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Assessing the competency in exploring the living world of high school students through practical examples: A case study in the Mekong Delta, Vietnam

Tien Thi Kieu Nguyen[a,b], Duan Nguyen[c,*], Thuy Thi Da Dang[b]

[a] *Hue University of Education, Hue University, Hue 530000, Vietnam*
[b] *Department of Biology, An Khanh High School, Can Tho 900000, Vietnam*
[c] *Hue University, Hue 530000, Vietnam*

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Abstract

The study aims to assess the competency in exploring the living word (CELW) of high school students in selected schools in the Mekong Delta region. The research was carried out from May to December 2022 and involved 464 students (217 males and 247 females) from nine high schools in this region. The study adopted a cross-sectional survey approach, utilizing quantitative and qualitative research methods, with data collection through Google Forms. The results indicate that students possessed CELW at a low level, particularly in scientific research skills, statistical data interpretation, and practical application of knowledge. These limitations were attributed to inadequate scientific research skills, analytical and problem-solving abilities, and the application of learned knowledge in real-world situations. Consequently, educators are advised to introduce innovative teaching content and methodologies to enhance the abilities of high school students regarding CELW at all learning levels.

Introduction

The Concept of "Capacity" and General Issues about "Teaching and Developing Capacity"

Competence is the ability of the subject to apply knowledge, skills, attitudes, experiences, values, ethical standards, and motivations to act appropriately and effectively in a context or practice (Woodruffe, 1993). According to Vietnam's 2018 General Education Program, *Competence* is understood as: "Personal attributes formed and developed thanks to existing qualities and the process of learning and training, allowing people to mobilize synthesis of knowledge, skills and other personal attributes such as interest, belief, will,... to successfully perform a certain type of activity, achieving desired results under specific conditions " (Ministry of Education and Training [MET], 2018a).

* Corresponding author.
E-mail address: nguyenduan@hueuni.edu.vn (Nguyen, D.).

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Since the beginning of the 19th century, educators have changed their thinking about teaching, moving from teaching to help students remember knowledge to the tendency to form problem-solving abilities for learners by fostering thinking and critical ability (Ha & Dao, 1998). By the 1970s, the concept of competency-oriented teaching for learners had emerged in the United States; and for this mode of education, the teaching process becomes scientific when quantifying the level of formation of the learning in educational programs (Consortium, 1996). Blank (1982) lays the rationale for teaching competency development and develops a competency training program handbook that discusses the actual contents of competency-based education, introducing learner capacity-building and development trends.

John (1995) followed that rationale by publishing competency-based education and training. The author clarifies the views and objectives of competency-based education, provides criteria and tools for assessing competencies, and improves Blank's draft competency training program. Stronge (2018) believed that performance capacity must be the goal of teacher training; that is, what should be done in teacher training? Because it is the teacher who lays the foundation, helping students form their abilities. The learner is a copy of the teacher's qualities, personality, and ability to perform professionally. According to the training model of the Massachusetts Institute of Technology, the development of engineering programs according to the CIDO approach (idea - design - implementation - operation) is based on the statement of *Learning Outcomes*: What knowledge, skills, qualities - attitudes graduates need to have and on that basis form practical competencies to meet the needs of employers (stakeholders) (Crawley et al., 2007). According to Stronge (2018), the qualities of an effective teacher include (1) The prerequisites for becoming an effective teacher; (2) Qualities of teachers; (3) Classroom organization and management; (4) Composing lessons and organizing teaching; and (5) Tracking student progress and potential. Thus, studies on teaching capacity have been conducted relatively early in countries around the world, which have shown the structure of teaching capacity and constituent concepts and identified the role and importance of training according to learners' ability.

Teaching Develops the Ability to Understand the Living World

According to Hoang Phe's Vietnamese dictionary, "*find out"* means considering, investigating, and understanding a particular issue (Hoang, 1997). In addition, according to naturalist Attenborough (1984), our world is a living world: we share the Earth with millions of other species of organisms in countless different forms, from microscopic bacteria to giant blue whales. Or, to put it briefly, "*living world*" is the world with life (Attenborough, 1984). The Ministry of Education and Training of Vietnam has introduced the concept that students' ability to learn about the living world is the ability to carry out the process of learning about the living world, including the following steps: Proposing issues related to the world living; make judgments and develop hypotheses; planning and implementing plans; write, present reports and discuss (MET, 2018b).

The 2018 general education program emphasized capacity development, including three general competencies - autonomy and self-study, communication and cooperation, and problem-solving - alongside specialized competencies. Specifically, the biology curriculum highlighted the importance of developing three distinct biology competencies in students, including the ability to perceive and understand the natural world (MET, 2018b). Individuals are better equipped to comprehend biological phenomena by cultivating this ability to perceive the living world. Furthermore, developing this ability encourages students to adopt effective learning and research methods, promotes proactivity and creativity, and facilitates the application of knowledge to solve real-world problems. Given the rapid advancement of science and technology today, these competencies are becoming increasingly vital (MET, 2021).

Several studies conducted in Vietnam have aimed to improve students' competency in exploring the living world (CELW). For example, Pham et al. (2020) surveyed 10th-grade students at the Hanoi National University of Education and found that teaching cell observation experiments could enhance students' ability to comprehend the natural world. Similarly, Dang and Nguyen (2020) proposed a framework for developing students' cognitive skills in this area, which includes 14 indicators of competence and a process for designing and organizing experimental activities to enhance their knowledge. Furthermore, conducting hands-on experiments in Biology in grade 11 effectively promotes students' CELW.

Using Outdoor Education (OE) methods to teach and develop a CELW is a frequently utilized approach. Previous research has shown that active teaching and learning processes can result in increased knowledge retention (Cooper el at., 2000; Grant, 1997), heightened motivation and learning (Kern & Carpenter, 1986), and practical skill development (Kent el at., 1997). Significant evidence suggests that well-planned and directed outdoor

teaching and fieldwork can positively impact long-term memory through memorable experiences. Such learning experiences, gained through fieldwork, can promote personal growth and improved social skills, ultimately facilitating the development of competencies required for the future. This study was conducted in the Mekong Delta, considered a low-lying education region in Vietnam, and encompassed three distinct areas: central, suburban, and remote. The study evaluated the competency status of high school students in their CELW, with a focus on nine representative high schools across the three regions. The study aimed to determine whether competency levels varied according to the region of study. The findings of this study are expected to become useful for teachers in designing appropriate lesson plans strategies to enhance high school students' CELW.

Thus, in the world and the country today, many authors are interested in researching teaching in the direction of developing student capacity and teaching in the direction of developing students' teaching practice capacity in all aspects, including different levels and fields. These research tools have built a basic theoretical system necessary for raising Vietnamese students' biological awareness. However, research on the difficulties in developing student capacity based on the current situation in each region is still limited. This is the gap that we want to exploit when choosing topics thoroughly. Therefore, this study served as a basis for expanding the research area and research subjects beyond the Mekong Delta region.

Methodology

Study Model

The study adopted a cross-sectional survey design, combining quantitative and qualitative research methods. The primary research tool was a questionnaire consisting of a list of questions to collect data, as recommended by Pham & Nguyen (2011). For this topic, the author determined the sample size based on the sample size distribution method of Krejcie and Morgan (1970). During the raw data processing, the author excluded inappropriate responses, so the sample size obtained was 464.

Document Research Method

Method applied to analyze data to develop a theoretical basis such as classification, coding, and comparison (Glaser & Strauss, 2014). Document sources are mainly collected from books, newspapers, scientific journals, summary reports of scientific research topics, doctoral theses at both national and international levels, and fields related to the problem that the project researches.

Sample Collection

According to Dinh et al. (2011a, 2011b), the survey form was designed and tested before the official study was conducted to ensure its effectiveness. The survey was conducted in three areas: Can Tho City, Soc Trang Province, and Ca Mau Province, representing the central, suburban, and countryside regions, respectively. Three high schools were chosen from each area to represent each region. The schools selected were An Khanh, Hoang Dieu, and Ca Mau City for the central region; Phan Van Tri, Tran Van Bay, and Cai Nuoc for the suburban region; and Thanh An, Doan Van To, and Vam Dinh for the remote region. The survey aimed to collect data from grade 10 biology students in each school, and the students were chosen randomly.

Measuring the Reliability of Questionnaires

The Cronbach Alpha method was used to assess the reliability of the survey questionnaires, following the approach introduced by Cronbach (1951). This method has been effectively applied to evaluate the quality of human resources trained at Can Tho University to meet enterprise demands in the Mekong Delta region, as Quan et al. (2012) described. The questionnaire used in the study was found to have a Cronbach Alpha value of 0.89, indicating high reliability and consistency in measuring the intended construct.

Data Analysis

Quantitative data analysis will use SPSS v.21 software (Hoang & Chu, 2008). Because the teacher's level of humor about the research problem is not a real value, this study uses non-parametric statistics (non-parametric statistics) for statistical processing. The Kruskal-Wallis H test was used to examine whether there were differences in students' perspectives across high schools, with a significance level set at $p < 0.05$. A Likert scale is also used to measure agreement/satisfaction/response (Allen & Seaman, 2007). To make relatively accurate judgments about speed, the Likert scale is around 5 with the range (5-1)/5 = 0.8 (Narli, 2010; Yavuz el at., 2013). The scale was classified into five categories, ranging from $1.0 \leq M < 1.8$ (do not know/strongly dislike) to $1.8 \leq M < 2.6$

(strongly disagree/dislike), $2.6 \leq M < 3.4$ (disagree/neutral), $3.6 \leq M < 4.5$ (agree/like), and $4.2 \leq M \leq 5.0$ (strongly agree/strongly like) to ensure a reasonably accurate assessment of the level.

Results and discussion

Survey Participant Information

A total of 464 students, 217 males (46.8 percent) and 247 females (53.2 percent), participated in the study across nine high schools. Phan Van Tri High School (PVT) had the highest number of participants (17.5 percent) with 81 students, 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) with approximately 10 percent of students each. The remaining four schools, 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 participating in the study.

Students' Perception of the Steps in the Scientific Research Process through Practical Examples

Students' perception of the scientific research process through the experiment on "germination of green beans"

> *The following are the details of an experiment about the sprouting of green beans:*
>
> *Tools and equipment needed: a hand-held ruler with 0.1 cm measurement accuracy, a pen for labeling, a glass cup, an alcohol lamp, a gas lighter, a plastic box, and tissue paper.*
>
> *Chemicals and specimens required: filtered water and 100 grams of good quality green beans.*
>
> *Experiment procedure: (I) Soak 15 green beans in warm water at 45-50°C (mix with water in a ratio of two parts boiling water to three parts cold water) and 15 green beans in ordinary water at 29-30°C for about three hours. (II) Choose green beans that have uniform color, size, and firmness. (III) Observe and record data on the number of sprouted beans, length of roots and stems, number of leaves, and size each day for seven days. (IV) Place damp paper towels in two separate labeled plastic containers. Put the soaked beans on the wet paper towels in the containers, then cover them with another paper towel. Check the paper towel daily with water to keep it moist and ensure the seeds germinate. One plastic box containing 15 seeds soaked in water will be the control box for comparison purposes.*

Students' Perception of the Content of Step 1: Observation and Questioning

One needs to identify questions relevant to the experiment's objective to determine a suitable research question for an experiment. In this case, the experiment's content is being analyzed, and the aim is to identify appropriate research questions. The investigation involves observing the germination of beans in different conditions, such as humidity, pH levels, and container types. Based on the experiment's content, the relevant research questions are listed as Q411, Q412, and Q413, which are "Does humidity affect the germination of beans?", "Does pH affect seed germination?" and "Does the plastic box affect the germination of beans?" respectively. The survey results reveal that students evaluated the relevance of these research questions, and the average scores for Q411 and Q414 were 3.42±0.07 SE and 3.78±0.06 SE, respectively, suggesting that the students found Q411 and Q414 relevant research questions. However, the students disagreed with Q412 (2.75±0.06 SE) and Q413 (3.78±0.05 SE), as seen in Table 1. The task was identifying relevant research questions based on the experiment's content. The survey results showed that students found Q411 and Q414 relevant research questions. On the other hand, the students did not consider Q412 and Q413 as relevant research questions.

After evaluating the survey results, high schools showed mixed opinions on Q411, with four schools agreeing and five disagreeing (Kruskal-Wallis H, $\chi^2 = 13.82$, $df = 8.00$, $p = .09$), as displayed in Table 2. On the other hand, for Q412, Q413, and Q414, students from all nine schools had similar evaluations. Despite Q411, Q412, and Q413 being the relevant research questions, most students disagreed with Q412 and Q413 but agreed with Q414. The survey aimed to assess students' understanding of the first step of the research process, "Observation and questioning." Unfortunately, the survey results demonstrated that students struggled to comprehend this step. In summary, high schools evaluated the survey results, with mixed opinions on Q411 but uniform opinions on Q412, Q413, and Q414. Despite Q411, Q412, and Q413 being the relevant research questions, most students agreed with Q414. The survey aimed to assess if students understood the first step of the research process, but the results showed that they did not.

Table 1 Students' perception of step "Observation and questioning" concerning sex

Code	Contents	Mean±SE	Assessment	Female	Male	Mann-Whitney U
Q411	Does humidity affect bean germination?	3.42±0.07	Agree	3.47±0.09	3.36±0.10	Z = -0.41, p = .68
Q412	Does pH affect bean germination?	3.14±0.06	Disagree	3.07±0.08	3.22±0.09	Z = -1.13, p = .26
Q413	Do plastic containers affect the germination of beans?	2.75±0.05	Disagree	2.67±0.07	2.85±0.08	Z = -1.42, p = .16
Q414	Does temperature affect bean germination?	3.78±0.06	Agree	3.75±0.08	3.82±0.08	Z = -0.9, p = .37

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.

Table 2 Students' perception of step "Observation and questioning" concerning school

Step	Schools									Kruskal-Wallis H
	An Khanh	Phan Van Tri	Thanh An	Hoang Dieu	Tran Van Bay	Doan Van To	Ca Mau	Cai Nuoc	Vam Dinh	
1	3.13±0.25	3.40±0.17	3.78±0.24	3.37±0.21	3.78±0.15	4.00±0.33	2.89±0.21	3.37±0.19	3.71±0.19	χ^2 = 13.82, p = .09
2	2.96±0.19	3.43±0.14	3.31±0.21	3.25±0.17	3.22±0.14	2.91±0.48	2.86±0.17	2.97±0.16	3.11±0.20	χ^2 = 11.1, p = .20
3	2.93±0.14	2.75±0.14	2.83±0.17	2.88±0.18	2.62±0.11	2.18±0.35	2.69±0.16	2.79±0.14	2.71±0.18	χ^2 = 5.73, p = .68
4	3.80±0.20	3.91±0.13	3.86±0.21	3.83±0.16	3.96±0.12	4.18±0.35	3.34±0.18	3.75±0.16	3.71±0.20	χ^2 = 10.64, p = .22

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; $2.6 \leq M < 3.4$ Neutral; $3.4 \leq M < 4.2$: Like; $4.2 \leq M \leq 5.0$: Strongly like.

Students' Perception of the Content of Step 2: Forming a Scientific Hypothesis

The scientific hypothesis for the experiment is that "If green beans are soaked at 45°C, they will germinate better than those soaked at 29–30°C (Q421). However, the general survey results showed that students from participating schools disagreed with hypotheses Q421, Q422, and Q423, with an average score of 2.80±0.07 SE, 3.06±0.06 SE, and 2.70±0.06 SE, respectively. Hypothesis Q423 had the lowest average score of 2.59±0.06 SE, indicating the highest level of disagreement among the students (Table 3).

Upon examining the survey results for the nine high schools presented in Table 4, it can be seen that for Q421, students from AK, CM, and VD rated the hypothesis as "strongly disagree", while students from the other six schools rated it as "disagree" (p = .02, Table 4). For Q422, only students from TA agreed with the scientific hypothesis, whereas students from the other eight schools disagreed (p = .00, Table 4). For Q423, students from PVT, TVB, and CN disagreed, while the other schools rated this scientific hypothesis as "strongly disagree," but this difference was not statistically significant (p = .16, Table 4). For Q424, students from PVT, HD, DVT, and VD strongly disagreed with this hypothesis; in contrast, students from other participating schools rated it as "agree," but this difference was not statistically significant (p = .18, Table 4). The survey results indicate that although Q421 is the correct hypothesis, its average rating is lower or equal to the inappropriate hypotheses of Q422, Q423, and Q424, suggesting that students do not understand Step 2, "Forming a scientific hypothesis," in the research process.

Table 3 Students' perception of the step "Forming a scientific hypothesis" concerning sex

Code	Contents	Mean±*SE*	Assessment	Female	Male	Mann-Whitney U
Q421	If the beans are soaked at 45oC, they germinate better than at 5oC.	2.80±0.07	Disagree	2.78±0.09[a]	2.83±0.10[a]	Z = -0.51, p = .61
Q422	If the beans are soaked in high humidity, they will germinate better at low humidity.	3.06±0.06	Disagree	3.02±0.08[a]	3.12±0.09[a]	Z = -0.79, p = .43
Q423	If the beans are soaked at high pH, they will germinate better at low pH.	2.59±0.06	Strongly disagree	2.47±0.08[a]	2.73±0.08[b]	Z = -2.21, p = .03
Q424	If you soak the beans in a small plastic container, they germinate better than in a large container.	2.70±0.06	Disagree	2.70±0.08[a]	2.71±0.08[a]	Z = -0.09, p = .93

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; different letter in each row shows significant difference.

Table 4 Students' perception of the step "Forming a scientific hypothesis" concerning school

Schools	Step 1	Step 2	Step 3	Step 4
An Khanh	2.48±0.21^{b}	3.11±0.19^{ab}	2.52±0.20^{a}	2.93±0.18^{a}
Phan Van Tri	2.99±0.17^{ab}	3.33±0.15^{ab}	2.79±0.15^{a}	2.56±0.14^{a}
Thanh An	2.81±0.22^{ab}	3.53±0.15^{a}	2.61±0.16^{a}	2.89±0.17^{a}
Hoang Dieu	2.62±0.19^{ab}	3.00±0.18^{ab}	2.38±0.19^{a}	2.46±0.19^{a}
Tran Van Bay	3.12±0.16^{ab}	3.07±0.12^{ab}	2.62±0.13^{a}	2.87±0.12^{a}
Doan Van To	3.27±0.45^{a}	2.91±0.48^{ab}	2.00±0.33^{a}	2.55±0.37^{a}
Ca Mau	2.39±0.18^{b}	2.52±0.16^{b}	2.38±0.16^{a}	2.81±0.16^{a}
Cai Nuoc	3.06±0.18^{ab}	3.18±0.15^{ab}	2.88±0.15^{a}	2.74±0.13^{a}
Vam Dinh	2.58±0.20^{ab}	2.82±0.20^{ab}	2.50±0.20^{a}	2.39±0.17^{a}
Kruskal-Wallis H	$\chi^2 = 18.92$, $p = .02$	$\chi^2 = 23.09$, $p = .00$	$\chi^2 = 11.89$, $p = .16$	$\chi^2 = 11.36$, $p = .18$

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; $2.6 \leq M < 3.4$: Neutral; $3.4 \leq M < 4.2$: Like; $4.2 \leq M \leq 5.0$: Strongly like; different letter in each column shows significant difference.

Students' Perception of the Content of Step 3: Making Research Report

The survey questions used in the experiment are considered suitable. However, based on the results, students from all nine participating schools rated questions Q431, Q432, Q433, and Q434 as "disagree" with the characteristics presented by the research team during the experiment. The average scores for these questions were 3.30±0.07 SE, 3.28±0.06 SE, 3.19±0.06 SE, and 3.38±0.06 SE, respectively, as shown in Table 5.

After analyzing the survey results from each school (Table 6), it was found that Q433 and Q434 received similar ratings across all schools with no significant differences, suggesting that students from all nine schools had similar opinions about these questions. However, for Q431 and Q432, AK, CM, CN, and VD students disagreed with the proposed characteristics, while the other schools agreed. This difference is statistically significant (Table 6), indicating that students did not understand step 3 of the scientific research process.

Table 5 Students' perception of the content "Making research report" concerning sex

Code	Contents	Mean±*SE*	Assessment	Female	Male	Mann-Whitney U
Q431	Length of mung bean stalks over each experimental day.	3.30±0.07	Disagree	3.33±0.09	3.27±0.10	$Z = -0.36$, $p = .72$
Q432	Length of mung bean roots over each experimental day.	3.28±0.06	Disagree	3.27±0.08	3.29±0.09	$Z = -0.08$, $p = .93$
Q433	The number of green bean leaves per day of the experiment.	3.19±0.06	Disagree	3.20±0.08	3.17±0.09	$Z = -0.23$, $p = .82$
Q434	Size of green bean leaves over each experimental day.	3.38±0.06	Disagree	3.40±0.08	3.34±0.09	$Z = -0.55$, $p = .58$

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.

Table 6 Students' perception of the content "Making research report" concerning school

Schools	Q431	Q432	Q433	Q434
An Khanh	3.09±0.23^{ab}	3.13±0.19^{ab}	3.15±0.19^{a}	3.48±0.19^{a}
Phan Van Tri	3.53±0.16^{ab}	3.57±0.14^{a}	3.38±0.15^{a}	3.53±0.15^{a}
Thanh An	3.58±0.21^{ab}	3.42±0.20^{ab}	3.42±0.18^{a}	3.64±0.18^{a}
Hoang Dieu	3.40±0.18^{ab}	3.37±0.17^{ab}	2.96±0.19^{a}	3.19±0.19^{a}
Tran Van Bay	3.60±0.16^{ab}	3.43±0.12^{ab}	3.41±0.12^{a}	3.43±0.14^{a}
Doan Van To	3.64±0.43^{a}	3.55±0.43^{a}	3.18±0.40^{a}	3.09±0.37^{a}
Ca Mau	2.61±0.19^{b}	2.64±0.17^{b}	2.81±0.17^{a}	3.05±0.18^{a}
Cai Nuoc	3.28±0.18^{ab}	3.31±0.16^{ab}	3.16±0.15^{a}	3.44±0.16^{a}
Vam Dinh	3.24±0.18^{ab}	3.29±0.18^{ab}	3.18±0.20^{a}	3.34±0.21^{a}
Kruskal-Wallis H	$\chi^2 = 22.74$, $p = .00$	$\chi^2 = 22.06$, $p = .00$	$\chi^2 = 11.73$, $p = .16$	$\chi^2 = 8.58$, $p = .38$

Note: Q431: Length of mung bean stalks over each experimental day; Q432: Length of mung bean roots over each experimental day; Q433: The number of green bean leaves per day of the experiment; Q434: Size of green bean leaves over each experimental day; $1.0 \leq M < 1.8$: Strongly dislike; $1.8 \leq M < 2.6$: Dislike; $2.6 \leq M < 3.4$ Neutral; $3.4 \leq M < 4.2$: Like; $4.2 \leq M \leq 5.0$: Strongly like; different letter in each column shows significant difference.

Students' Perception of the Content of Step 4: Scientific Hypothesis Testing

Based on the survey results, the appropriate order of experimental arrangements is II → I → IV → III, as stated in Q443. However, students from all nine schools disagreed with the experimental sequences proposed in the survey questions. Q441 and Q442 were rated as "strongly disagree" by the students, with an average score of 2.41±1.36 SE and 2.31±0.05 SE, respectively. Q443 and Q444 were rated as "disagree" with an average score of 2.98±0.06 SE and 2.60±0.05 SE, respectively (Table 7). This indicates that students do not understand the correct experimental arrangement order, as proposed in Q443, which is consistent with the scientific research process.

Upon evaluation of the survey results, it was found that the experimental arrangement order of II → I → IV → III (Q443) was deemed suitable. However, students from all nine schools rated the inappropriate experimental sequences as "strongly disagree" and "disagree". More specifically, students "strongly disagree" with Q441 (2.41±1.36 SE) and Q442 (2.31±0.05 SE), and "disagree" with Q443 (2.98±0.06 SE) and Q444 (2.60±0.05 SE) (Table 7). Further analysis of the survey results from the student's perspective at the nine schools (Table 8) revealed that all students rated Q442 as "strongly disagree" and Q443 as "disagree". For Q441, all schools except Thanh An and Vam Dinh High Schools rated it as "strongly disagree". For Q444, TA, TVB, and VD students rated it as "disagree", while the rest rated it as "strongly disagree". Although there are differences in the level of student's assessment of the experimental arrangements, these differences are not statistically significant for Q441 (Kruskal-Wallis H, χ^2 = 8.59, *df* = 8.00, *p* = .38), Q442 (χ^2 = 11.38, *df* = 8.00, *p* = .18), Q443 (χ^2 = 10, 70, *df* = 8.00, *p* = .22), Q444 (χ^2 = 11.82, *df* = 8.00, *p* = .16). The survey results indicate that although the Q443 process is appropriate, students at all nine schools rated it at the "disagree" level. Therefore, it can be concluded that students have not understood step 4 of the scientific research process.

Assess the Level of Awareness about the Scientific Research Process of Students

The survey results suggest that most students lack an understanding of the scientific research process mainly because of the limited opportunities for students to engage in scientific research projects and competitions. Building models, creating technical products, and generating ideas require significant time, but students' busy schedules with classes and homework leave little time for research. Additionally, schools are not motivated to encourage teachers to guide students in scientific research activities. There is also a shortage of facilities, equipment, and laboratories for research and technical activities. Furthermore, insufficient research time, inadequate teacher guidance, poor coordination between schools and universities, and a lack of awareness among officials, teachers, parents, students, and the broader community about scientific research activities are all hindering students' ability to engage in scientific research (Le, 2020).

Table 7 Students' perception of the content "Scientific hypothesis testing" concerning sex

Code	Contents	Mean±*SE*	Assessment	Female	Male	Mann-Whitney U
Q441	I→II→III→IV.	2.41±0.06	Strongly disagree	2.47±0.08	2.33±0.09	Z = -1.40, p = .16
Q442	II→II→I→IV.	2.31±0.05	Strongly disagree	2.34±0.06	2.27±0.07	Z = -1.24, p = .21
Q443	II→I→IV→III.	2.98±0.06	Disagree	3.09±0.09	2.85±0.10	Z = -1.82, p = .07
Q444	I→II→IV→III.	2.60±0.05	Disagree	2.62±0.07	2.56±0.08	Z = -0.64, p = .52

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

Table 8 Students' perception of the content "Scientific hypothesis testing" concerning school

Code	Schools									Kruskal-Wallis H
	An Khanh	Phan Van Tri	Thanh An	Hoang Dieu	Tran Van Bay	Doan Van To	Ca Mau	Cai Nuoc	Vam Dinh	
Q441	2.20±0.19	2.44±0.16	2.72±0.21	2.08±0.16	2.49±0.15	2.55±0.47	2.33±0.18	2.44±0.18	2.63±0.23	χ^2 = 8.59, p = .38
Q442	2.30±0.16	2.28±0.12	2.50±0.16	2.29±0.15	2.53±0.11	1.91±0.31	2.11±0.10	2.29±0.14	2.29±0.13	χ^2 = 11.38, p = .18
Q443	3.13±0.21	3.00±0.16	3.14±0.23	2.92±0.21	3.13±0.17	3.00±0.49	2.48±0.14	3.03±0.17	3.13±0.21	χ^2 = 10.7, p = .22
Q444	2.59±0.19	2.58±0.14	2.92±0.19	2.40±0.15	2.74±0.13	1.91±0.25	2.44±0.15	2.59±0.14	2.76±0.17	χ^2 = 11.82, p = .16

Note: Q441: I→II→III→IV; Q442: II→II→I→IV; Q443: II→I→IV→III; Q444: I→II→IV→III; 1.0 ≤ *M* < 1.8: Strongly dislike; 1.8 ≤ *M* < 2.6: Dislike; 2.6 ≤ *M* < 3.4 Neutral; 3.4 ≤ *M* < 4.2: Like; 4.2 ≤ *M* ≤ 5.0: Strongly like.

Students' Perception of the Scientific Research Process through the Experiment on "The Nutritional Composition of Some Foods"

The survey questions were designed to evaluate students' ability to report research results using information from Table 9.

Which of the Following Information does the Nutrition Facts Table Describe?

The information provided in the nutritional composition table pertains to Q51, Q52, and Q54. The table indicates that plain rice and sweet potato are rich in starch, while sprouts and bok choy are good sources of fiber. The protein content in pork and eggs is relatively lower than that of plain rice, sweet potatoes, and bok choy. It is vital to consume a variety of foods to ensure adequate nutrition and nourishment. However, according to the survey results, students at the schools disagreed with the content of Q51 (3.33±0.07 *SE*), Q52 (2.82±0.06 *SE*), and Q53 (2.69±0.06 *SE*). On the other hand, most students agreed with the content of Q54 (3.85±0.05 *SE*) (Table 10), indicating that students may have a limited understanding of the nutritional composition of different foods, with some misconceptions highlighting a need for educational programs to enhance students' knowledge of food and nutrition.

Table 9 The nutritional composition of some foods (Ministry of Health of Vietnam, 2007)

Kind of food (100g)	Protein (g)	Lipid (g)	Carbohydrate (g)	Fiber (g)
Rice	8.1	1.3	75	0.7
Sweet potatoes	0.8	0.2	28.5	1.3
Kale	1.4	0.2	2.4	1.8
Price of green beans	5.5	0.2	5.1	2.0
Pork belly	20.3	13.1	0.0	0.0
Egg	14.8	11.6	0.5	0.0

The survey results from Table 11 show significant differences in how students at nine schools rated four questions related to the nutritional composition of certain foods. For Q51, CM students strongly disagreed, AK, PVT, HD, and DVT disagreed, and the remaining four schools agreed. The level of assessment differed significantly among these schools, as indicated by the statistical analysis (p = .00). For Q52, students at TA, DVT, and CM strongly disagreed, while the remaining

Table 10 Students' view of food nutritional composition experiments concerning sex

Code	Contents	Mean±*SE*	Assessment	Female	Male	Mann-Whitney U
Q51	Starch is from plain rice and sweet potatoes; fiber is from sprouts and bok choy.	3.33±0.07	Disagree	3.43±0.09	3.22±0.10	Z = -1.31, p = .19
Q52	Plant-based lipids are the main cause of atherosclerosis.	2.82±0.06	Disagree	2.82±0.08	2.81±0.08	Z = -0.42, p = .67
Q53	The protein content in pork and eggs is less than in plain rice, sweet potatoes, bok choy	2.69±0.06	Disagree	2.62±0.07	2.76±0.08	Z = -1.00, p = .32
Q54	We need to use a variety of foods to provide adequate nutrition for the body.	3.85±0.05	Agree	3.91±0.09	3.79±0.09	Z = -1.32, p = .19

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

Table 11 Students' view of food nutritional composition experiments concerning school

Schools	Q51	Q52	Q53	Q54
An Khanh	3.15±0.24^{ab}	2.70±0.19^{ab}	2.57±0.16^{a}	3.72±0.21^{ab}
Phan Van Tri	3.38±0.17^{ab}	3.01±0.14^{ab}	2.79±0.13^{a}	3.89±0.15^{ab}
Thanh An	3.72±0.22^{a}	2.56±0.18^{ab}	2.53±0.19^{a}	4.17±0.22^{b}
Hoang Dieu	3.29±0.19^{ab}	2.65±0.18^{ab}	2.60±0.16^{a}	3.67±0.19^{ab}
Tran Van Bay	3.57±0.14^{ab}	3.24±0.14^{a}	2.99±0.12^{a}	4.25±0.12^{b}
Doan Van To	3.36±0.43^{ab}	2.36±0.34^{b}	2.36±0.34^{a}	3.91±0.39^{ab}
Ca Mau	2.59±0.18^{b}	2.55±0.15^{ab}	2.70±0.15^{a}	3.38±0.18^{a}
Cai Nuoc	3.50±0.18^{ab}	2.79±0.15^{ab}	2.56±0.12^{a}	4.03±0.16^{ab}
Vam Dinh	3.61±0.21^{ab}	2.89±0.16^{ab}	2.66±0.17^{a}	3.66±0.23^{ab}
Kruskal-Wallis H	χ^2 = 23.69, p = .00	χ^2 = 19.02, p = .01	χ^2 = 12.09, p = .15	χ^2 = 20.57, p = .01

Note: Q51: Starch is from plain rice and sweet potatoes; fiber is from sprouts and bok choy; Q52: Plant-based lipids are the main cause of atherosclerosis; Q53: The protein content in pork and eggs is less than in plain rice, sweet potatoes, and bok choy; Q54: We need to use a variety of foods to provide adequate nutrition for the body; $1.0 \leq M < 1.8$: 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; different letter in each column shows significant difference.

schools disagreed, and this difference was statistically significant (p = .01). For Q53, students at AK, TA, DVT, and CN strongly disagreed, while the rest disagreed, but this difference was insignificant (p = .15). For Q54, students at CM and CN disagreed, while TVB strongly agreed, and the remaining schools disagreed. The difference in opinions was statistically significant (p = .01). Overall, results indicate significant differences in students' views among nine schools for all four questions, highlighting the need for a more comprehensive approach to nutrition education that considers differences and tailors the curriculum accordingly.

According to the survey results, students assessed Q51 and Q53 as "disagree," despite their correct views, which should be assessed at the level of "agree" or higher. This suggests that students' ability to extract and read table information is unsatisfactory. This skill is crucial for students as textbooks and learning materials of high school subjects worldwide and in Vietnam are often presented as informational text or summarized into tables. However, the ability of high school students in Vietnam to read informational texts and extract information has not improved because reading comprehension skills are not taught. This lack of skills negatively impacts their learning quality and self-study ability. To meet the demands of practice and international trends, it is necessary to have specific teaching orientations that enhance students' self-study and research abilities by teaching them how to read and comprehend informational texts in high school subjects in Vietnam.

The survey results indicate that students can utilize graphs that include drawing descriptions. Figure 1 illustrates two key points: (1) as the number of cigarettes smoked per day increases, the incidence of lung cancer also increases (Q62), and (2) to reduce the incidence of lung cancer, it is recommended to either limit the number of cigarettes smoked per day or quit smoking altogether (Q64).

The survey results indicate that students disagreed with two incorrect answers, namely, Q61 and Q63, with an average score of 2.77±0.06 SE and 3.02±0.05 SE, respectively. On the other hand, they agreed with the correct answers to Q62 and Q64, with an average score of 3.78±0.06 SE and 3.85±0.06 SE, respectively, as shown in Table 12. The results highlight that the students disagreed with two inappropriate answers and agreed with the correct answers in the other two questions.

The statistical analysis suggests that high school students have good skills in reading charts. Therefore, it is appropriate to encourage the development of their chart reading skills as visualization techniques are widely used in various subjects. Visualization is a comprehension approach that involves creating mental images based on text or spoken words (Van Wijk, 2005). Images serve as a visual aid to supplement text-based learning and are a valuable source of knowledge that encourages students to be active and creative during the learning process. Moreover, images help to form cognitive pathways, leading to a deeper understanding of the subject matter, and aid teachers in designing their instruction for optimal learning outcomes.

Students were asked to complete the open questions (e.g., What is the research question? What is the scientific hypothesis? What is the scientific conclusion? And how can you measure your BMI and how do you keep/improve your BMI?) regarding an actual situation:

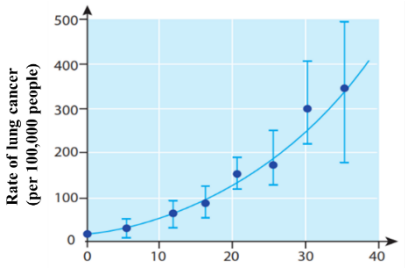

Figure 1 The average number of cigarettes smoked per person per day

Table 12 Students' assessment for cigarette number smoked per day experiment concerning sex

Code	Contents	Mean±*SE*	Assessment	Female	Male	Mann-Whitney U
Q61	The number of cigarettes smoked per day is the dependent variable lung cancer rate is the independent variable.	2.77±0.06	Disagree	2.79±0.09[a]	2.75±0.09[a]	Z = -0.21, p = .83
Q62	The more cigarettes smoked daily, the higher the risk of lung cancer.	3.78±0.06	Agree	3.89±0.08[a]	3.66±0.09[b]	Z = -2.15, p = .03
Q63	If you don't smoke, you won't get lung cancer.	3.02±0.05	Disagree	3.06±0.07[a]	2.96±0.08[a]	Z = -0.91, p = .36
Q64	To reduce the risk of lung cancer, you should limit or not smoke.	3.85±0.06	Agree	3.91±0.09[a]	3.78±0.08[b]	Z = -2.07, p = .04

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; different letter in each row shows significant difference.

The body mass index (BMI) formula, as stated by FAO, is BMI = body mass (kg)/[height]^2 (m). The BMI ranges are as follows: BMI<16: grade III underweight; BMI = 16-16.99: grade II underweight; BMI = 17-18.45: grade I underweight (thin); BMI = 18.5-24.99: normal; BMI = 25-29.99: grade I overweight; BMI = 30- 39.99: grade II overweight (obesity); BMI>40: grade III overweight. The research was conducted on a cohort of 1200 students (600 males and 600 females) aged 16-18 from two typical residential areas in Hanoi. The findings indicate that urban students generally have a better BMI (male BMI = 20.47; female BMI = 23.6) than rural students (male BMI = 17.24; female BMI = 17.85). Genetic, endocrine, or racial factors, environmental factors, nutrition, psychology, physical activities, economic conditions, and other natural factors influence the BMI of high school students in Hanoi city.

The survey results suggest that only a tiny proportion of students (less than 15 percent) could answer the critical thinking questions correctly (Table 13), which indicates that they may have limited skills when it comes to applying their knowledge to real-world problems. This is likely due to the conventional teaching methods used by teachers, which involve lectures and may not motivate students to take control of their learning or relate the material to practical issues that are relevant to their lives. To overcome this challenge, it is recommended that teachers adopt innovative teaching methods that focus on developing problem-solving skills, enhancing creativity and critical thinking, and encouraging self-directed learning among students. These approaches will enable students to acquire contemporary scientific and technological expertise and help them connect theory with practice, resulting in a more holistic education (Khai, 2001).

Conclusions and recommendations

The survey examined a sample of 464 high school students from nine schools, with 217 males (46.8%) and 247 females (53.2%) participating. The results indicated that students face challenges in CELW, especially in scientific research skills, data interpretation, and practical applications of knowledge. These difficulties may stem from scientific research skills, analytical and problem-solving skills, and real-world knowledge application. Therefore, educators should introduce innovative teaching content and approaches to improve high school students' CELW and enhance their skills at all learning levels. From these results, the authors propose to expand the scope of research and simultaneously delve deeper into the causes of difficulties in CELW of students to propose appropriate measures to address these difficulties.

Conflict of Interests

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

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Table 13 Assessment of students for BMI experiment

Survey question	Survey question	Survey question (%)	Survey question
What is the research question?	~ 53	~ 11.4	An Khanh High School, Cai Nuoc High School, Ca Mau High School
What is a scientific hypothesis?	~ 35	~ 0.7	An Khanh High School, Cai Nuoc High School
What is the scientific conclusion?	~ 74	~ 15	An Khanh High School, Ca Mau High School
How can you measure your BMI, and how do you keep/improve your BMI?	~ 45	~ 0.9	An Khanh High School, Cai Nuoc High School, Ca Mau High School

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