Enhancing scientific literacy – research the case of teaching the topic Water in life

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Abstract: Scientific literacy has been a strong target in many countries for many years, including Vietnam. Educating students to become future citizens has been emphasized in the science curriculum, with the goal of providing students with the tools they need to be able to adapt and solve practical issues in a responsible way. The article mentions the proposal for structure of scientific literacy and research the case of enhancing scientific literacy through activities to explore while learning the topic Water in life.

1. Introduction

The nature of science is humanitarian, and so science activities are responsible for society. After all, scientist is a member of society, and cannot stand outside or above society, so their scientific research must contribute to the community. Therefore, teaching science must towards bigger goals not only the scientific knowledge and skills but also the application of scientific knowledge in the problems of reality and society.

Over the years, educating students to become future citizens has become a major challenge for science education in many countries, especially in Europe and in developing countries. \cite{8}\cite{12}, including Vietnam. Scientific education for all should be directed to scientific literacy, including attitudes of learners to the community.

There are many organizations and programs in the world which are interested in researching scientific literacy such as the Organization for Economic Co-operation and Development (OECD), such as Australia, Singapore and Germany \cite{10}. However, there are certain differences in the structure of the scientific literacy. In the general, education program of Germany, the competence model of natural sciences is divided into four groups of competency components: specialist knowledge, knowledge discovery, communication and assessment. In the US and Singapore programs, the structure of scientific literacy includes elements: questioning and problem identification; development and use of the model; planning and conducting surveys; analyze and present data; use mathematical thinking; solution design and solution design; gathering evaluations and exchanging information. PISA is initiated and directed by the OECD. It recognizes scientific literacy as a basic ability of students to study science and proposes a suitable structure to evaluate secondary school students \cite{2}. In Vietnam, scientific literacy is one of the goals of the general education program after 2018, so many authors have been interested in research. In our study, we emphasize that the knowledge that is taught in schools should refer to the social issues that the learner lives in. We use the term Scientific Literacy but the term Scientific Competency in order to emphasize the attitude of using their scientific knowledge.

The research topic is how to select the topic of teaching and how to organize learning activities to meet the scientific literacy goal of the learner?
2. Research content

2.1. Scientific literacy

2.1.1. Concept. The concept of competency has been mentioned in many domestic and foreign documents with different approaches, so there are many different definitions of competence. At present, there are three different terms that are translated into Vietnamese as "năng lực": competency, ability and literacy.

The term Competency emphasizes the ability to effectively implement actions, issues related to a certain area is based on knowledge, skills and willingness to act [9], [13]; Perrenond. P [7] and consider competency as such as qualities, psychology, personal attributes [1].

In the term Literacy - this term when translated into Vietnamese means academic level, the ability to read and write. The PISA’s documents use the term Literacy. The authors translated into Vietnamese as “năng lực” [2]. According to PISA, Literacy includes knowledge, skills and cognitive processes. PISA and some other countries emphasize the use of knowledge and skills accumulated in schools in the context of real life situations in order to contribute to changing attitudes of learners.

In our opinion, Literacy refers to understanding in general and applying that knowledge into real-world contexts to emphasize the responsibility of future citizens for the problems of society, community. The term (literacy) is different from the word competency. In terms of competency, competence consists of a fairly complex set of elemental powers. In terms of literacy, it cannot be divided into elements but only express their manifestations. It emphasizes understanding in order to solve problems in a real context as responsible citizens with the future, with the society.

From the two terms of competency, it leads to two different ways of describing scientific competency.

- The first group is the term "Scientific competency". It is the ability to perform scientific activities to create new concepts, new methods, new tools of a scientist or a future scientist. This concept emphasizes the scientific ability associated with the scientific process. Therefore, enhancing scientific competency for students emphasizes the fostering process of scientific research. Therefore, teaching science according to scientific process has become a central issue in educational reform in some countries such as the United States, France, and Canada.

- The second group is the term "Scientific literacy". PISA 2006 [5] uses the concept of scientific literacy - when translated into Vietnamese, the authors have called it năng lực khoa học (scientific competency). According to PISA, scientific literacy is the ability to use scientific knowledge, analyze questions and draw reasonable conclusions to make sound decisions about the natural world and human changes. Created for the natural world. This concept emphasizes that teaching aims are attitudes toward science, to the problems of society.

OECD has defined the scientific literacy as follows: Scientific literacy is the individual's scientific knowledge and the ability to use knowledge to identify questions, acquire new knowledge, explain scientific phenomena, and draw conclusions; the ability to identify problems and the ability to draw conclusions based on issues related to science; Scientific literacy is the ability of the individual awareness of the impact of science and technology on human life, material and cultural life. Scientific literacy is also expressed in the willingness to solve issues such as a citizen with scientific knowledge and thinking [2]. In this view, a person with scientific ability should have the following elements:

1. Have scientific knowledge.
2. Understand the characteristics of science as a form of human knowledge and discovery activities of human.
3. Use knowledge to identify, acquire new knowledge, identify scientific issues, explain scientific phenomena and draw conclusions on the basis of evidence on scientific issues.
4. Aware of the role of science and technology in shaping the cultural, spiritual and material environment.
5. Willingness to participate as an active citizen, applying scientific understanding to solving related problems.

Thus, the manifestations of scientific literacy do not overemphasize the process of scientific research and the scientific knowledge that attaches importance to the use of knowledge and attitudes to the use of scientific knowledge. This is very suitable for students in secondary schools.
2.1. Structure of scientific literacy. According to PISA, scientific literacy is structured by three components: (a) Explaining the facts in a scientific way; (b) Evaluation and design of scientific research; (c) Present the data and evidence in a scientific way [5].

PISA has a broader approach to assessing students' knowledge, skills and attitudes, which is aimed at assessing the capacity to use knowledge in addressing everyday tasks and challenges. This broad and practical approach helps PISA to better reflect changes in the curriculum, more specifically, a model based on a lifelong learning model in which the accumulation of knowledge and skills is needed to adapt in an ever-changing world and a lifelong process, not limited to school.

However, this structure only evaluates the students after the study but not interested in the research activities of learners during the study. On the one hand, based on the structure of PISA's scientific literacy, on the other hand, based on the point of view that learning activity is in fact the learning activity in the scientific process, we add activities on scientific discoveries and propose the structure of scientific literacy in teaching science in junior high school.

Table 1. Proposing structure components of scientific literacy

| Components/ Behavior index                  |
|---------------------------------------------|
| 1. Explain the phenomenon in a scientific way |
| 1.1. Recognize (recall) and apply scientific knowledge appropriately |
| 1.2. Create models to explain the phenomenon in a scientific way |
| 1.3. Make trusted predictions/ Provide hypotheses to explain |
| 1.4. Explaining the meaning of scientific knowledge to life, society. |
| 2. Evaluation, design and implementation of scientific discovery |
| 2.1. Ask questions to discover a scientific mission. |
| 2.2. Propose how to carry out research tasks (proposed solutions) |
| 2.3 Select research solution |
| 2.4 Do the research |
| 3. Present data and evidence in a scientific way |
| 3.1. Analyze and process data |
| 3.2. Review and compare the results |
| 3.3. Show the results |

2.1.3. Enhancing scientific literacy. In the world, there are many authors interested in researching the literacy of science by various means such as [4, 3, 6, 11]… Many of these studies emphasize:

First of all, enhancing scientific literacy must be through the learner's own activities. The research by Holbrook. J & Rannikmae. M indicates that the nature of science teaching based on the theory of enhancing scientific literacy should be linked to the goals that individual learners need to attain, including personality and attitudes, positive, civic responsibility with goals in the field of social education [4].

Secondly, teaching should put learners in a practical context so that problem solving can change the attitude and responsibility of learners to society. Derek Hodson believes that it is time for the school's science curriculum to move towards social responsibility. The author believes that in order to solve the current social and environmental issues, a generation of citizens with scientific understanding is needed. From there, the author proposes a scientific program focusing on seven areas of concern (human health, food and agriculture, land, water and mineral resources, energy and consumption, public communications, transport, ethics and social responsibility) with the participation of the community. Therefore, it is necessary to focus on how to choose teaching content to direct learners to social responsibility and community [3].
Finally, attention should be paid to the role of social interaction in enhancing scientific literacy. Janice D. Gobert and Barbara C. Buckley show that learning science is effective when learners develop and evaluate models of their own, others, and scientists. The study also found that group discussion and collaboration were measures to enhance students' cognitive and metacognitive skills. [6]

Fourthly, Care should be taken with the role of the learner's conception and the teaching of science with changing the conceptions of students in explaining the phenomenon in a scientific way. Reinders Duit & David F. Treagust believe that one of the ways to dramatically improve teaching and learning science is to change the perceptions of learners, which discuss the research that changes our perception. analyze, explain the practical phenomena with scientific knowledge [11].

Putting students into activities, organizing group interaction, accessing the process of exploring science comes from life issues, linked to individuals, local, national and global issues. are of interest to researchers worldwide. Research will mention discovery activities in the process of building knowledge as well as in the application of knowledge to solve issues that are linked to the real context of society to change attitudes and responsibilities of the learner.

2.2. Develop the topic of enhancing scientific literacy for students

2.2.1. Principles of selecting topics. With the connotation and structure of the concept of scientific literacy as presented, teachers need to choose practical situations that are linked to science. This focus on situations is also consistent with the emphasis on "life context" in PISA surveys. The context of life related to health, natural resources, environment, environmental and technology risks will be an opportunity for learners to understand and be responsible for individuals, local, global and society.

With the topic of health: at the local level, it is the matter of preservation and food safety, nutritional issues. At the social level, that is production and distribution of resources. And at the global level, that's the problem of the growth of the world population and the sustainable use of resources.

Thus, in order to gain scientific literacy, learners must have scientific knowledge, knowledge of scientific process to explain the practical phenomena in a scientific way. Local, social, and global contexts are the top priorities for developing teaching topics. This may lead to inconsistencies in the choice of teaching content. On the one hand, it emphasizes the scientific nature of the scientific knowledge itself (science teaching is primarily prepared for the training of scientists rather than future citizens). On the other hand, it emphasizes the "social" aspect of scientific knowledge. The emphasis on the social aspect of scientific knowledge leads to the appearance of alternative subjects instead of traditional subjects (such as physics, chemistry, biology). These subjects are characterized by the integration of knowledge content at different levels.

However, in our opinion, it is important to establish a balance between these two tendencies, in addition to emphasizing the nature of scientific knowledge, it also needs to concern the social nature of the knowledge. This means that in selected topics, discovery activities to build knowledge with explaining the phenomenon in a scientific way always support one another. If the social nature of knowledge is concerned so much, it can lead to the risk of teaching "beyond the subject".

In order to enhance the scientific literacy of the students, the selection of subject content requires the teacher to follow the following steps (Diagram 1):
Diagram 1. Steps to select teaching content

Analyzes the social, cultural and economic needs of the community as well as the needs and aspirations of their students or parents.

Carry out a detailed analysis to clarify the educational intentions and purpose, and to identify values and priorities that need to be taught in order to meet aspirations to encourage action to solve the issues of the event, living, serving the society.

Establishing teaching goals and specific objectives of the situations revolves around a central theme that relates to the content of knowledge and methodology in the various subjects.

Social responsibility is associated with the need to solve complex situations of social life, requiring the use of knowledge and methods of many subjects. In other words, integrative teaching has created a favorable opportunity for enhancing social responsibility for students.

2.2.2. Teaching the topic Water in life

Water is one of the topics chosen for enhancing scientific literacy because of its importance to every aspect of life. Topics include the following contents:

Diagram 2. The topic Water in life
After defining the content of the topic, the next issue is the need to design discovery activities that ensure opportunities for fostering scientific capacity in learners. The table below shows the opportunities for enhancing scientific literacy in two activities of the content “The use of water”.

| Table 2. Opportunities for enhancing scientific literacy when teaching the topic The use of water |
|----------------------------------------------------------|
| **The process of exploring, discovering** | **Opportunities for enhancing behavior indexes of scientific literacy** |
| How is water distributed to the family and used at home? | Explain the principle of distribution to households |
| | Create models to distribute water to households |
| | Make research questions: how do you know how water is used at home? Assess how much water is used? What causes wasted water? |
| | Implement research solution |
| | - Learn how to use water at home. |
| | Solution Review: Learn how to use water at home |
| | Analyze and interpret data to draw conclusions about the amount of water used in the studied families. |
| | Propose and adjust solutions to save water in your family. |
| | Make research questions: How is water used in agriculture? What is the role of water in plants? |
| | Implement the solution |
| | - Understand the role of water in agriculture |
| | Describe the research results on the role of water for crops. |
| | Propose solutions: Smart and saving irrigation model |
| | Evaluate and adjust solutions on smart and saving irrigation model |
| What is the role of water in agriculture? | Explain how is the water used in your home (or the surrounding family) reasonable? |
| | How do you adjust the right amount of water use in your home? |
| | Proposed water quality test plan is reasonable? |
| | - What is your family's and your child's daily use? |
| | - Find out how much water is used daily, monthly by tracking water meters and charting, reading water bills, collecting data |

2.3. Assessing the scientific ability

2.3.1. Use the observation checklist (Rubic). To assess scientific literacy in the process of learning each specific knowledge unit of the topic Water in life, the research makes description table of the structure of scientific literacy and levels of quality criteria. In order to preserve the value of the measurement tool, a description of the capacity structure was consulted by expert opinions. After processing expert opinions, the checklist has been adjusted, revised and concretized as shown in the table below. In the topic “What is water?”, the checklist of behaviors of scientific literacy is as follows:

| Table 3. Scientific literacy assessment checklist in the topic "How is water used at home?" |
|-----------------------------------------------|
| **1. Explain the phenomenon in a scientific way** | Explain the important role of water for self, community and social life |
| Explain the meaning of scientific knowledge to life, society. | How is the water used in your home (or the surrounding family) reasonable? |
| Ask questions to discover a scientific mission. | How do you adjust the right amount of water use in your home? |
| | Proposed water quality test plan is reasonable? |
| | - What is your family's and your child's daily use? |
| Propose how to carry out research | - Find out how much water is used daily, monthly by tracking water meters and charting, reading water bills, collecting data |
2. Evaluation, design and implementation of scientific discovery

Select research solution

- Analyze, evaluate, select the optimal solution for the proper use of water in the family.
  - Do you have a detailed plan for researching and checking water usage?
  - Make a detailed plan for the design of water-saving appliances and equipment in the home
  - Assign specific tasks in the group
  - Select and prepare raw materials.

Do the research

- Successfully follow the steps of the plan

Analyze and process data

- Select and arrange the appropriate information to present the report

3. Present data and evidence in a scientific way

Review and compare the results

- From the chart, does the collected data compare the amount of water consumed or less, saved?
- Comment on the results of water use after the implementation of water-saving measures
- Review comments on the operation of automatic spill prevention devices and watering tools save.

Show the results

- Choice of scientific presentation: poster, apphiche...

Using this checklist, the study confirmed the behavioral manifestation of the student's scientific literacy while learning the subject matter.

From the checklist that has been developed, observations have been made, the research has collected evidence on the behavior of scientific literacy. Specifically, with the task of discovering "How to use water at home", the behavioral manifestation of the student's scientific literacy has been demonstrated:

- Explain the important role of water for self, community and social life
- Ask questions to discover a scientific mission.
- Proposed water quality test plan.
- Evaluate the amount of water used in a single family day. Students track the amount of water used in the household by reading the water bill, tracking the water meter...
Students evaluate the amount of water used in the home for various needs such as bathing, washing, toilet use, etc. From that set up evaluation.

**Figure 1.** Learn how water is used in various home activities such as laundry, showering, hand washing and face cleaning.

- Devise measures to regulate the use of reasonable water in your home such as automatic spill prevention design, water-saving plant watering design.
- With solutions designed to save water, students also assign each other to search, purchase tools to assemble and operate the equipment. The individual and team working out the plan have outlined:
  - Preparing instruments:
    - Assemble the equipment according to the design plan
    - Check the layout and assembly of test instruments
  - Analyze, evaluate and select the optimum design options with the use of simple, easy-to-find materials.
  - Present, discuss and identify the stage of designing product.

**Figure 2.** Fabrication of equipment to avoid wastage of water: "Automatic anti-spill equipment"

2.3.2. **Scientific literacy test.** Test is a fairly popular assessment tool that allows researchers to collect data through answers or describe the way students think about a system of questions or tasks that require people. must demonstrate knowledge of knowledge and skills required. Therefore, designing tests must follow a strict process that includes the following steps: clarifying the purpose of the test, identifying the object to be evaluated, determining the variables to be measured, determining the method and condition take quizzes, set up test matrices, compile items and score guides, discuss quizzes and items; test and evaluate, complete the test.

After the student finishes studying the topic Water in Life, the research uses the test to assess the scientific literacy. The test was standardized with Conques and SPSS software to test the tool.

- Assess the reliability of the test
  - The Cronbach Alpha coefficient considers the correlation of the performance of a question with the whole test. Calculation of the coefficient Cronbach alpha using SPSS software gives:
In the table above, the Cronbach alpha coefficient is 0.749. This coefficient is at average (from 0.6 to 0.8). So the test used to measure the scientific literacy is relatively good.

- Information curve of the test subject

For this test, the information curve is given by the following figure:

![Information curve of the test subject](image)

**Figure 3.** Information curve of the test subject

Looking at the information curves of the test, which can be seen as an average test for students, and this test has the most information in the range from -1 to 0.5.

- *Map of balance between the difficulty of the task and the competency of the learner*

Figure 2 shows the balance between the difficulty of the 16 questions and the competency of 43 students in the same Logit scale, with "0" is the average value.

![Difficulty balance map of 16 questions and student's competencies](image)

**Figure 4.** Difficulty balance map of 16 questions and student's competencies.

The outer left of the map is Logit scale. Next is the distribution of students' competency along the logit scale, for every 0.3 children denoted by an 'x'. The right side of the map is the difficulty level of 16 questions. Students in the same position as the question, the probability of answering the question correctly is 0.5. When the student is in higher or lower position, the probability of answering the question correctly will be higher or lower than 0.5.

The map shows that the test has a degree of difficulty that is distributed fairly to the student's competency (spread evenly over the scale). Some questions are easy such as the 2nd, 5th question (most students are able to answer correctly), and some difficult questions like the 3rd, 10th, 16th question (few students have the correct answer). However, there are some students who has competency with the same difficulty level of questions in the subject.

After normalization, determination of the difficulty and reliability of the test, the test was conducted in two control and experiment classes with 43 students in grade 6 - the first grade of lower
Based on the equality test of the two variances, it shows that:

The sig. value in the Levene test = 0.978 (> 0.05), so the variance between the two experimental and control classes remains unchanged, we will use the results of the Equal variances assumed.

Sig. value in Equal variances assumed in the t-test < 0.05 so it can be concluded that there is a significant difference in the average values between the two experimental and control classes. This shows that the goal of enhancing scientific literacy for students when teaching the topic Water in life has been initially confirmed.

3. Conclusion
The research results in the teaching of the theme Water in Life have shown that the construction of a scientific literacy structure model and the design of learning activities have responded to the need to demonstrate the behavior of the Literacy, it is suitable for junior high school students.

The results of these learning activities not only allow students to have a common understanding of water, but also help them to apply this knowledge in real life situations, with a focus on the responsibility of future citizens with the problems of individuals, local and global - here is Water in Life.

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