduce innovative content and teaching approaches to improve high school students' abilities and enhance their understanding of the living world.



## Introduction

Biology itself is an experimental science. By organizing experimental and practical activities, Biology helps students explore the natural world, develop the ability to apply knowledge into practice and orientate a career after general education. The leading role of Biology is to form and develop students' ability to understand the living world.

The 2018 general education program emphasized capacity development by including three general competencies (autonomy, communication and cooperation, and problem-solving) and specialized competencies. The biology curriculum highlights the importance of cultivating three specific biology competencies in students, including the ability to perceive and understand the world (Ministry of Education

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and Training [MET], 2018). The ability to perceive the living world enables individuals to investigate and uncover natural phenomena related to biology. Enhancing this ability to perceive the living world helps learners develop learning and research methods, encourages proactivity and creativity, and enables the application of knowledge to solve practical problems. These competencies are increasingly crucial in today's world, where science and technology are rapidly advancing (MET, 2021).

Evidence suggests that well-planned and directed outdoor teaching and fieldwork can impact long-term memory through memorable experiences (Cooper et al., 2000; Grant, 1997). Such learning experiences gained through fieldwork can promote personal growth and improved social skills, facilitating the development of competencies needed for the future. This study was conducted in the Mekong Delta, considered a low-lying education region in Vietnam, and included three distinct areas: central, suburban, and remote. The study evaluated the competency status of high school students regarding their understanding of the living world, with a focus on nine high schools representative of the three regions. The study aimed to determine whether competency levels vary by region. The findings of this study will be beneficial for teachers and education professionals in designing appropriate lesson plans and instructional strategies to improve the living world.

These specific studies have built up a basic theoretical system, which is essential for raising awareness of Biology for students in Vietnam. However, there is still not much specific research on developing high school students' mathematical literacy when teaching topics of ecology and environment in Biology at the high school level. This is the gap that we wanted to fill in this research.

## Literature review

Utilizing Outdoor Education (OE) methods for teaching and developing an understanding of the living world is a commonly employed approach. Previous research has indicated that active teaching-learning processes lead to increased knowledge retention (Cooper et al., 2000; Grant, 1997), heightened motivation and learning (Kern & Carpenter, 1986), and practical skill development (Kent et al., 1997).

Several studies have been conducted in Vietnam on developing students' understanding of the living world. For instance, Tu et al. (2020) surveyed 10th-grade students at the Hanoi National University of Education and found that teaching cell observation experiments contribute to student's understanding of the living world. In another study, Thuy and Phuong (2020) provided a framework for developing students' cognitive skills in understanding the living world. This framework includes 14 indicators of competence and provides a process for designing and organizing experimental activities to enhance student's knowledge of the living world. Additionally, hands-on experiments in Biology grade 11 effectively promote students' living world competency.

## Methodology

The research employed a cross-sectional survey model (data on various variables of interest was collected from participants simultaneously) utilizing quantitative and qualitative research methods. The primary research instrument used was a questionnaire designed as a list of questions to gather information, as suggested by Pham and Nguyen (2011). Consent, satisfaction, and response were measured using the Likert scale, which had a range of 5 and an interval of 0.8, as recommended by Allen and Seaman (2007); Narli (2010); Yavuz et al. (2013). The scale's meanings were categorized as follows: $1.0 \leq M < 1.8$ (strongly dislike/never/do not know), $1.8 \leq M < 2.6$ (dislike/rarely/strongly disagree), $2.6 \leq M < 3.4$ (normal/occasionally/disagree), $3.4 \leq M < 4.2$ (like/open/agree), and $4.2 \leq M \leq 5.0$ (strongly like/ very open/strongly agree) to provide relatively accurate judgments about the level.

For the sample collection, the survey form was first designed and used to adjust the survey before the official study was conducted, as noted by Dinh et al. (2011a; 2011b). The survey was conducted in Can Tho city (CT), Soc Trang province (ST), and Ca Mau province (CM), which respectively represented central, suburban, and remote areas. Three high schools were selected in each province/city, representing one of the three regions: central, suburban, and remote areas. The selected high schools were An Khanh (in CT), Hoang Dieu (in ST), and Ca Mau city (in CM) for the central region; Phan Van Tri (in CT), Tran Van Bay (in ST), and Cai Nuoc (in CM) for the suburban region; and Thanh An (in CT), Doan Van To (in ST), and Vam Dinh (in CM) for the remote region. The survey targeted grade 10 students learning biology in each school, and the students were selected randomly.

To measure the reliability of the survey questionnaires, the Cronbach Alpha method was employed, as described by Cronbach (1951). This method has previously been successfully used to evaluate the quality of human resources based on enterprise requirements in the Mekong Delta region trained at Can Tho University, as noted by Quan et al. (2012).

The data were encrypted and processed using SPSS v.21 software for analysis. Kruskal-Wallis H test was utilized to verify whether students' viewpoints varied across high schools, with a significance level of $p < .05$.

## Results and discussion

### *Reliability of the Questionnaire*

The results of the Cronbach Alpha analysis suggest that the student questionnaire, which comprises seven essential questions, was a reliable tool for assessing students' comprehension of the living world. The Cronbach Alpha value of the questionnaire was found to be 0.89, indicating this value is greater than the required reliability value of 0.7. Therefore, these results suggest a questionnaire is suitable for assessing students' living world understanding competency.

### *General Information about Survey Participants*

Figure 1 presents the number of student participants in the study, with 464 students. The group comprised 217 males (46.8%) and 247 females (53.2%). The Figure also shows the distribution of students across participating schools. Phan Van Tri high school (PVT) had the highest number of participants, with 81 students (17.5%). This was followed by Cai Nuoc high school (CN), Tran Van Bay high school (TVB), Ca Mau city high school (CM), and Hoang Dieu high school (HD), each of which had more than 10 percent of the total students. The remaining schools, including Doan Van To high school (DVT), An Khanh high school (AK), Vam Dinh high school (VD), and Thanh An high school (TA), had less than 10 percent of students.

### *The Reality of Teaching and Learning to develop Living World Understanding Competency for High School Studentsm*

Table 1 presents the perspective of high school students on their preferred location for studying Biology. The Table shows that Research Centers are the most interesting place for learning, with an average score of 4.23±0.07 SE. This is closely followed by nature and local practice, Laboratory, and School Garden, with average scores of 4.18±0.04 *SE*, 4.18±0.06 *SE*, and 3.96±0.04 *SE*, respectively. This suggests that students prefer to be trained through experiments and experiences. The Table also indicates that students like studying in class (3.55±0.06 *SE*) and via production facilities (3.77±0.06 *SE*). On the other hand, self-study at home is a relatively acceptable choice for students (3.04±0.06 *SE*). These findings provide insights into the students' preferences for learning environments and can be helpful for educators and curriculum planners to design effective learning strategies that meet students' needs and interests.

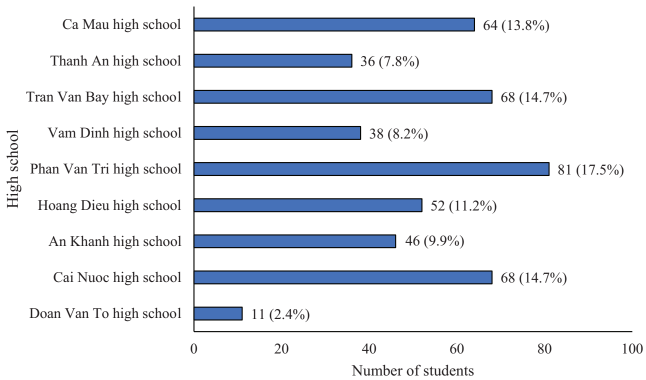


**Figure 1** Number of students from nine high schools participating in the survey

**Table 1** The viewpoint of students on biological studying places concerning sex

| Code | Studying place | Mean±*SE* | Viewpoint | Female | Male | Mann-Whitney U |
|---|---|---|---|---|---|---|
| Q11 | Class | 3.55±0.06 | Like | 3.50±0.04 | 3.61±0.06 | $Z$ = -1.21, $p$ = .22 |
| Q12 | Laboratory | 4.18±0.06 | Like | 4.19±0.05 | 4.18±0.06 | $Z$ = -0.34, $p$ =.74 |
| Q13 | School Garden | 3.96±0.04 | Like | 3.93±0.05 | 4.00±0.06 | $Z$ = -1.01, $p$ = .31 |
| Q14 | Self-study at home | 3.04±0.06 | Normal | 3.03±0.06 | 3.05±0.07 | $Z$ = -0.36, $p$ = .72 |
| Q15 | Production facilities | 3.77±0.06 | Like | 3.80±0.06 | 3.74±0.06 | $Z$ = -0.81, $p$ = .42 |
| Q16 | Research Centers | 4.23±0.07 | Very like | 4.23±0.05 | 4.22±0.06 | $Z$ = 0.01, $p$ = .99 |
| Q17 | Nature, local practice | 4.18±0.04 | Like | 4.19±0.06 | 4.18±0.06 | $Z$ = -0.06, $p$ = .95 |

*Note:* $1.0 \leq M < 1.8$: Strongly dislike; $1.8 \leq M < 2.6$: Dislike; $2.6 \leq M < 3.4$ Normal; $3.4 \leq M < 4.2$: Like; $4.2 \leq M \leq 5.0$: Strongly like.

Table 1 shows no significant difference in preferred learning places between male and female students. Both genders prefer natural environments, local practices, and research centers for learning Biology. Studying at home is less favorable due to limitations and a lack of practical conditions. Learning environments, such as classrooms, laboratories, school gardens, research centers, and local practices, shape students' preferences and attitudes toward learning Biology. These findings highlight the need for educators and policymakers to consider these factors when designing and implementing educational programs that align with students' needs and preferences. Moreover, the results suggest that male and female students share similar interests and motivations for learning Biology, emphasizing the importance of promoting equity and inclusivity in science education.

Table 2 displays students' perspectives on their preferred biological studying place within the school. The Table reveals that students appreciate exciting activities and social interaction with friends, indicating that they value a supportive and engaging learning environment that can enhance their motivation and academic achievement. The Table also highlights the importance of studying Biology in the natural environment, allowing students to explore firsthand the relationships between people, animals, and plants, as observed in Trung's research (Trung, 2017). These findings underscore the significance of providing students with diverse learning environments that cater to their interests and needs. Incorporating experiential learning opportunities in natural settings can enhance students' understanding and application of scientific concepts and theories. Hence, educators and policymakers should consider such factors when designing and implementing educational programs to ensure students' practical and engaging learning experiences.

Table 3 presents the results of a survey that assessed the performance level of various learning activities used in the Biology study. The findings indicate that students typically engage in textbook research activities at an average level (3.87±0.04 SE), meaning they utilize

**Table 2** The viewpoint of students on biological studying places concerning school

| High schools | Q11 | Q12 | Q13 | Q14 | Q15 | Q16 | Q17 |
|---|---|---|---|---|---|---|---|
| An Khanh | 3.46±0.09 | 4.07±0.12[a] | 3.85±0.12 | 2.85±0.13 | 3.78±0.15 | 4.20±0.12 | 4.07±0.12 |
| Phan Van Tri | 3.44±0.08 | 4.14±0.09[a] | 3.95±0.09 | 2.96±0.11 | 3.77±0.09 | 4.21±0.09 | 4.12±0.09 |
| Thanh An | 3.64±0.11 | 4.11±0.10[a] | 3.81±0.10 | 3.14±0.16 | 3.78±0.15 | 4.33±0.13 | 4.03±0.14 |
| Hoang Dieu | 3.35±0.11 | 4.00±0.11[a] | 3.83±0.13 | 2.83±0.14 | 3.88±0.12 | 4.21±0.13 | 4.33±0.13 |
| Tran Van Bay | 3.59±0.09 | 4.18±0.09[ab] | 4.09±0.09 | 3.25±0.10 | 3.75±0.12 | 4.18±0.11 | 4.13±0.12 |
| Doan Van To | 3.64±0.20 | 4.73±0.14[a] | 4.45±0.21 | 2.55±0.37 | 3.73±0.41 | 4.73±0.14 | 4.64±0.15 |
| Ca Mau | 3.69±0.10 | 4.44±0.09[ab] | 4.08±0.12 | 3.19±0.12 | 3.95±0.11 | 4.38±0.10 | 4.23±0.11 |
| Cai Nuoc | 3.75±0.10 | 4.19±0.11[ab] | 4.00±0.10 | 3.10±0.12 | 3.78±0.12 | 4.18±0.10 | 4.25±0.11 |
| Vam Dinh | 3.42±0.14 | 4.13±0.16[a] | 3.84±0.13 | 3.05±0.16 | 3.37±0.19 | 4.00±0.16 | 4.16±0.15 |
| Kruskal-Wallis H ($df$ = 8) | $\chi^2$ = 14.64, $p$ = .07 | $\chi^2$ = 19.05, $p$ = .01 | $\chi^2$ = 11.99, $p$ = .15 | $\chi^2$ = 13.63, $p$ = .09 | $\chi^2$ = 8.10, $p$ = .42 | $\chi^2$ = 9.84, $p$ = .28 | $\chi^2$ = 9.94, $p$ = .27 |

*Note:* Q11: Class; Q12: Laboratory; Q13: School Garden; Q14: Self-study at home; Q15: Production facilities; Q16: Research Centers; Q17: Nature, local practice; $1.0 \le M < 1.8$: Strongly dislike; $1.8 \le M < 2.6$: Dislike; $2.6 \le M < 3.4$ Normal; $3.4 \le M < 4.2$: Like; $4.2 \le M \le 5.0$: Strongly Like; different letter (a and b) in each column shows significant difference.

**Table 3** The viewpoint of students for biological teaching activities concerning sex

| Code | Contents | Mean±SE | Viewpoint | Female | Male | Mann-Whitney U |
|---|---|---|---|---|---|---|
| Q21 | Studying textbooks | 3.87±0.04 | Open | 3.98±0.05[a] | 3.75±0.06[b] | $Z$ = -2.97, $p$ = .00 |
| Q22 | Research with relevant documents | 3.30±0.04 | Occasionally | 3.29±0.05[a] | 3.31±0.06[a] | $Z$ = -0.33, $p$ = .74 |
| Q23 | Simulation with diagrams and pictures | 3.01±0.04 | Occasionally | 3.00±0.06[a] | 3.02±0.06[a] | $Z$ = -0.09, $p$ = .93 |
| Q24 | Watch movies and tapes | 3.26±0.05 | Occasionally | 3.18±0.06[a] | 3.35±0.07[a] | $Z$ = -1.97, $p$ = .05 |
| Q25 | Join the game role play | 2.50±0.05 | Rarely | 2.42±0.07[a] | 2.59±0.08[a] | $Z$ = -1.48, $p$ = .14 |
| Q26 | Use experiments practice | 2.91±0.05 | Occasionally | 2.83±0.07[a] | 3.00±0.07[a] | $Z$ = -1.39, $p$ = .16 |
| Q27 | State and solve the situation | 3.10±0.05 | Occasionally | 2.98±0.06[a] | 3.24±0.07[b] | $Z$ = -2.85, $p$ = .00 |
| Q28 | Creative experiential activities | 2.88±0.05 | Occasionally | 2.73±0.07[a] | 3.06±0.08[b] | $Z$ = -3.11, $p$ = .00 |
| Q29 | Project Learning | 3.10±0.05 | Occasionally | 3.07±0.06[a] | 3.14±0.08[a] | $Z$ = -0.69, $p$ = .49 |
| Q210 | Study on science and technology topic | 2.79±0.05 | Occasionally | 2.65±0.06[a] | 2.95±0.08[b] | $Z$ = -2.94, $p$ = .00 |
| Q211 | STEM | 2.38±0.05 | Rarely | 2.23±0.07[a] | 2.54±0.08[b] | $Z$ = -2.79, $p$ = .01 |
| Q212 | STEAM | 2.38±0.05 | Rarely | 2.23±0.07[a] | 2.54±0.08[b] | $Z$ = -2.81, $p$ = .00 |

*Note:* $1.0 \le M < 1.8$: Never; $1.8 \le M < 2.6$: Rarely; $2.6 \le M < 3.4$: Occasionally; $3.4 \le M < 4.2$: Open; $4.2 \le M \le 5.0$: Very often; different letter (a and b) in each row shows significant difference.

textbooks as their primary resource for learning. Occasionally, they use related simulation literature and simulations through diagrams, pictures, and models (3.30±0.04 *SE*) and watch movies and video tapes to supplement their learning (3.01±0.04 *SE*). However, students less frequently perform certain learning activities. These include game-playing and role-playing, experiments and practical exercises (2.91±0.05 *SE*), stating and solving situations, creative experience activities (2.88±0.05 *SE*), and project-based learning (3.10±0.05 *SE*). Students also demonstrate low levels of engagement with scientific and technical research topics (2.79±0.05 *SE*). STEM and STEAM modeling activities are rarely utilized (2.38±0.05 *SE*). These findings indicate room for improvement in the diversity and frequency of learning activities. Educators may consider more interactive and hands-on activities like experiments and game-playing to enhance students' engagement and learning outcomes. Tinh's research on differentiated teaching (Tinh, 2018) and Nhi and Nhan's study on Physics Education (Nhi & Nhan, 2019) shed light on the complexities of organizing such activities.

The evaluation of the performance level of learning activities in studying Biology across nine high schools is presented in Table 4. The results show that textbook research activities (Q21), research by other relevant documents (Q22), and simulation by diagrams and models (Q23) were assessed similarly by all schools. However, for Q24, only three high schools DVT, CM, and CN organized activities using movies and videos, while the other six schools' teachers occasionally taught through these mediums (Kruskal-Wallis H, $\chi^2 = 45.44$, $df = 8.00$, $p = .00$). For Q25, except for AK, CM, and CN teachers who occasionally organized role-playing games, schools' teachers rarely did activities ($\chi^2 = 15.06$, $df = 8.00$, $p = .04$). Regarding Q26, only CM, CN, and VD teachers (CM, CN, and VD) rarely organized activities through experiments and practice, while the other six schools' teachers occasionally did so ($\chi^2 = 88.35$, $df = 8.00$, $p = .00$). For Q27, except for DVT, where teachers regularly organized activities, and another school, where they rarely did, all surveyed schools' teachers occasionally organized activities for students to state and solve situations ($\chi^2 = 30.29$, $df = 8.00$, $p = .00$).

Similarly, for Q28, all schools' teachers sometimes organized creative and experiential student activities, except for VD, where teachers rarely did ($\chi^2 = 31.44$, $df = 8.00$, $p = .00$). For Q29, except for VD teachers who rarely organized this activity, all schools organized project-based learning activities occasionally ($\chi^2 = 31.44$, $df = 8.00$, $p = .00$). For Q210, only two school teachers

**Table 4** The viewpoint of students for biological teaching activities concerning school

| Code | Schools | | | | | | | | | Kruskal-Wallis |
|---|---|---|---|---|---|---|---|---|---|---|
| | An Khanh | Phan Van Tri | Thanh An | Hoang Dieu | Tran Van Bay | Doan Van To | Ca Mau | Cai Nuoc | Vam Dinh | |
| Q21 | 3.74±0.12 | 3.73±0.09 | 3.81±0.10 | 3.92±0.13 | 4.12±0.09 | 4.18±0.18 | 3.84±0.10 | 3.82±0.10 | 3.89±0.15 | $\chi^2 = 13.47$, $p = .10$ |
| Q22 | 3.24±0.12 | 3.27±0.09 | 3.14±0.11 | 3.10±0.13 | 3.46±0.09 | 3.36±0.20 | 3.48±0.11 | 3.35±0.10 | 3.16±0.15 | $\chi^2 = 10.84$, $p = .21$ |
| Q23 | 3.07±0.12 | 3.05±0.11 | 3.00±0.13 | 3.04±0.12 | 3.19±0.10 | 3.18±0.26 | 2.84±0.13 | 3.01±0.13 | 2.68±0.17 | $\chi^2 = 8.71$, $p = .37$ |
| Q24 | 3.39±0.11 | 2.98±0.12 | 2.83±0.12 | 3.29±0.13 | 3.06±0.12 | 3.91±0.25 | 3.72±0.12 | 3.53±0.12 | 2.95±0.15 | $\chi^2 = 45.44$, $p = .00$ |
| Q25 | 2.63±0.14 | 2.53±0.12 | 2.11±0.14 | 2.42±0.18 | 2.46±0.12 | 2.55±0.39 | 2.72±0.16 | 2.71±0.15 | 2.05±0.18 | $\chi^2 = 15.06$, $p = .06$ |
| Q26 | 3.09±0.10 | 3.37±0.10 | 3.11±0.14 | 3.37±0.11 | 3.19±0.10 | 2.82±0.38 | 2.44±0.15 | 2.57±0.15 | 1.82±0.16 | $\chi^2 = 88.35$, $p = .00$ |
| Q27 | 3.28±0.13$^{a}$ | 3.16±0.12$^{a}$ | 2.83±0.15$^{ab}$ | 3.17±0.14$^{a}$ | 3.28±0.12$^{a}$ | 3.55±0.31a | 2.92±0.13$^{ab}$ | 3.32±0.12$^{a}$ | 2.39±0.15$^{b}$ | $\chi^2 = 30.29$, $p = .00$ |
| Q28 | 3.11±0.13 | 3.05±0.12 | 2.67±0.16 | 2.96±0.15 | 3.07±0.12 | 3.27±0.36 | 2.73±0.15 | 2.94±0.13 | 2.05±0.16 | $\chi^2 = 31.44$, $p = .00$ |
| Q29 | 3.15±0.15$^{abc}$ | 3.14±0.13$^{abc}$ | 2.81±0.14$^{abc}$ | 3.08±0.13c$^{d}$ | 3.22±0.12$^{abc}$ | 3.64±0.31$^{a}$ | 3.33±0.11$^{ab}$ | 3.13±0.13$^{abc}$ | 2.50±0.18$^{d}$ | $\chi^2 = 19.00$, $p = .01$ |
| Q210 | 3.02±0.13 | 2.86±0.13 | 2.50±0.16 | 2.60±0.15 | 2.93±0.12 | 2.91±0.37 | 2.92±0.13 | 2.97±0.15 | 2.11±0.18 | $\chi^2 = 24.74$, $p = .00$ |
| Q211 | 2.61±0.12$^{ab}$ | 2.43±0.13$^{ab}$ | 2.06±0.14$^{ab}$ | 2.21±0.15$^{ab}$ | 2.62±0.15$^{a}$ | 2.45±0.47$^{ab}$ | 2.38±0.16$^{ab}$ | 2.51±0.14$^{ab}$ | 1.79±0.16$^{b}$ | $\chi^2 = 20.83$, $p = .01$ |
| Q212 | 2.61±0.12 | 2.38±0.12 | 2.06±0.14 | 2.25±0.15 | 2.57±0.16 | 2.73±0.49 | 2.38±0.16 | 2.54±0.14 | 1.79±0.16 | $\chi^2 = 20.07$, $p = .01$ |

*Note:* Q21: Studying textbooks; Q22: Research with other relevant documents; Q23: Simulation with diagrams, picture models; Q24: Watch movies and tapes; Q25: Join the game role play; Q26: Use experiments/practice; Q27: State and solve the situation; Q28: Creative experiential activities; Q29: Project Learning; Q210: Research on science and technology topics; Q211: STEM; Q212: STEAM; $1.0 \le M < 1.8$: Strongly dislike; $1.8 \le M < 2.6$: Dislike; $2.6 \le M < 3.4$ Normal; $3.4 \le M < 4.2$: Like; $4.2 \le M \le 5.0$: Strongly like; different letter (a and b) in each column shows significant difference.

(TA and VD) rarely organized scientific and technical research activities, while the other teachers sometimes did ($\chi^2 = 27.74$, $df = 8.00$, $p = .00$). Notably, for Q211 and Q212, except for two schools where students were assessed occasionally, all seven schools where students participated in the survey rarely organized students to participate in STEM and STEAM. In particular, for Q211 and Q212, except for AK and DVT, where students were assessed from time to time, all seven schools where students participated in the survey rarely organized students to participate in STEM ($\chi^2 = 20.83$, $p = .01$) and STEAM ($\chi^2 = 20.07$, $p = .01$).

The survey findings suggest that the schools in the surveyed group mostly rely on textbook research and do not conduct other activities regularly. This approach to teaching may limit students' knowledge of the natural world. Therefore, it is crucial to encourage implementing various teaching approaches, such as project-based teaching, STEM, STEAM, etc., within school premises, with a particular emphasis on VD. Biology is a subject that is closely related to real-life situations and requires practical learning. Therefore, teachers need to use various teaching techniques to enhance students' practical abilities. However, the survey results reveal that teachers primarily use the "textbook lookup" method and infrequently use other approaches. This may be because textbooks provide a foundation for teaching and learning activities and offer a structured approach for teachers and students to create lesson plans, deliver content, and provide a comprehensive range of activities, exercises, and support. Additionally, textbooks offer standardized teaching materials, making it easier for new teachers to organize their teaching activities.

Practical teaching methods (e.g., researching related literature, using diagrams and models to simulate experiments, watching videos, conducting experiments, problem-solving, engaging in creative activities, project-based learning, and exploring science and technology topics) effectively enhance students' abilities. However, it can be challenging for teachers to implement these activities due to time constraints within a typical 45-minute lesson. Furthermore, game and role-playing activities are not commonly used in biology since the subject is more research-oriented, which limits the availability of suitable content for teachers to create engaging activities for their students.

STEM/STEAM education has become increasingly popular worldwide as an integral approach to enhancing students' capacity in the education sector. This educational model originated in the US and has been incorporated into general education curricula globally, including in Vietnam, to promote sustainable development. However, surveys have revealed that teachers face difficulties implementing STEM/STEAM education. Despite undergoing training, teachers must research and explore these methods independently since reference materials are limited (Bui et al., 2003). Additionally, most high schools still evaluate students based on their scores, reinforcing the traditional knowledge transmission method. Furthermore, a significant challenge remains a lack of equipment and facilities to organize STEM/STEAM teaching, particularly in remote areas. Students still heavily rely on their teachers, and their participation in the lesson is often not voluntary.

### *The Sequence of Scientific Research Assessed by Students*

Biology is a scientific field that studies the natural world and aims to uncover fundamental laws and principles that can be applied to daily life. Unlike production activities that generate material wealth, scientific research creates new knowledge and understanding, valuable cognitive assets for humanity. The scientific research process involves several steps, starting with observation and questioning. Scientists then form a hypothesis to explain their observations, make a research plan, and test the hypothesis through experiments or observations. However, a recent survey showed that students rated each step in the scientific research process relatively poorly. For instance, students rated step 1 (observation and questioning) as "don't know," with a mean score of 1.34±0.07 *SE*. Step 2 (forming a scientific hypothesis) received a rating of "strongly disagree" with a mean of 2.16±0.06 *SE*, as did step 3 (making a research report). Step 4 (testing the scientific hypothesis) received a rating of "disagree" with an average score of 3.33±0.06 *SE* and 3.23±0.06 *SE*, respectively (Table 5). Overall, these findings suggest

**Table 5** Students' awareness of a scientific research process concerning sex

| Step | Contents | Mean±*SE* | Level of assessment | Female | Male | Mann-Whitney U |
|---|---|---|---|---|---|---|
| 1 | Observation and questioning | 1.34±0.07 | Do not know | 1.35±0.06 | 1.34±0.06 | $Z = -0.28$, $p = .78$ |
| 2 | Forming a scientific hypothesis | 2.16±0.06 | Strongly disagree | 2.19±0.05 | 2.13±0.05 | $Z = -0.85$, $p = .39$ |
| 3 | Making research report | 3.35±0.06 | Disagree | 3.32±0.06 | 3.38±0.06 | $Z = -1.17$, $p = .24$ |
| 4 | Scientific hypothesis testing | 3.28±0.06 | Disagree | 3.33±0.06 | 3.23±0.06 | $Z = -1.75$, $p = .08$ |

*Note:* $1.0 \leq M < 1.8$: Do not know; $1.8 \leq M < 2.6$: Strongly disagree; $2.6 \leq M < 3.4$: Disagree; $3.4 \leq M < 4.2$: Agree; $4.2 \leq M \leq 5.0$: Strongly agree.

a need to improve science education and increase awareness of the importance of scientific research among students. By enhancing students' understanding of the scientific research process, we can encourage them to appreciate scientific knowledge.

Upon evaluating the survey results for the nine high schools, it was observed that for steps 1 and 4, the students from all nine schools had similar rating levels, and the difference in their evaluation was not statistically significant (Kruskal-Wallis H, $\chi^2$ = 8.23, $df$ = 8.00, $p$ = .41) and ($\chi^2$ = 7.56, $df$ = 8.00, $p$ = .48), respectively (Table 6).

This Table suggests that all students, regardless of their school, had a similar understanding of the importance and process of observing and testing scientific hypotheses. However, for steps 2 and 3, all nine schools' students rated step 2 as "strongly disagree," indicating that students had difficulty forming scientific hypotheses. For steps 2 and 3, all nine schools' students rated step 2 as "strongly disagree". However, students of AK, TA, HD, TVB, and CN rated step 3 as "agree," and the remaining rated it as "disagree." The difference between the ratings was statistically significant for both step 2 ($\chi^2$ = 14.30, $p$ = .07) and step 3 ($\chi^2$ = 35.17, $p$ = .00) (Table 6). This suggests that some schools may be more effective than others in teaching students how to write a research report. These findings highlight the importance of improving science education, particularly in helping students develop skills related to forming scientific hypotheses and writing research reports. Educators can tailor their teaching methods and curriculum to better prepare students for scientific research and future endeavors by identifying areas where students struggle the most.

The survey results suggest that students have a limited understanding of the scientific research process, indicating a need for improved teaching methods to help them comprehend and apply it. This could be due to the current school curriculum, which prioritizes knowledge acquisition and may not provide enough opportunities for hands-on scientific research. A study by Huynh & Nguyen in 2021 revealed that many high school teachers are unfamiliar with "scientific research study" and have never engaged in scientific research. This lack of experience and understanding among teachers may result in students struggling to comprehend the research process, as they rely heavily on their teachers for guidance and assistance. There is a need to enhance science education in high schools, both in the curriculum and teacher training to address these challenges. Teachers should be equipped with the knowledge and skills necessary to guide students in conducting scientific research activities effectively. This would require teacher training programs emphasizing practical, hands-on training and providing opportunities for teachers to engage in scientific research. Additionally, the curriculum should be designed to encourage students to engage in scientific research activities early on and provide adequate resources and support to facilitate these activities. Overall, the survey results highlight the need to enhance science education in high schools, focusing on improving teacher training and curriculum design. By doing so, students will be better equipped to comprehend and apply the scientific research process, ultimately leading to enhanced scientific literacy and the development of future scientists and innovators.

## Conclusion and Recommendations

The findings from the survey indicate that students did not have proficiency in and understanding of the living world, particularly in scientific research skills, data interpretation, and the application of knowledge to practical scenarios. These limitations are influenced by various factors, such as the learning environment, the organization of biology teaching and learning activities, scientific research skills, self-study ability, analytical and problem-solving skills, and the ability to apply learned knowledge to real-life situations.

**Table 6** Students' awareness of a scientific research process concerning school

| Step | Schools | | | | | | | | | Kruskal-Wallis |
|---|---|---|---|---|---|---|---|---|---|---|
| | An Khanh | Phan Van Tri | Thanh An | Hoang Dieu | Tran Van Bay | Doan Van To | Ca Mau | Cai Nuoc | Vam Dinh | |
| 1 | 1.11±0.08 | 1.26±0.09 | 1.39±0.16 | 1.42±0.14 | 1.32±0.10 | 1.18±0.18 | 1.44±0.13 | 1.40±0.13 | 1.47±0.17 | $\chi^2$ = 8.23, $p$ = .41 |
| 2 | 2.07±0.08 | 2.17±0.08 | 2.25±0.15 | 1.90±0.09 | 2.12±0.07 | 2.36±0.24 | 2.17±0.12 | 2.24±0.10 | 2.37±0.14 | $\chi^2$ = 14.30, $p$ = .07 |
| 3 | 3.54±0.12[ab] | 3.16±0.11[ab] | 3.78±0.10[a] | 3.40±0.12[ab] | 3.46±0.09[ab] | 3.18±0.38[ab] | 2.95±0.12[b] | 3.50±0.10[ab] | 3.26±0.14[ab] | $\chi^2$ = 35.17, $p$ = .00 |
| 4 | 3.20±0.11 | 3.36±0.09 | 3.25±0.08 | 3.19±0.14 | 3.28±0.09 | 2.82±0.33 | 3.34±0.13 | 3.34±0.11 | 3.34±0.13 | $\chi^2$ = 7.56, $p$ = .48 |

*Note:* 1: Observation and questioning; 2: Forming a scientific hypothesis; 3: Making research report; 4: Scientific hypothesis testing; $1.0 \leq M < 1.8$: Strongly dislike; $1.8 \leq M < 2.6$: Dislike; $2.6 \leq M < 3.4$ Normal; $3.4 \leq M < 4.2$: Like; $4.2 \leq M \leq 5.0$: Strongly Like; different letter (a and b) in each row shows significant difference.

## Conflicting of Interests

The authors declared no potential conflicts of interest concerning the research.

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