CURRENT SITUATION OF NATURAL SCIENCES LABORATORIES AND FACTORS AFFECTING THE FREQUENCY OF NATURAL SCIENCE LABORATORY TEACHING AT SOME LOWER SECONDARY SCHOOLS IN THE NORTH CENTRAL REGION OF VIETNAM

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ABSTRACT

Science laboratory plays an essential role in teaching science subjects in general and natural sciences in particular. The laboratory is not only a place to realize theoretical knowledge learned but also to faciliate lively and visualized learning where students can demonstrate their creativity in learning, stimulate their passion for scientific research, nurture their love and protection for nature and the environment through practical experiences. This study aims to evaluate the current situation of the natural sciences laboratory and its influencing factors, accordingly proposes some solutions to promote the use and efficiency of the natural sciences laboratory at lower secondary schools in the North Central region of Vietnam. The study was conducted in 3 provinces of North Central Vietnam, Thanh Hoa, Nghe An, and Ha Tinh, at 21 secondary schools, with 189 teachers and 252 students (from June 2019 to December 2019). Data is purposefully collected by regions, namely urban, rural, and mountainous areas, from key teachers, well-qualified and reputed teachers, and students of the selected schools via questionnaires about the current situation of the laboratory, and factors influencing the frequency of teaching science subjects in the laboratory. The survey results showed that: school laboratories are mostly for general purposes, and the system of specialized laboratories for each science subject is inadequate, especially in urban areas with a low rate (below 50%) due to the large number of students. Many schools transform the laboratories into theory classrooms. In terms of laboratory equipment, chemicals and samples, urban schools are better-equipped than rural and mountainous ones.

Keywords: Laboratory; Secondary school; Practical activity; Natural sciences.

INTRODUCTION

In recent years, STEM education has become essential in many countries worldwide and is the concern of many policymakers (Ha et al., 2020). The development of STEM education has

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a positive impact on student achievement and the development of various skills. (Batdi et al., 2019). In this context, it is necessary to have adequate human resources and supporting facilities for learning and teaching activities in school. Diah and Nailatul (2020) concluded that human resources and facilities and infrastructure had a significant influence on the satisfaction of the practitioners.

In 2018, Vietnam Ministry of Education and Training (MoET) has issued the General Education Program and the 19-subject Education Program for primary, lower secondary, and upper secondary school levels to replace 2006 program (VMoET, 2018). The new curriculum is a turning point in comprehensive educational innovation in Vietnam, which focuses explicitly on practical capacity, enhancing teaching through practical experiences. Natural science is a new subject forming by integrating three subjects of Physics, Chemistry, Biology of the current general education program and the new subject: earth science subject (VMoET, 2018).

The new programme of natural science subject has an effective combination of theory and experiment in which practical experiments in the laboratory or subject classrooms, along with the fieldwork maintain an important role and significance, as a typical teaching organization of this subject. Thereby, the student's capacity to explore is formed and developed. Much of natural science knowledge is very familiar in students' daily life, which is a favourable condition for students to experience and improve their capacity of perceiving scientific knowledge, their ability to explore and applying scientific knowledge in practice. However, laboratories have a particularly important role in teaching the natural sciences, and organizing natural science learning activities in laboratory is an urgent need in the context of the current comprehensive and fundamental innovation of education in Vietnam.

Although the benefits of the laboratory's activities to the natural sciences educational process are enormous, Vietnam's educational innovation also highly appreciates the role of experimental practice and the quality of operations of natural science laboratories in secondary schools. However, the findings from a survey on 40 teachers of natural sciences at some lower secondary schools in the north-central provinces of Vietnam conducted by Huong et al. (2020) revealed that: The facilities of the laboratories are unsatisfactory with insufficient quantity and lack of structural synchronization, as well as low-quality items (33 comments); Technicians are unqualified for specialized laboratories (28 comments); Teachers are not proactive enough in using experiments in teaching (13 comments); Some school managers have not properly considered the management of experiments in teaching (11 comments). Those are an alarming numbers because Vietnam implements the new general education program with the primary focus on teaching time in laboratories for grade 1 students from September 2020, from September 2021 for grade 6 students, and from September 2022 for grade 10 students.

It can be said that the organization of the National Science and Technology Competition for high school students, from the 2012-2012 school year, is the beginning of the implementation of STEM education in Vietnam. Next, on 3rd September 2015, the Vietnam Ministry of Education and Training had Official Letter No. 4509/BGDDT-GDTrH to issue a guideline for the implementation of integrated STEM education (Vietnam Ministry of Education and Training (VMoET, 2015). Then Vietnamese schools, teachers and educators have deployed STEM education with a variety of STEM activities, such as STEM shows, robotics mini-contests, science camps, STEM clubs, etc. (Thi To Khuyen, et al., 2020). However, this leads to quite an interesting partnership in Vietnam, where schools cooperate with STEM education centres in

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organizing STEM activities on certain occasions. This is especially noticeable through the development of STEM festivals in big cities, the spread of STEM education centres to not only urban but also suburban areas (STEM day 2020 at Ho Chi Minh City (Vietnamnet, 2020); Program of training of stem education to high school students (Vin University, 2020), ... But during the learning hours, how to exploit the experimental tools of science subjects? have been used thoroughly or with interest in use as well as planning for additions.

This study aims to evaluate the current situation of natural sciences laboratories and the factors influencing the frequency of laboratory use, thereby to propose solutions to promote the usage of laboratories for practical teaching of natural sciences at selected lower secondary schools in 3 different regions of the North Central region of Vietnam. Therefore the research questions are:

• Are the laboratories of the selected lower secondary schools sufficient and well-equipped enough for teaching natural sciences there?

• How do factors affect the frequency of operations of science labs in teaching natural sciences in lower secondary schools?, and what are the affecting factors to the frequency of science labs usage in teaching natural sciences in the selected lower secondary schools?

The answers to the above questions are expected to act as the basis for the local education managers and the Vietnam Ministry of Education and Training to have accurate insights of the current situation of laboratories, whether this reality at lower secondary schools has met the requirements of educational innovation or not. Consequently, laboratories can be restructured and invested adequately to fulfill their roles and functions.

LITERATURE REVIEW

Nowadays, it must be affirmed that it is impossible to teach science, especially natural sciences such as physics, chemistry, biology, without practical activities taking place in the laboratory. Hofstein (2004) recounted the old story of Ira Ramsent (1846-1927), who narrated his memories as a child undergoing a chemical phenomenon. While reading chemistry textbooks, he was so curious about the effects of nitric acid that he decided to do an experiment with it by himself. As a result, the laboratory experiments were confirmed indispensably significant. This story serves as evidence for the long existence of students' need for learning through practical experiments with natural sciences and the role of experiments in natural sciences, especially physics and biology.

For a long time, laboratory activities have had a special and central role in science education programs for students and educators have suggested that many benefits are accumulated by engaging students in learning activities in the science laboratory (Hofstein & Lunetta, (2004).

The role and significance of the laboratory in teaching and learning natural sciences has been studied and acknowledged by many authors. According to Daba et al. (2016), the laboratory is an essential resource for teaching natural sciences as science learning is enhanced, and understanding levels are improved when students are engaged in learning in science labs to conduct practical experiments. It is also believed that without practice, whether individually or in a group, knowledge learned becomes passive knowledge (Daba et al., 2016).

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The role of the laboratory in science learning activities has been studied by many authors. Sharpe & Abrahams (2019) state that conducting experiments is important in the learning of science subjects and motivates students to study science. Therefore, the laboratory plays an essential role in helping the practice activities to be conducted effectively and with pedagogical significance. Franklin (2007) studied the roles of experiments in the natural sciences: examples from physics and biology. The results showed that the experiment could provide an excellent foundation to believe in the theories learned, which is stated as one of the outstanding roles of experiments in science. The research by Khamali et al. (2017) also found that students routinely taken them to the lab in practice lessons perform better on practical exams. Farounbi (1998) argued that students tend to understand and recall what they see more than what they hear thanks to the use of laboratories in teaching and learning science.

In laboratory services, Sidik et al. (2019) have shown that a modern, clean, high-quality instructional and practice laboratory is a key factor in mathematics, basic teaching satisfaction and quality and applied sciences. Zengele and Alemayehu (2016) pointed out that the laboratory is essential for creating qualified and scientific human resources. According to Pickering (1980); and Hofstein and Lunetta (2003) practical activities play a key role in the science curriculum, and science educators have suggested that many benefits are accumulated from engaging students in scientific practice activities. Laboratories are capable of developing students' competencies and skills including raising scientifically oriented questions, forming hypotheses, designing and conducting scientific investigations, building and modifying scientific interpretations, imparting and defending scientific arguments Hofstein and Lunetta (2003). Science process skills will also be communicated to students by teachers through activities in the laboratory (Kruea-In & Thongperm, 2014).

Beyessa (2014) studied major factors that affect grade 10 students' academic achievement in Science Education at Ilu Ababora General Secondary of Oromia Regional. He pointed out that the absence of laboratory chemicals, rooms, apparatuses, technicians, and well-organized laboratory manuals exerts negatively influence on the effective implementation of science education and students' academic achievement as well. Khamali et al. (2017) pointed out that students' learning outcomes and interests are influenced by the organization of practical lessons in the laboratory.

Along with research on the role and impact of laboratories on students' learning of science subjects, the role of modern laboratories with the application of information and communication technologies is increasingly Educators interested in research. Conducting, testing, and observing experiments in teaching science subjects has been assessed to be so important that researchers have designed online laboratories. Lorusso and Shumskaya (2020) designed an online laboratory activity using computational biology techniques to maintain the practice in the context of social distance. This online exercise introduces bioinformatics skills into existing curricula in the form of guided tutorials based on molecular data on SARS-CoV-2 virus. There is more and more discussion about the need to create virtual laboratory works and to transfer, partially or completely, practicums from laboratories to computer classrooms (Korshunov & Knyazeva, 2020). Laboratory practice (chemistry) with the assistance of information and communication technologies has been recommended and proven to be effective, suitable for current conditions (Korshunov & Knyazeva, 2020). This shows the need to invest in laboratory equipment but also virtual test equipment, the role of auxiliary equipment for school

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experiments. Kolil et al. (2020) shown that students often develop anxiety towards performing experiments due to the perceived negative outcomes resulting from lack of understanding and improper experimentation. This study reveals the positive impact of virtual laboratories in enhancing students' experimental self-efficacy (Kolil et al., 2020). In their research, Moorberg and Crouse (2017) re-introduced the idea of building an Open-Source Laboratory to save costs, increase interoperability, and exploit resources in teaching and learning.

METHODOLOGY

Research Context

The research takes place in the context that the Vietnam Ministry of Education and Training has just introduced the general education program, the 19-subject educational program for all grades from grade 1 to grade 12 to implement nationwide since December 2018. The North Central region as a typical socio-economic regions of Vietnam possesses diverse and complicated topography, including midlands, mountains, and islands with various geographical features such as hills facing the sea, having slopes, fast-flowing water, etc. As a consequence, the area constantly suffer from flash floods and natural unfavorable conditions for people's working and living. Therefore, this region has always been the top priority of the Government of Vietnam with numerous investments for regional science and technology development in order to improve the economy of the North Central region. However, up to now, the North Central region is still an underdeveloped economic region with GDP per capita in 2019 of only 28.8 million VND/person/year, equal to 52% of the national average and people's disadvantaged lives in many aspects. Despite that fact, this is a relatively well-educated residential area thanks to locals' traits of industriousness, courage, and determination to fight against harsh natural disasters.

Population of the Research

The research samples taken are the teachers of natural sciences and students in grades 6, 7, 8, and 9 at selected lower secondary schools in the north-central provinces of Vietnam. The study was conducted in 3 provinces of North Central Vietnam, Thanh Hoa, Nghe An, and Ha Tinh, at 21 secondary schools, with 189 teachers and 252 students. The teachers in this study are teachers currently teaching physics, chemistry, and biology. Because, these teachers will be fostered to teach science subjects under the new general education curriculum, which will be implemented from September 2021.

Research Design, Methods of Data Collection and Sampling

Research design

A survey is employed to evaluate the current situation of the natural sciences laboratory and teaching activities of natural sciences in the laboratory at lower secondary schools in the North Central region of Vietnam (from June 2019 to December 2019).

Survey content: + Current situation of laboratories for subjects in general; + Current situation of facilities in physics, chemistry, and biology laboratories, including experimental

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equipment, instruments, and chemicals, model - symbolic specimens, real specimens processed and preserved; + Factors affecting the teaching frequency in physics, chemistry, and biology laboratories; + Solutions to improve the effectiveness of teaching natural sciences in the laboratory.

Sampling method

21 lower secondary schools were selected, including representatives from different regions:

Group 1: Urban area: This is a flat terrain area with economic development largely based on industry, commerce, and other service professions. People's living standards are high.

Group 2: Rural area: This is an area with flat terrain with lower economic development than group 1, which is urban plain. People's living standards are lower than those of group 1.

Group 3: Mountainous region: This is an dangerous and complicated terrain area with many hills and mountains, an underdeveloped economy, people's lives are still difficult.

Each group selected some core teachers of the natural sciences of the 21 upper secondary schools for the survey, and each school chose nine teachers including enough physics teacher, chemistry teacher, and biology teacher). So there are a total of 189 teachers, and 252 students were selected from the schools. Each school chose 12 students representing grades 6, 7, 8, and 9. They were randomly selected from lower secondary schools and taught science subjects by the teachers selected above. Thus, the total number of teachers and students participating in the survey was 441 people.

Methods of data collection

Data was collected with the self-designed questionnaire for the survey, which is directly distributed to the teacher respondents during the training courses for key lower secondary teachers nationwide. Therefore the sample selection and collection of survey data was very convenient.

For students, the questionnaires were given by the participating teachers at the class meetings on the weekends so that the difficult questions could be explained clearly directly.

Data analysis

Collected data were analyzed with SPSS 20 software. Then the collected data were discussed qualitatively and quantitatively, as indicated in the charts and reports.

RESULTS

Current Situation of the Laboratory

Figure 1 shows the current situation of the natural science laboratories in the studied area. Meanwhile, the rate of natural sciences laboratories is quite high and the lowest rate is still from the urban area.

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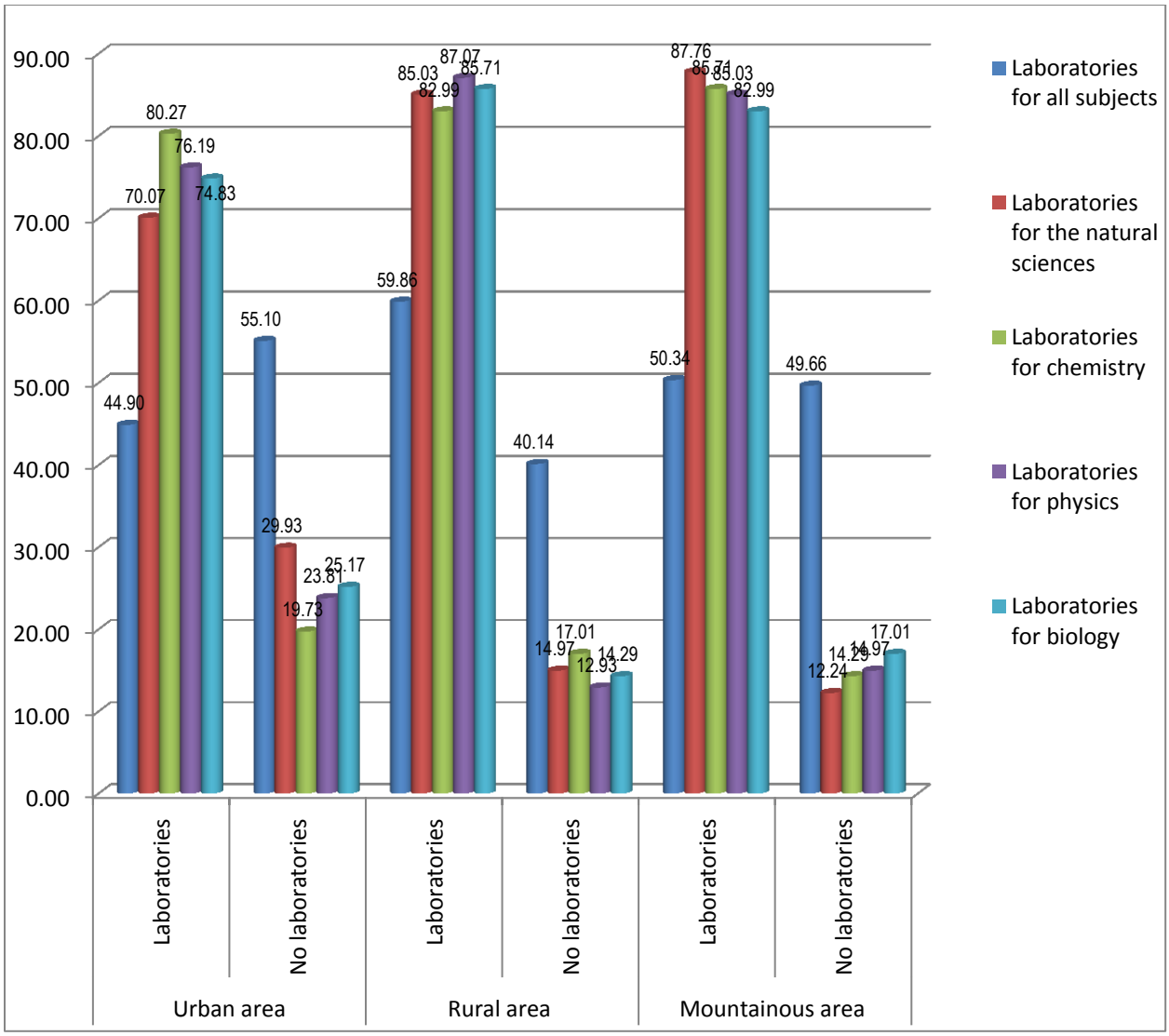

FIGURE 1

CURRENT SITUATION OF THE NATURAL SCIENCE LABORATORIES

Current Situation of Chemicals, Equipment, and Tools in the Laboratories of Physics, Chemistry, Biology

Figure 2 shows the state of the facilities, including experimental equipment, tools, and chemicals, model - symbolic samples, real samples in the specialized laboratories for physics, chemistry, and biology in 3 areas of the North Central region in Vietnam. The survey results showed that, in both rural and mountainous areas, 100% of respondents admitted that their school had inadequate facilities. For urban areas: Regarding experimental equipment, 10.20% of

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respondents chose ‘adequate’, 6.8% chose ‘no facilities or broken facilities’, the remaining 82.99% chose ‘inadequate’; Regarding experimental tools, 12.24% chose ‘adequate’, 8.16% chose ‘no facilities or broken facilities’, the rest selected ‘inadequate’; Regarding experimental chemicals, model - symbolic samples, real samples which have been treated and preserved, 100% of the opinions selected ‘inadequate’.

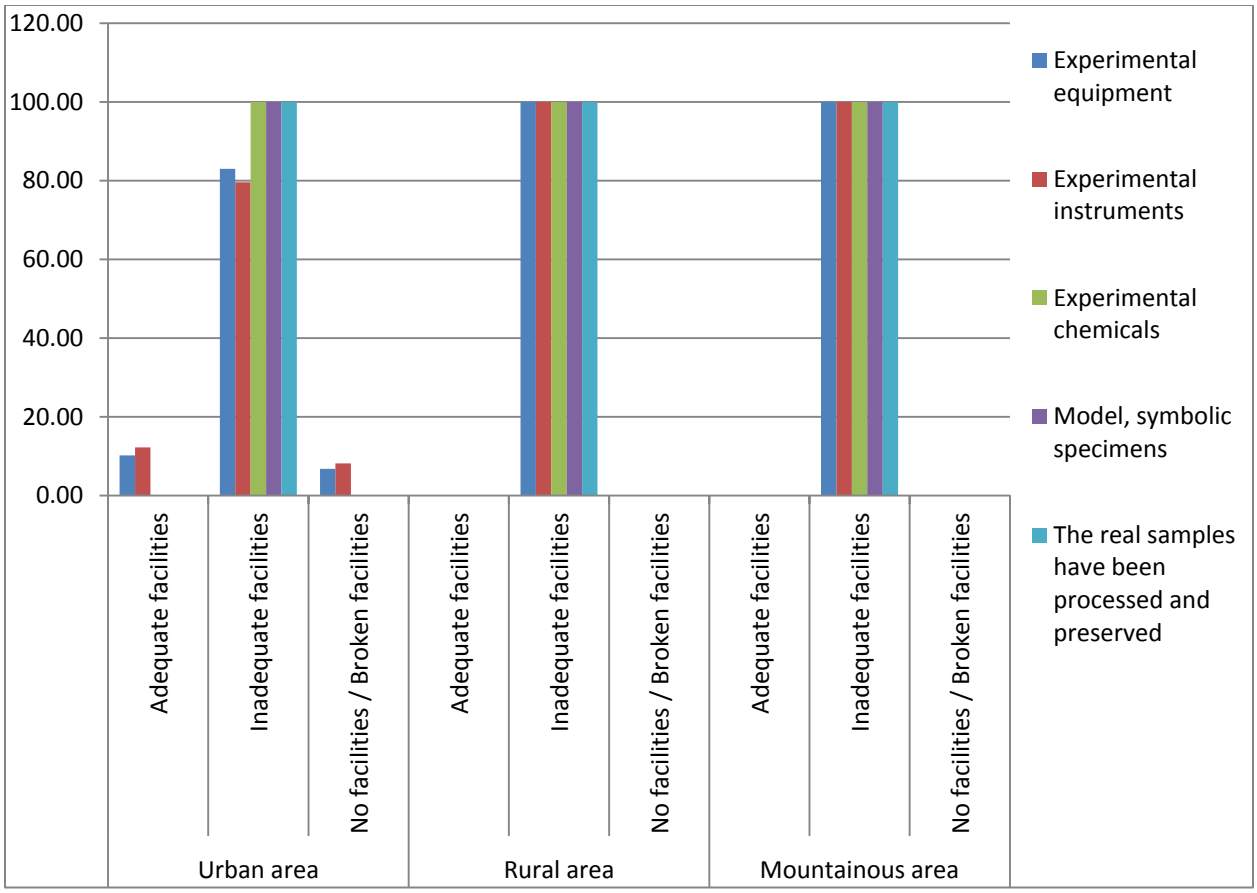

FIGURE 2

CURRENT SITUATION OF THE FACILITIES IN THE LABORATORIES OF PHYSICS, CHEMISTRY, BIOLOGY

Factors Affecting the Frequency of Teaching the Natural Sciences in the Laboratories

Figure 3 shows the survey results regarding factors affecting the frequency of teaching natural sciences in the laboratory in 3 areas as follows:

- *The statement ‘The content of teaching practice in the textbook is optional’* is highly selected by teachers from all three areas, from 91.84% (rural area) to 96.60% (urban area)

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- *The lack of experimental facilities, equipment, and samples* also affects the frequency of teaching activities in the laboratory, ranging from 85.03% (in the urban area) to 95.24% (in a mountainous area).

- *The qualifications of teachers of natural sciences* are claimed as influential by 80.27% of teachers from rural area and 89.80% from urban area.

- *The teaching management in the natural sciences laboratory* is selected by 42.86% (mountainous area) and 60.54% (urban area).

- *The assessment of students' ability to practice natural science experiments* is also one of the factors affecting the frequency of teaching in laboratories. The percentage of surveyed teachers and students who opted for this factor is from 64.63% (mountainous area) to 95.24% (urban area).

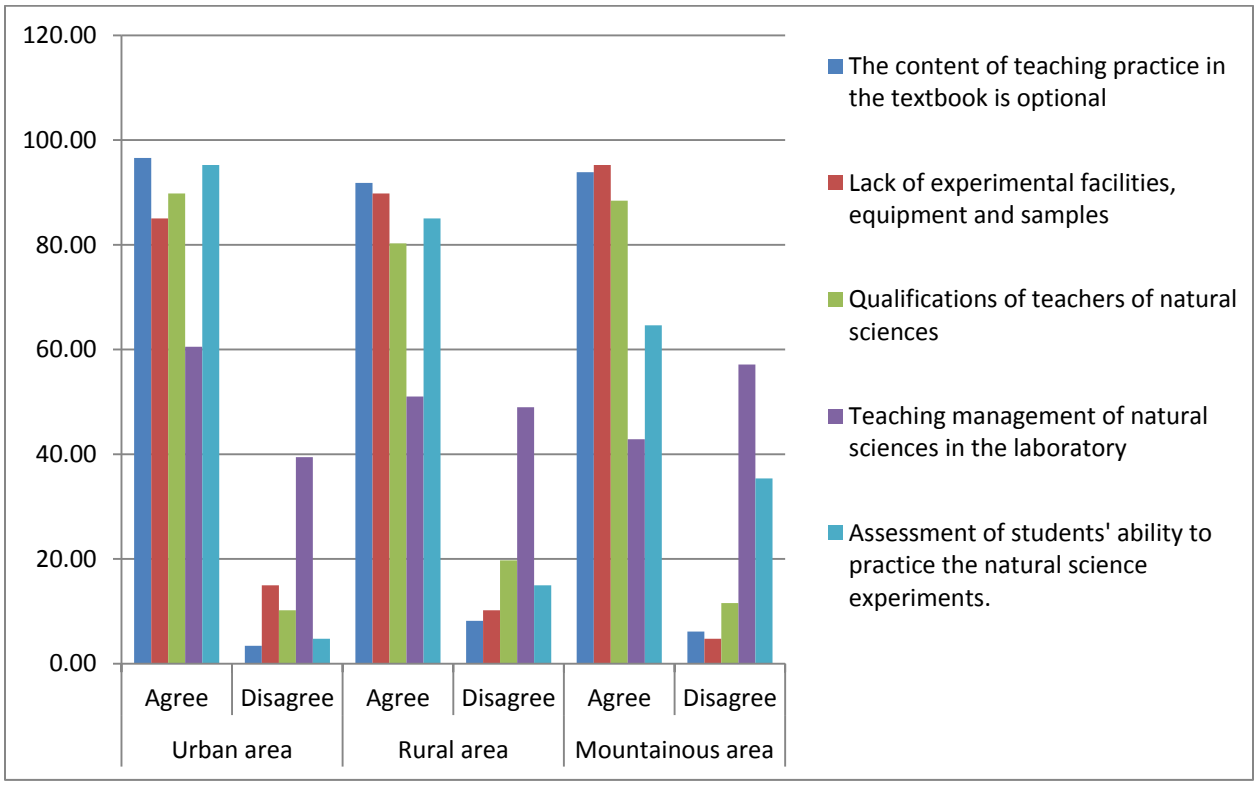

FIGURE 3

FACTORS AFFECTING THE FREQUENCY OF TEACHING NATURAL SCIENCES IN THE LABORATORY

Solutions to Improve the Effectiveness of Teaching Natural Sciences in the Laboratory

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Figure 4 shows the survey results relating to some solutions to improve the effectiveness of teaching natural sciences in the laboratory as follows:

- *Investing synchronously in natural science laboratories to meet the requirements of teaching natural sciences*: chosen by 89.12% (urban area) and 100% (mountainous area).

- *Enhancing the teacher's capacity to teach the practice of natural sciences* agreed by 89.12% (rural area) to 100% (mountainous area)

- *Strengthening the teaching management in the natural sciences laboratory selected by* 42.86% (mountainous area) and 88.44% (urban area)

- *Including the assessment of the students' ability to practice natural science experiments in exams*, chosen by 63.95% (mountainous area) and 97.96% (urban area)

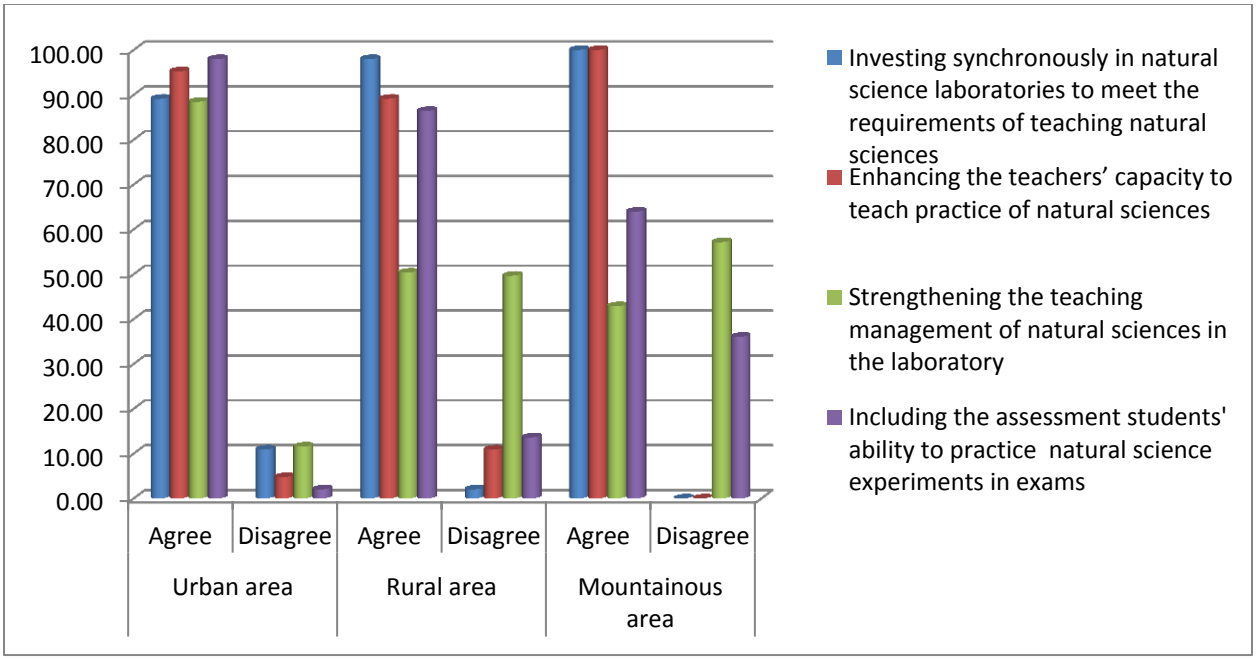

FIGURE 4

SOLUTIONS TO IMPROVE THE EFFECTIVENESS OF TEACHING NATURAL SCIENCES IN THE LABORATORY

DISCUSSION

Laboratories for all subjects at the lower secondary level in 3 areas namely urban, rural, and mountainous areas are relatively insufficient, as only half of the respondents confirmed the availability of general laboratories, quite consistent among three areas in question, ranging from 44.9% to 59.86%. The availability rate of specialized laboratories for the natural sciences is about 20-30% higher than that for general purposes. Among the natural science laboratories, chemistry laboratories recorded the highest percentage. The survey results are completely

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consistent with the current lower secondary school curriculum in Vietnam in which only few subjects focus on practice, such as natural sciences are physics, chemistry, and biology. Contrary to our belief that more schools in urban areas would have a laboratory, the survey results revealed that the percentage of laboratories in the mountainous area was the highest, followed by the rural area and the lowest in the urban area. This can by put down to the fact that urban area has a much larger population of students than those in the other two areas. The shortage of classrooms might enforce the conversion of some original labs into classrooms, which resulted in the insufficiency of labs.

The results regarding experimental equipment, instruments, and chemicals, model - symbolic specimens, real specimens which have been processed and preserved in practice rooms for physics, chemistry and biology in three areas: urban, rural, and mountainous of the North-Central provinces in Vietnam showed that in the urban area, although the number of specialized laboratories is inadequate with interdisciplinary usages, several laboratories in the urban area are quite well-equipped with adequate chemicals and samples for experiments compared to schools in rural and mountainous areas, largely due to the attention to practical exercises - experiments in the curriculum from city schools. Also, better economic conditions in this area guaranteed the timely investment in the necessary equipment, chemicals, specimens, and replacement of the damaged ones. In particular, some schools which are high-quality schools, specialized schools, or international private schools invested by individuals or non-public organizations possess very modern laboratory systems.

Regarding factors affecting science subjects teaching in laboratories, it was pointed out that the frequency of using the laboratory in teaching does not only depends much on the insufficiency of facilities, equipment, and specimens but also on other factors. For example, a majority of teacher participants (over 90%) chose the factor '*the content of practical teaching in the textbook is not required*', which means that laboratory teaching was not teachers' preference. This may be resulted from the lack of equipment in the laboratory which stopped teachers from sending students to the lab. Among the mentioned factors, 'no summative assessment of the ability to practice natural science experiments' is also chosen by a significant proportion of participants , 95.24% in the urban area, 85.03%in the rural area, and in the mountainous area - 64.63%. This disparity may be explained with the lack of facilities, equipment, and samples in the highlands.

In terms of solutions to improve the effectiveness of teaching natural sciences in the laboratory, *'Investing synchronously in natural science labs to meet teaching requirements of natural sciences*' and '*Enhancing the teaching capacity of teachers of natural sciences'* are both selected by 100% of the teachers and students in mountainous areas. This is similar to the percentage of teachers opted for the lack of facilities and the capacity of teachers to teach natural sciences practice as factors affecting laboratory use with 95.24% and 88.44% respectively. In urban and rural areas, the participants also highly appreciated the role of teachers' teaching capacity regarding natural sciences practice.

International scientists focus on issues such as creating an ecosystem that fosters practice (Hofstein & Kind, 2011), which is concerned with laboratory tasks (Chin & Malhorta, 2002) and organizational principles and teacher role in the laboratory (Abi-El-Mona & Abd-El-Khalick, 2006). Meanwhile, due to limited economic conditions, the concern of having sufficient minimum laboratory equipment is an issue for the Government and of each school. One of the

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solutions that can overcome the lack of equipment as well as improve capacity and excitement as well as efficiency in practice and experiments is to connect with universities like Goldstein et al. (2018) introduced.

Although studying natural sciences in the laboratory offers many benefits to students, at the selected schools in 3 areas (urban, rural, and mountainous) of the North Central region in Vietnam, at present, the teaching quality as well as students' interests and academic achievement of natural sciences have been negatively affected by the following hindering factors:

1. Laboratories for all natural sciences are not sufficient and adequately exploited.
2. Equipment in the laboratory (including experimental equipment, instruments, chemicals, and samples) is inadequate, especially at schools in a mountainous area.
3. Teachers are not qualified and confident in teaching in the laboratory.
4. The management of natural sciences teaching in the laboratory is not efficient.
5. Most schools do not include practical experiments into the official evaluation.

CONCLUSIONS AND RECOMMENDATION

In this study, it has been widely stated that teaching natural sciences without practical activities affects students' achievement and interest in science subjects. As a result, many teacher participants complained that their students did not like studying science subjects and showed little concentration or interest during their classes. The research findings pointed out that despite the insufficiency of specialized laboratories for individual subject, the majority of selected schools have general laboratories. However, many teachers hardly exploit the laboratory system for their practical lessons, which caused the lack of learning motivation for real-life activities and negative learning outcomes with natural science subjects, which are closely associated with laboratory experiments.

In general, there has been a constant lack of attention to experimental facilities provision and implementation of experimental activities in secondary schools from the education department, school administrators, and the community in the region in questions. Also, there is only a limited number of policies that encourage laboratory teaching activities or include this specific activities in the summative assessment. Therefore, it is crucial for Vietnamese Ministry of Education and the Department of Education of the North Central region to propose and implement a project to enhance the teaching efficiency of scientific experimental contents in the researched area, focusing on completing the system of laboratories in schools and improving facilities as well as enhancing teachers' knowledge and skills of teaching experimental practice in natural sciences.

PISA 2016 points out that Vietnamese students have a low willingness to pursue science, engineer, and technology careers (OECD, 2016). Vietnamese teachers perceived the foci STEM education and value STEM competencies (Thi To Khuyen et al., 2020). But teachers and administrators do not pay enough attention to the role of laboratory equipment in schools, especially STEM subjects.

Experts, educational institutions, and teachers must be more acutely aware of the importance of laboratories in teaching natural sciences. On the other hand, it is also advisable to educate

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students to actively participate in laboratory practice lessons, proactively ask teachers and schools about the completion of their labs, ask teachers for support in using the laboratory for studying. The Ministry of Education and localities should build specialized standard laboratories for each science subject; foster laboratory technicians of natural sciences; investing in chemicals, equipment, and samples for teachers and students to perform basic and advanced experiments in the program. Collaborating with regional universities to enhance the capacity of science teachers, reconstructing the existing laboratories, repairing and maintaining the usable machines and equipment, making the available labs work by organizing training, arranging labs through their community service project. Thereby, to help students obtain outstanding achievements in natural sciences, schools need to pay special attention to the implementation of effective practical activities and experiments in teaching natural sciences and attract students to natural science classes at the secondary school level.

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