

VIEWS ABOUT SCIENTIFIC INQUIRY (VASI): THE CASE OF SPAIN AND SWEDEN

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ABSTRACT: There is agreement among researchers that one of the main objectives of scientific literacy is that all students understand Scientific Inquiry (SI). Even with many educational proposals guided by SI, there is still difficulty assessing learners' notions about it. The results presented in this paper represent the Spain and Swedish sample using the VASI questionnaire. The objective was to evaluate the notions of scientific investigation of the 7th grade students. Analyzing the responses of students, it can be considered that they can conceptualize some aspects of the nature of scientific inquiry, but cannot identify them in real situations.

KEYWORDS: Scientific Inquiry; Assessment; Knowledge of Inquiry

INTRODUCTION

Understanding scientific inquiry (SI) is considered critical to the development of students' scientific literacy (Lederman, Lederman & Antik, 2013). Current science education reform documents emphasize the importance of developing abilities adequate to do inquiry as well as have informed visions about SI (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 2012). Therefore, students should be able to understand how scientists do their work and how scientific knowledge is developed, critiqued, and accepted by the scientific community as well as be able to develop such skills. SI also refers to the activities of students in which they develop knowledge and understanding of scientific ideas (NRC, 1996). According to Lederman, Lederman, Bartos, Bartels, Meyer and Schwartz (2014), we need to provide authentic learning contexts that allow the explicit reflection and develop a sound understanding of the different aspects of SI and they defined eight key aspects related with knowledge of inquiry: There is no a single method, scientific investigations begin with a question, the procedures are guided by the question asked, the same procedures do not necessarily have same result, the procedures can influence the results, the conclusions must be consistent with data collected, data and evidence are different, and explanations are based on data and previous knowledge. However, little research has been done on Understandings of Scientific Inquiry. One of the reasons is the lack of available instruments to provide a meaningful assessment of learners' views

of SI. Lederman et al, (2014) provide a valid and reliable instrument called Views About Scientific Inquiry (VASI) questionnaire that focuses on understanding about inquiry and students' actions while engaged in inquiry activities. Therefore, the aim of this study was to evaluate the notions of scientific investigation of the 7th grade students in Spain and Sweden.

METODOLOGY

Data collection

For both countries, the VASI questionnaire was given in the students' language of science instruction. The questionnaire was translated, back translated, to the corresponding language. After administration of VASI, the responses were coded independently by the members of each team. Each student was given a code of informed (I), mixed (M), naïve (N), and no answer (N/A) for each aspect. At least 20% of the students were interviewed to ensure that the coding of the VASI was accurate. The inter rater reliability reported for the VASI was 80% or better for each aspect.

The Case of Spain

Three public middle schools in Spain participated in the international VASI study. Two schools were from Seville and the other was from Granada. The schools were diverse on socioeconomic status. The first school represents the provincial colleges from Spain, the second school the peripheral marginal schools from Spain and the third school the rural schools from Spain. The sample consists of 159 seventh-grade students. The majority were Spaniard with, also, students belonging to minority ethnic groups. Female and male students were represented in similar proportions in this study. Most of the students had no difficulties answering the VASI questionnaire, but for some, we had to clarify some vocabulary words that were not clearly understood.

Results and conclusions of Spain

In general, most of 7th grade Spanish students showed a Naïve or Mixed knowledge of the aspects of SI as shown in figure 1.

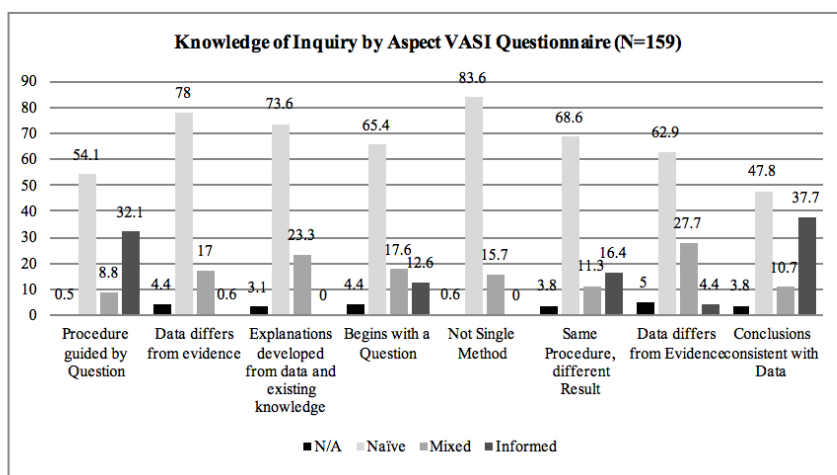


Fig. 1. Percentages of students and knowledge by aspects of Scientific Inquiry

Begin with a Question

65.4% of students showed a naïve view about the importance of the question to begin a scientific investigation and only 12.6% of students showed an informed view to this aspect. Some students mentioned that the questions are not important because scientific research can begin with the observation of a phenomenon, problem, experimentation or even testing. 17.6% have a mixed view about this aspect and 4.4% of students did not answer the question.

No Single Method

83.6% of students stated that there is just a single scientific method and only 15.7% expressed a mixed response about it. No student expressed that scientist can use more than one method to do science. It seems that students have a reductionist view about the scientific method. Only 0.6% did not answer the question.

Procedure guided by Question

32.1% of the students showed an informed view related with procedures are guided by the question asked. On the other hand, 54.1% of the students have a naïve idea about the procedures are designed to answer a question and 8.8% students showed mixed idea. Only 5% did not answer this question.

Same Procedure, different Result

Only 16.4% of the students thought that from the same procedures, the researchers can interpret the conclusions differently and get different results because of subjectivity and previous knowledge. On the other hand, 68.6% of the students think that when the scientists do the same procedures, they have to get the same results. 11.3% of the students have a mixed view for this aspect and only 3.8% did not answer.

Conclusions consistent with Data

37.7% of the students showed an informed answer to this question. However, more than 47.8% still show a naïve answer. Also, 10.7% show a mixed answer and 3.8% did not answer. This could show little ability of students to critically interpret tables and graphics.

Data differs from Evidence

78% of the students were not able to explain the difference between data and evidence, showing that, for most of them, data and evidence are the same. 17% have problems defining one or the other term. Only one student (0.6%) explained correctly the difference between data and evidence, and 4.4% did not answer.

Explanations developed from Data and existing Knowledge

No student was able to provide an informed answer for this question. Again, more of the half of the students showed a naïve answer for this aspect and 74.6% and 23.3% showed a mixed answer for this aspect. Only 3.1% did not answer. Similar to the category Conclusions consistent with data collected,

students had difficulty interpreting the information in charts as well as having a naive conception of it.

In general, Spanish students showed a naive view, over 50%, for all aspects of SI. One of the reasons for this result is the lack of an adequate understanding of students about science and SI. The results emphasize the view that there is a single scientific method and the difficulty distinguishing between data and evidence. Students in our system seem able to use scientific reasoning, but they are unable to understand the phenomena that affect them in their day to day lives. Another reason that may explain these results is related to teaching methods and content, these include the lack of SI as relevant science curricular content, lack of adequate understanding of the aims and objectives to facilitate their inclusion in science lectures, resistance against reforms and educational innovations, lack of effective teaching approaches related to SI, and performing SI reflective activities. On the other hand, informed views of Conclusions consistent with Data collected corresponding to 37.7% can be explained because students learn how to create and interpret data tables from 7th to 12th grade in science classes. Another aspect with a high percentage of informed answers was procedure guided by question at 31.2%. Spanish students discriminated between two statements in order to answer a scientific question and this could be explained because 7th grade students have to work in laboratories and take decisions related with protocols during experiments. However, for both aspects, the percentage of naive views were considerably higher than informed views.

The Case of Sweden

126 students and five teachers from five different schools with different socioeconomic levels participated in the study. The teachers facilitated the access to the classrooms and helped with getting permission from parents for the interviews. The schools represent a cross-section of schools in the Stockholm area (table 1).

Table 1.
Students and school participants in the VASI study.

	N	Ethnicity	Economic level	Type
School A	23	Mixed	Average	Public school with a "culture profile", i.e. a focus on artistic expression is supposed to be theme in all subjects.
School B	26	Mainly Swedish	Average and above average	Public school with a "technical profile", i.e. something similar to the above. A bit unclear though what it actually means.
School C	22	Mainly Swedish	Above average	Public school with profile classes in natural science, social science, music and sports.
School D	36	Higher number of Swedish language learners	Below average	Public school with a stated focus on helping students from different cultural backgrounds and Swedish language learners to adapt (they probably have no alternative but to make this the profile of the school).
School E	19	Mainly Swedish	Average and below average	Public school, no particular profile.

RESULTS AND CONCLUSIONS OF SWEDEN

Scientific investigations begin with a question

(Informed: 29%, Mixed: 17%, Naïve: 30%, N/A: 23%)

Students that agreed with this aspect provided some of the following reasons: It is logical because searching for answers implies that there is a question or it would be difficult to know what to do otherwise and students who did not agree provided the following reasons: An interest to know more about something can be enough, an accident or fluke may initiate an investigation, it is enough to know how to do the investigation or you can't know if an investigation is scientific until you have tried to do it. Two students changed their answer during the interview to more informed views.

There is no single set of steps followed in all investigations

(Informed: 21%, Mixed: 33%, Naïve: 30%, N/A: 17%)

Students who stated that there is only one way to do scientific investigations did not express a uniform and clear image of "the scientific method" as a set sequence of steps and students who said there is more than one way often had trouble giving examples. The examples tended to be versions of collecting data or information and doing an experiment, and the answers mirrors what the previous questions already suggest. Collecting information or data often referred to books or the Internet and different ways to do investigations was not something they had talked about explicitly in their science classes according to the interviews.

Inquiry procedures are guided by the questions asked

(Informed: 28%, Mixed: 32%, Naïve: 43%, N/A: 26%)

17 students were interviewed. Nine had initially an incorrect answer and eight changed their answers when examined closely at the formulation of the question in the VASI. These students had focused on the fact that tires are used on different surfaces choosing team B's investigation better. Out of the eight that initially had the correct answer, three referred to the question posed by the researchers. The reasoning of the other five was based on the content of that question without referring to it explicitly.

Same procedures may not get the same results

(Informed: 20%, Mixed: 36%, Naïve: 30%, N/A: 14%)

Only 20% of the students thought that from the same procedures, the researchers can interpret the conclusions differently and get different results, 36% of showed a mixed view, and 30% expressed a naïve answer for the aspect.

Inquiry procedures can influence results

(Informed: 21%, Mixed: 21%, Naïve: 31%, N/A: 27%)

Many students referred to collecting data/facts/information from books and the Internet and some have difficulty understanding how collecting data/information without the Internet could be done. Yet, several students made comments about people thinking in different ways, having different opi-

nions, perspectives and experience, and interpreting data/information differently. There were also comments about making mistakes in collecting data or doing an experiment that may result in different conclusions.

Conclusions must be consistent with data collected

(Informed: 29%, Mixed: 11%, Naïve: 30%, N/A:30%)

Some students gave the correct answer but failed to refer to data in the table. Students that did refer to the data sometimes did so in terms of trends but more often looked at the extreme points in the table. One student referred to data correctly but gave an incorrect answer, but changed the answer during the interview. Students missed the meaning of the question by focusing on what they know about plants perhaps because of the school culture of how questions are usually asked and answered.

Scientific data are not the same as scientific evidence

(Informed: 2%, Mixed: 14%, Naïve: 56%, N/A: 28%)

No student indicated in the interviews that they were familiar with these terms and they did not seem specifically associated with scientific inquiry to the students. Data were often described as information and in particular digital information, including that they are intangible. This is not surprising as the word data means computer in Swedish and is also used as a synonym to digital information. Evidence was mostly stated as more true and data were associated with facts sometimes true or not. In Swedish the verb to prove has the same root as evidence. So, to prove something is to evidence something. It should also be mentioned that the distinction between data and evidence is not self-evident even in a research context in Sweden unless it is specifically made a point of.

Explanations are developed from data and previous knowledge

(Informed: 1%, Mixed: 21%, Naïve: 37%, N/A: 34%)

No student answered this question beyond the particular context of the dinosaurs even with some coaxing during the interviews. Most students answered in terms of which figure would be more reasonable, logical, probable or natural without giving much reasons. The most informed answers included ideas about how the animal would move and keep its balance, the weight distribution and the law of gravity. Another reason was to consider the shape of the bones and how they can fit together as a jigsaw puzzle comparing with other skeletons. Finally, there were also explicit references to previous knowledge found in books or online including information about what it used eat, where it lived, and other animals of its habitat.

In general, students do not seem to have had any systematic teaching regarding the nature of scientific inquiry and related concept such as experiment. In spite of this many students still seem to have a fair understanding of the basic principles of an experiment as involving some active manipulation to test how one thing affects another. Evidence and data were terms virtually all students had difficulties with. The interviews indicated that these were not used or addressed in their science class. Finally, students tend to related research and inquiry to their own school task such as laboratory work and finding information on the Internet rather than scientific inquiry per se.

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