INTERNATIONAL COLLABORATIVE INVESTIGATION OF BEGINNING SEVENTH GRADE STUDENTS' UNDERSTANDINGS OF SCIENTIFIC INQUIRY

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ABSTRACT: Although understanding of scientific inquiry is included in science education reform documents around the world, little is known about what students have learned about inquiry during their elementary school years. This is partially due to the lack of any assessment instrument to measure understandings about scientific inquiry. However, a valid and reliable assessment has recently been developed and published, Views About Scientific Inquiry (VASI). The purpose of this large scale international project was to get the first baseline data on what beginning middle school students have learned. The participating countries for this symposium are: Brazil, China, Israel, South Africa, Spain, and Sweden. In many countries, science is not formally taught until middle school, which is the rationale for choosing seventh grade students for this investigation. This baseline data will simultaneously provide information on what, if anything, students learn about inquiry in elementary school, as well as their beginning knowledge as they enter secondary school. A concerted effort was made to provide a relatively representative picture of each country.

KEY WORDS: Science Education, Scientific Inquiry, Elementary School

INTRODUCTION

Scientific inquiry has been a perennial focus of science education for the past century and it generally refers to the combination of general science process skills with traditional science content, creativity, and critical thinking to develop scientific knowledge (Lederman, 2009). Recent reform documents have emphasized that students should develop the abilities necessary to do inquiry as well as have an understanding about inquiry (e.g., A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, National Research Council (NRC), 2011). However, the National Science Education Standards (NRC, 2000) was most explicit in their differentiation between the abilities to do inquiry and knowledge about scientific inquiry. This distinction also continues to be evident in the NGSS. Similar distinctions are becoming more prominent in reform documents throughout the world. Quite simply, it seems logical that students will improve their ability to do inquiry if they have an understanding about what they are doing, and this knowledge combined with knowledge of science will enable students to make more informed decisions about scientifically based personal and societal decisions. Research indicates that, much like research on understandings of NOS, neither teachers nor students

typically hold informed views of scientific inquiry (Lederman & Lederman, 2004; Schwartz, Lederman, Khishfe, Lederman, Matthews, & Liu, 2002). The research base for SI is markedly smaller than that for NOS. This small research base is partly due to both the conflation of NOS and scientific inquiry and the lack of a readily available, or frequently utilized, instrument similar in nature to the various forms of the Views of Nature of Science questionnaires (VNOS; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). Now with the development of the VASI Questionnaire (Lederman, Lederman, Bartos, bartels, Antink-Meyer, & Schwartz, 2014) the research base for SI can begin to grow. While scientific inquiry is inextricably linked with NOS, what is notable is the lack of a robust research base centered on students' understandings about inquiry. What is evident is the preponderance of research focused on the doing of inquiry, which oftentimes is assumed to imply an understanding of inquiry. The belief that doing SI is a sufficient condition for developing understandings about SI, unfortunately, is a misconception. (e.g., Wong & Hodson, 2009, 2010). The intent of this collaborative project is to report on students' understandings of SI across the globe. Now that a valid and reliable assessment tool is available, we can begin to see what students of the same grade levels know about SI in various countries. The purpose is not to focus on comparisons across countries (especially since instruction, curricula, and cultures vary widely across nations), but rather to develop a baseline of understandings worldwide.

The aspects of scientific inquiry that follow are considered appropriate in the context of K-12 science education and are derived from various reform documents. Specifically, students should develop an informed understanding that: scientific investigations all begin with a question but do not necessarily test a hypothesis; there is no single set or sequence of steps followed in all investigations; inquiry procedures are guided by the question asked; all scientists performing the same procedures may not get the same results; inquiry procedures can influence results; research conclusions must be consistent with the data collected; scientific data are not the same as scientific evidence; and explanations are developed from a combination of collected data and what is already known. These aspects of SI are aligned with what is typically advocated in science education reform documents and is the focus of the VASI questions. It is important to note that the aspects of inquiry noted are not meant to be a definitive list of outcomes with respect to inquiry. However, there is little debate about the importance of these aspects of inquiry and research has shown they are accessible to precollege students within the context of existing curricula (Antink-Meyer, Bartos, Lederman, & Lederman, 2016; Lederman, et. al., 2014; Lederman, Bartels, Lederman, & Ganankkan, 2014; Lederman, Bartels, Liu, & Jimenez, 2013).

STATEMENT OF THE PROBLEM

Although the teaching of scientific inquiry is valued around the world, there has never been an international assessment of what students actually know. This study sought to examine grade seven students' understandings, at the beginning of the school year, of SI in various countries worldwide. This baseline study will give us data on what, if anything, students learn about inquiry in elementary school, as well as their beginning SI knowledge as they enter secondary school. It will provide the global science education community a starting point from which instructional, curricula, and policy decisions can be made.

SAMPLE, METHOD, DATA COLLECTION AND ANALYSIS

There were approximately 100 seventh grade students sampled from countries around the world, with the exception of Antarctica. The research sites for this study were Brazil (n= 102), China (n=166), Israel (n=102), South Africa (n=106), Spain (n=159), and Sweden (n=126). The total sample size of grade seven students was 761 students. The students who were selected for this study were representati-

ve for their region; their selection was based on average academic ability, representative diversity of the region and socioeconomic background. There was a total of 6 primary contact people participating in this study, one contact person in each country, who almost always worked with a team of colleagues. The contact people across the continents were responsible for; completion of training in the coding of the VASI questionnaire, language translation/back translation for VASI validity, selection of a representative, sample, data collection (including paper and pencil assessments and individual interviews), data analysis, and the writing of location specific aspects of the results. This study took place at the start of the grade seven school year which varied in timing depending on the start time of the school year in the various continents and hemispheres. Then, each student was given a VASI to complete in a 60-minute time period. The VASI was given in the students' language of science instruction. After administration of the VASI, the responses were coded by the team in each country. Student answers were coded as: No Response, Naïve, Mixed or Informed for each aspect of SI. If a respondent provides a response consistent across the entire questionnaire that is wholly congruent with the target response for a given aspect of SI they are labeled as "informed". If, by contrast, a response is either only partially explicated, and thus not totally consistent with the targeted response, or if a contradiction in the response is evident, a score of "mixed" is given. A response that is contradictory to accepted views of an aspect of SI, and provides no evidence of congruence with accepted views of the specific aspect of SI under examination, is scored as "naïve." Lastly, for scores that are incomprehensible, unintelligible, or that, in total, indicate no relation to the particular aspect, a categorization of "no response" is assigned. At least 20% of the students were interviewed to ensure that the coding of the VASI was accurate. This insured face validity for the questionnaire. The inter rater reliability required for the study was 80%.
Table 1. Understanding of Scientific Inquiry aspects per country expressed in percentages (%).

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Understanding of Scientific Inquiry
aspects per country expressed in percentages (%).

Procedures are guided by the question asked			
Country	Naïve	Mixed	Informed
Brazil (.95)	75	7	1
South Africa (.80)	53	15	30
Sweden (1.0)	42	3	28
Spain (.87)	54	9	32
China (.95)	14	26	57
Israel (.95)	16	32	43

Science does not have one single method			
Country	Naïve	Mixed	Informed
Brazil (.97)	74	11	1
South Africa (.80)	32	42	23
Sweden (1.0)	38	41	26
Spain (.93)	83	15	0
China (.88)	33	50	3
Israel (.95)	46	26	18

Conclusions and data collected			
Country	Naïve	Mixed	Informed
Brazil (.88)	66	8	3
South Africa (.80)	14	67	17
Sweden (1.0)	46	30	5
Spain (.81)	73	23	0
China (.91)	12	80	5
Israel (.92)	27	21	41

Procedures influence results			
Country	Naïve	Mixed	Informed
Brazil (.98)	81	7	1
South Africa (.80)	24	33	39
Sweden (1.0)	39	27	27
Spain (.82)	62	27	3
China (.84)	21	58	15
Israel (.89)	48	15	19

Data and evidence are not the same			
Country	Naïve	Mixed	Informed
Brazil (.98)	76	5	1
South Africa (.80)	51	20	18
Sweden (1.0)	56	14	2
Spain (.84)	78	17	1
China (.90)	43	52	4
Israel (.95)	38	38	17

Same procedures may not yield the same results			
Country	Naïve	Mixed	Informed
Brazil (1.0)	85	10	0
South Africa (.80)	57	30	8
Sweden (1.0)	30	36	20
Spain (.94)	68	11	16
China (.95)	57	30	8
Israel (.88)	41	21	21

Scientific investigations begin with a Question			
Country	Naïve	Mixed	Informed
Brazil (.95)	83	11	1
South Africa (.80)	21	31	48
Sweden (1.0)	30	17	29
Spain (.89)	30	55	9
China (.85)	78	10	2
Israel (.94)	46	29	21

Conclusions must be consistent with data collected			
Country	Naïve	Mixed	Informed
Brazil (.92)	68	17	1
South Africa (.80)	33	17	48
Sweden (1.0)	30	11	29
Spain (.92)	47	10	38
China (.94)	17	45	36
Israel (.92)	27	21	41

SIMPOSIUM: GENERAL DISCUSSION AND GENERAL RESULTS

Frequency data were used for each aspect of SI for each country. When there were multiple sites in a country the data were aggregated, unless the researchers felt that there were large differences across locations. Each aspect of SI has its own data table containing a list of the participating countries. In parentheses after each country's name is the reliability for that aspects' data. All of the numbers for each category (naïve, mixed and informed) are percentages. Not all of the percentages add up to 100 due to the fact that students left some of the questions on the VASI blank, therefore we could not categorize their answer (table 1).

CONCLUSIONS AND IMPLICATIONS

Overwhelmingly, the results from this study show that students around the world have an overall naïve view of scientific inquiry although there were instances in which students in a country did better than "naïve" on a particular aspect of SI. This is consistent with the studies that have been done with secondary students, pre service and in service teachers. The findings are not surprising since students are rarely taught understandings of inquiry in an explicit, reflective manner. Science is often taught by lecture and with students simply doing inquiry activities, with little reflection on what was done and why. It is clear that no matter where students live worldwide that understandings of inquiry are not cultivated. It is important to note that no statistical comparisons were made among the countries as the purpose here was just to get a baseline of beginning middle school students' understandings. Statistical comparisons across countries would be inappropriate.

Middle school is just over half way through a student's schooling and the data collected in this study indicate that most students hold a naïve view of most of the aspects of SI in seventh grade. Some may argue that grade seven is only half way through a student's academic career and there is a good deal of time for students to fully understand aspects of scientific inquiry. However, previous studies have found that very young children (grade one and above) are able to adequately understand several aspects of scientific inquiry; science begins with a question, there is no single scientific method and conclusions are based on data gathered and what is already known (Lederman, J., 2012). Students should at the very least have informed views of at least some of the aforementioned aspects by grade seven.

In this study we found that students do not understand SI. Our inference is that SI is not taught in an explicit/reflective manner. These understandings are consistently naïve around the world. This study provides evidence to pre service and in service educators that they need to explicitly teach about scientific inquiry and how such understandings can be facilitated in their students. On the other hand, the country specific data will provide the science education community with information that can be used to guide instruction, curricula development, teacher education, and policy. For example, a particular country may not be concerned by their students' lack of understanding about the difference between data and evidence, while they may be very concerned that their students think there is only one scientific method. Finally, a follow up study is planned for next year to assess graduating high students in the same locations to see if anything has changed during middle and high school education. Any countries that did not participate in this study will be encouraged to participate in the follow up study and further studies will be discussed at the symposium.

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