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Developing Preservice Science Teachers' Beliefs about New Approaches to Science Education[i]

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ABSTRACT

Science education has to take responsibility, and also the challenge, to include comprehensive perspectives that address a number of aspects of very different nature. In this sense, teachers' beliefs take an important role, given the influence of their actions in the classroom. In this paper, we have researched about the beliefs of a group of pre-service science teachers about new approaches to science education and how such beliefs influenced the reflective process that took place in the activities performed to change those beliefs. The study was carried out in the University of Malaga (Spain), in the fields of "Biology and Geology" and "Physics and Chemistry". The results and conclusions, which have been obtained by applying a qualitative data analysis methodology, contribute to understand that there are beliefs, with common characteristics, that present a great resistance to change and how certain methodological processes, based on reflection and confrontation of ideas, help to bring certain beliefs near to more innovative approaches.

Keywords: Beliefs; Pre-service Science Teachers; Science Education; Reflection.

INTRODUCTION

Nowadays, science and technology education to the citizens of the 21st Century poses great challenges to science and technology teachers, who have to worry not only about what to teach, but how to do it in a more relevant way so that students learn significantly and develop the skills, attitudes and values needed in the world they are going to find.

What teachers believe and think greatly influence the way they conduct their teaching. Lopez & Hinojosa (2012), Mellado (1998), Porlán & Martin del Pozo (2004 & 2006) and Solbes, Vilches & Gil (2001), among others, argue that a major overhaul of science education is necessary, and also those teachers' conceptions about their teaching must be questioned.

Porlán et al. (2010) emphasize the need to influence teachers' beliefs, if we want to change the dominant model of science education. They believe that in doing so, a greater proportion of students will consider scientific disciplines interesting enough to choose them (McMinn, Kadbey & Dickson, 2015).

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Therefore, in pre-service science teacher training, the promotion and the development of new teaching skills are necessary, as curriculum changes are demanding (Tribó, 2008). We have to produce innovations grounded in rigorous research of science education (Gil, Furio & Gavidia, 1998; Martín, Prieto & Jiménez, 2015).

According to the above considerations, teachers' beliefs should be challenged in the initial teacher training programmes, so that those beliefs may evolve in the proper direction that allows the consideration of new approaches in science education. That means pre-service science teachers should gain awareness about the importance of developing students conceptual understanding and attitudes, critical thinking and problem solving skills. These objectives, which include social and conceptual considerations, are pursued bystudying cases involving scientific, technological and moral issues (Çinar, Pirasa, Uzun & Erenler, 2016; Tal, Dori, Keiny & Zoller, 2001).

The research presented here starts from our awareness, as science teachers' trainers , of the nature of this problem, which has led to ask ourselves questions such as: how science teachers's beliefs about today's science education can be challenged in their initial training in order to encourage their development and meet our objectives?

When accessing their educational programmes, teachers in training have a repertoire of beliefs about many aspects of science education, which must be taken into account when planning training activities (Mellado, 1998; Porlán & Martin del Pozo, 2004 & 2006). In doing so, we will help them to overcome obstacles posed by those beliefs that affect their progression.

Hewson et al. (1999) emphasize that constructivist proposals to foster conceptual change in science students are valid when applied to science teachers in training. The interest in the application of these proposals in teacher's education has grown in recent years, both in scientific concepts and in more general aspects, such as those related to teaching and learning (Kyle, Abell, & Shymansky, 1989; Porlán & Martín del Pozo, 2004; Stofflett, 1994; Watts & Jofili, 1998).

According to constructivism, the process of making sense of new experiences is fedby individual reflection and awareness, social interaction and consensus (Medwell & Wray, 2014; Perrenoud, 2004). According to Van Driel & Beijaard (2001), when we reflect on the professional knowledge of teachers and their willingness to implement the innovative ideas that the curriculum proposes, we realize the processes by which teachers build them and become aware of the relevance of applying the model of conceptual change to teacher's education.

Reflection and Metacognition in Changing Beliefs

Promoting the processes of change in pre-service science teachers' beliefs should involve interactions between old and new conceptions. The result will depend, among other things, on the nature of such interactions.

According to Loughran, Mulhall, & Berry (2008), these interactions are encouraged when they are given the opportunity to argue, discuss and reflect in those contexts where they can increase their awareness about not just their beliefs, but, more important, the ways they are learning and how the progression in their beliefs, models and conceptions about teaching and learning science is happening.

Those processes and situations entail reflection on their own knowledge and beliefs, as well as the way these are being challenged. They are metacognition processes. In this kind of contexts, our pre-service science teachers find themselves in a position in which they become aware of their own beliefs and think, contrast, argue and write about their different views. Therefore, special relevance must be given to the reflections, both individual and collective, the contrast of opinions and the debate as part of the decision-making process.

These initial explicit beliefs have been considered as key mobilizing concepts and, from this point of view, have a great deal of potential to promote progression (Porlán et al., 2010; Solis & Porlán, 2003). Reflection requires teachers to analyse the thinking and assumptions on which their teaching is based (Abd-El-Khalick & Akerson, 2004).

Reflection, as a methodological tool, is valuable and classic (Kagan, 1992; Mellado, 1998; Schön, 1991). Hewson et al. (1999) recognize the critical role it plays in education and the role it can play in research on science teacher education, by the research through action (Schön, 1991; Sweeney, Bula & Cornett, 2001). A proper way of promoting the above is through social interaction, negotiation, construction of meaning, practice and reflection (Cabero & Guerra, 2011; Carvalho et al., 2015; Öztürk-Akar, 2016; Schön, 1991; Tribó, 2008).

By integrating these processes into teacher training, we connect with a vision of learning as a generative process, where the construction of meanings and the peer's interaction are very important, as they offer opportunities to express different views and negotiate their knowledge in a democratic and critical way.

Therefore, we should encourage activities in which reflection and debate emerge. Those activities may be performed in the context of real educational problems (Burton, 2007), or in the management of certain types of problems, for example, those known as "socio-scientific problems" (Edwards et al., 2004; Pedretti et al., 2008). They are complex and there are deeply interconnected global challenges that require action mechanisms, which are also carried out, both at global and individual scale (DeBoer, 2011; Fensham, 2011; Zeidler, Sadler, Simmons & Howes, 2005). In other words, they are social problems in which science and technology are involved and have much controversy (España & Prieto, 2010). By working with them, pre-service science teachers may appreciate the opportunities that they have to develop students' skills and, therefore to promote citizens' literacy in science and technology (Sadler & Zeidler, 2009).

METHODOLOGY

a) Research questions

In this paper we aim to get insights of how certain beliefs on science education, which have been previously identified (Martín, Prieto & Jiménez, 2013 & 2015) in a group of pre-service science teachers, are used in a reflective process that has been carried out in the course of activities designed with the purpose of changing those beliefs towards the new approaches in science education (the management of social problems; the promotion of values and attitudes; the treatment of interdisciplinary contents; the approach of science education to everyday life).

We started from the premise that when our teachers in initial training come into their training programme, they bring ideas with them and beliefs about what teaching and learning science is, as a result of their own experience, mainly in school under the benchmark of their own teachers (Hewson & Hewson, 1987; Mellado, 1998).

Specifically, we aimed to answer the following research questions:

- Did the development of activities based on the reflection and the exchange of ideas have any impact on the evolution of pre-service teachers' beliefs in the direction towards new approaches in science education?
- Did the activities based on reflection help them to overcome their beliefs about science teaching?

b) Sample

The context of this study has been the training programme of the University Master for Teachers of Secondary Education. There has been a total of 29 participants, among which 12 were training in the specialization of "Physics and Chemistry" and 17 in "Biology and Geology". The group consisted of 17 women and 12 men.

The intention was to bring our teachers in training faced to new approaches in science education, and make them compare their ideas with those that we were offering them, in order to encourage their reflection and critical thinking about an innovative way of teaching science.

As we have already published, many pre-service science teachers (Martin, Prieto & Jimenez, 2013; Martin, Prieto & Lupión, 2014), tend to consider that the analysis of socio-scientific issues, the promotion of values and attitudes, or the treatment of interdisciplinary aspects, cannot be addressed if the basic scientific concepts of the topic treated have not been previously mastered. We are also aware of the fact that those teachers undervalued other approaches based in fostering students' skills such as reflection, critical thinking and decision making as ways of conceptual learning.

c) Design of the activities

Our purpose has been to develop an approach based on socio-scientific issues, which serves as a springboard for learning, both scientific concepts and other more social aspects, as an innovative way to teach science and as a context well suited to promote attitudes and values in students.

We assume that reflection on the own conceptions is an efficient methodological strategy for conceptual change.

Porlán & Martin del Pozo (2006) suggest that, in pre-service science training strategies, activities such as the work with socially relevant issues, the awareness of the own conceptions and patterns of action and the analysis of innovative teaching experiences, among others, should be fostered, in order to make the evolution of beliefs easier in a social and responsible context, and also to leave the door open to the exchange of ideas between the members of working groups.

Taking into account the above considerations, we designed two activities to be developed in the training course: one individual and the other to be performed in small groups. Both activities began with a reflective reading of a text extracted from the article "Research for the future of science education: new ways of learning, new ways of living" of Lemke (2006).

This text invited participants to reflect on the "education through science", taking into account several non-scientific considerations, without which it is not possible to understand some of the great problems that humanity faces nowadays. Their proposals included some aspects of the new approaches to science teaching, such as the promotion of values and attitudes by using science as an instrument, as well as the direction necessary for science education to provide for the treatment of social problems, with the consequent requirement for interdisciplinarity and applicability in everyday life that this can entail.

Their reflections were used as a tool to promote awareness of both their initial beliefs and the evolution of them through negotiation and discussion, as they performed the activity in a small group on innovative proposals in the document.

In the case of the individual activity, participants had 20 minutes to read the text. Much emphasis was put on the fact that they should take notes and ask questions concerning the understanding of the text, and about what activity was demanded from them. After reflecting on the reading, they were requested to select 5 ideas from the text and express their agreement or disagreement with them in a reasoned way. They spent about 45 minutes to complete this activity.

Just when the individual activity had finished, the small group activity was conducted. For its development, participants were divided into 9 groups (of 3 or 4 members each), in which one participant assumed the role of spokesperson and another one acted as secretary who took record of the agreements and consensus reached. Further to their discussions, they were requested to reach a consensus about: a) three ideas from the text on which there was more agreement and b) three ideas on which there was more disagreement). It took them about 45 minutes to carry out this activity.

The small group activity required participants to select some ideas at the expense of not considering others. The aim was to determine: a) the assumptions rejected when consensus was reached, b) the mainstream, and c) the main considerations raised.

This consensus gave us important information about the fate of the different proposals in the context of the small group. In addition, it put participants in the specific situation to defend their proposals that were to be included in the consensus.

By searching for these evidences, we wanted to approach the number and nature of the considerations, in every group, in connection with the importance of teaching science through the development of values and attitudes, and guiding science education for the purpose of solving social problems. Both aspects must consider the application of scientific knowledge to everyday life and interdisciplinarity in order to promote the integration of theoretical and experimental approaches.

d) Data Analysis

Data collection was carried out as follows:

a) Participants' report from individual activity.
b) Groups' reports from the small group activity.
c) Participant teacher’s observation.
d) Teacher’s diary.
e) Interviews.

Apart from the participants’ reports, information on the development of the activities and the subsequent reflections were registered in the teacher's diary, in order to cover the broad range of opinions expressed during the process, and the most significant ideas that were proposed.

All groups were asked by the teacher-researcher during the progress of the work.

Two groups were selected to be interviewed by the teacher, according to the following criteria: a) one from each speciality, and b) variety of initial starting points.

We used a qualitative approach in the analysis, which was applied to the contents of the activities, the classroom observations, the teacher’s diary and the answers from interviews (Stake, 1999). The contents of the activities and the answers from interviews were independently organised and developed in categories by the three authors. We agreed with 90% of the categories that were relevant responses and reached a consensus for the remaining responses after further discussion.

The ideas that had been initially put into play were gradually highlighted throughout this process, as well as the way some participants were gaining strength in their arguments while others were losing it.

Fragments in quotation marks, selected from different documents, allow us to illustrate concepts of participants linked to their previous ideas about learning and teaching science and their changes.

FINDINGS

Individual activity

The whole range of considerations and concerns from all participants were organized into the following categories:

a) Science education as an instrument to improve society.

All pre-service science teachers (pst.) mentioned this idea and strongly agreed with it. Their reasoning emphasized the importance of education in the promotion of improvements in people's lives, giving them opportunities to access social standing, progress and welfare. The arguments brought forward by them are expressed in a general way, although, more specific arguments were included in the text.

Example:

"One of the fundamental educational purposes is the training of students, so they can improve their lives and influence the appropriate development of society." (pst.12)

b) The importance of learning beyond the classroom.

Most of them (18) agreed with this idea, defending the usefulness and desirability of integrating learning from their real lives into the classroom in order to use it in the teaching processes. However, many considerations were exposed in a sceptical way.

Example:

"Our life is an ongoing learning process. However, a different issue is whether these lessons are useful and suitable for the education of citizens living in society. Obviously not all of them are appropriate." (pst.7)

c) Approaching science education to students' everyday life

For 18 participants, science education is isolated from the real world and the students' everyday world and, therefore, it is necessary to break away from this isolation.

Example:

"Linking science to daily living situations enables a better understanding and assimilation of concepts." (pst.12)

However, this principle does not arise as a determinant factor when choosing the contents to work in the classroom. Their responses indicate, by contrast, that the contents to teach are there and we have to work with them. Later in their lives, students will find relationships between those contents and real life.

d) Science education oriented towards social problems.

This idea was suggested by 12 participants. Most of them noted the convenience of working with concepts first and then with their application to problems. They did not consider the possibility of starting with a problem and, through its analysis, making progress in learning the concepts involved in the same.

When they talked about encouraging attitudes and values, they treated them as objectives to be achieved by using specific methodologies, which are accepted only on the basis of motivation in students. They insisted on the importance of learning with the only purpose of gaining knowledge.

Example:

"I agree with the position of science guided to social problems, in order to contribute to its attractiveness to students. However, I consider we should not forget that concepts we call "abstract" are needed as a learning platform [...]." (pst.7)

e) Division of curricular disciplines and interdisciplinary approach

For some pre-service science teachers (10), the lack of interdisciplinary approaches in science classes is closely related to the division into disciplines of knowledge caused by the curriculum. In this respect, the idea that this is something which is in other people's hands, but not in ours, predominates. They consider that teachers are not responsible for this situation.

Example:

"I do not share the idea of separating science learning from other disciplines, as they must be linked and interact with each other. Certainly there are cases where some specialization is required, but isolation of concepts should be avoided." (pst.28)

f) Students exhibit a negative attitude towards science.

Six participants manifest this idea.

Example:

"Some students show a negative attitude towards science, although I have met students who loved science [...]." (pst.26)

Finally, most participants appreciated science teaching as a way of providing prosperity to people and accessing to certain professions that may provide them a certain social status. The contribution to achieve that social status explained their tendency towards teaching and learning scientific concepts and their emphasis on knowledge, without paying attention to the need to find interconnections with the reality in which students live.

Additionally, participants showed some difficulties to expand their views to the inclusion of interdisciplinary issues in science subjects, which would help students to understand the problems we are facing. They believe that this multidisciplinary approach is not possible because they have to play with a closed curriculum.

Small group activity

The summary of ideas resulting from the consensus of the nine groups is shown in Table 1 below. Generally, groups paid more attention to the aspects under agreement than to those in which no consensus was reached. These agreements were very helpful to find meaning in the various aspects raised and set up the discourse of consensus. Regarding the disagreements, these tended to occur in those areas where conflicts between certain beliefs were noted.

An example of this was given when two groups expressed their disagreement with the following statement: *"Science teaching should not be so focused on teaching conceptual knowledge"*. They justified their position arguing that it is first necessary to introduce students to the basic concepts that will be necessary to explain everyday problems.

The contribution of group E illustrates this matter and, at the same time, demonstrates the usefulness of debates and how, sometimes, certain elements enrich the discussion:

"It was more difficult to reach common positions in relation to those issues on which there had been an initial disagreement. In the end, the group activity brought us to agree with the following ideas:

It is important to explain conceptual contents in science lessons, but always connecting them to everyday life.

Students' negative attitude does not only relate to science matters, but to everything in general." (group E)

Table 1. *Proposals generating agreement or disagreement during the activity in small groups*

Ideas/proposals generating agreement among groups	**Groups**								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Interdisciplinary approaches in teaching science should be promoted	x	x			x				x
Science education should contribute to improve social life	x		x		x	x	x	x	
Applicability of science concepts to real life should be encouraged		x	x	x		x	x		x
Convenience of focusing on the context of individual and social problems		x		x		x			x
Convenience of bringing science closer to everyday life			x				x	x	
Convenience of teaching and learning science in a variety of contexts			x		x			x	
Life-long learning						x			
Ideas/proposals generating disagreement among groups	**Groups**								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Scientific concepts can be taught without links to everyday life	x								
In the science classroom, modern science has to be differentiated from ancient science		x				x			
In science teaching, learning scientific concepts should not be so predominant			x		x				
The criteria for selecting science concepts to be taught in school does not have to be globalised				x				x	
When finishing primary school, students are unmotivated towards science							x		
What students do not learn in school can be learned from their parents									x

Interviews

a) Biology-Geology

A high degree of agreement had been reached when the interview took place in this group. Therefore, they had arrived to consensus in an easy way. They had selected three major ideas: interdisciplinary approach, applicability in everyday life and science teaching focused on social problems.

"Science should be integrated with other disciplines to find common goals and foster literacy and responsibility in citizenship." (pst. 5, 15 & 19)

"Classroom learning should be extended to students' social reality and applied to their lives" (pst. 5, 15 &19).

"Science teaching should be focused on social issues, rather than on abstract and theoretical concepts."(pst. 5, 15 & 19)

The three members of the group concluded that science education must consider the practical applicability of what has been learned, and contribute to achieve a meaningful learning.

"We believe that, nowadays, one of the major problems of science teaching is its lack of meaning in students' everyday lives. They are not aware of the importance of scientific advances in social welfare, probably due to the lack of applicability." (pst. 5, 15 & 19)

On the idea of interdisciplinary approaches as key elements to science teaching, two members of the group expressed their agreement, explaining their positions to the third member as follows:

“If we get this connection (science with economy, politics, history, etc.) and introduce science as something that may affect other areas, we will be promoting the development of students’ awareness of how scientific advances may affect society and how political decisions about science can influence it [...], the way in which R & D of a country affects its economy, employment, etc." (pst.5)

“Education should be addressed as a multidisciplinary process where every topic or discipline can contribute to train future citizens." (pst.15)

Facing these statements, pst. 19 confirmed his agreement, as long as "abstract knowledge" was not relegated. This argument re-appears when the group draws attention to the idea of scientific education oriented to socially relevant problems. Participants pst. 5 and pst.15 supported this approach and explained it to participant pst.19 in the following way:

“Our aim is not to train students to become scientists in secondary schools, but to promote their science learning so that they become responsible citizens who are able to understand events and situations in their daily lives." (pst. 5)

“Throughout the educational period we train citizens, so it is important to provide them with critical thinking and skills that will help them face the future. Making them understand the scientific knowledge that may be useful at some stage of their lives is more important than scientific theories or more abstract scientific concepts." (pst. 15)

The pst.19 was only partly convinced, and made the following comment:

“Science education should not abandon the paradigm of abstract concepts completely, in favour of a connection with the real world. Those concepts, as well as abstraction and imagination, are part of knowledge and human development." (pst.19)

This idea would be later defended by the pre-service science teacher in order to face his/her colleagues' informal questions, after agreeing with the proposal of the group in opposition to his/her own arguments. It becomes clear how deeply rooted these traditional ideas are, as this is the case of this person, who accepted the agreement of the group, changing his/her mind as soon as the context changed (teacher`s diary).

b) Physics-Chemistry

In this group some individual participants have a more innovative profile although, in the interest of consensus, they accept traditional ideas expressed by other participants. In the end, after having reflected and discussed, they only agreed on the idea of providing an interdisciplinary nature to science subjects.

“Interdisciplinarity: When we acquire the knowledge that science is directly connected to other disciplines, then the learning process is reinforced and concepts are better understood." (pst. 7, 18 y 28)

All members of the group supported this idea, which was the only one they shared from the beginning. They expressed it as follows:

“Human knowledge is not divided into strict compartments, without mutual communication. All disciplines are related in one way or another, and when considered in this way, we encourage the role of scientific knowledge within the context of our society"(pst.7).

“When teaching science under an interdisciplinarity approach we are promoting more solid ideas that connect it with other disciplines." (pst. 18)

“I disagree with the idea that science is separated from other subjects, as they must be closely linked and related to each other [...]." (pst. 28)

Two members of the group agreed on the importance of giving a prominent role to students' everyday life when teaching science. They explained the following points of view:

"We need to approach science teaching in a way that is relevant for students' lives, generating a critical thinking in them about current debates in society. [...]." (pst.28)

"I totally agree with this idea, we should broaden our methods in order to make connections with the practical and useful knowledge that is of interest to students' everyday lives [...].It is absolutely true that science education has been isolated from students' everyday life, which is a serious mistake. There is a clear need to establish connections between science and other disciplines" (pst.28)

This idea generated disagreement, when the third member of the group claimed that the curricular approaches already consider such kind of relationships. In this way, he convinced the rest of the group by defending that this should not be a matter of concern for teachers.

With respect to a teaching approach oriented towards social problems, only one participant in the group claimed his/her agreement, and explained to his/her colleagues that:

"Science teaching should not be limited uniquely to laws and abstract concepts, but should be focused on current issues in society, so that students can see their applications and, this way, we would encourage them to understand science." (pst. 28)

The other members of the group accepted this idea, but manifested some exceptions:

"I agree with the approach of science education through social problems, in order to make this teaching more appealing to students. However, we should always keep in mind that those concepts that we consider "abstract" are also necessary [...]." (pst. 7).

The group disagreed with the above reasoning and dismissed the idea raised by pst. 28.

DISCUSSION AND CONCLUSION

We have conducted an educational innovation with pre-service science teachers whose development has been investigated. These results can help to design interventions in their trainings as teachers, in which the aims could be the encouragement and the assumption of new approaches to science education.

Results show that for many participants, science subjects remain isolated from social issues, favouring the idea of disconnection between science and society. However, it can also be seen in them a willingness to consider attitudes and values as fundamental mainstays in students' scientific and technological literacy.

These considerations are shown in a lesser extent when they are asked to give specific reasons justifying such an approach. Instead, they put emphasis on the obstacles and impossibilities to undertake innovations. Such is the case, for example, of interdisciplinarity, in respect of which curricular impediments and difficulties of coordination between the different subjects are alleged.

Participants, most of whom initially tended to conceive a teacher-centred education, make some progress along interventions in respect of certain actions that students should perform throughout their learning process, in which the teacher's role remains in the background. They also make progress when considering a wider range of strategies and more innovative connotations that allow, not only the assimilation and learning of concepts, but also other learning processes which are equally important. .

Furthermore, results show a high degree of coincidence among the ideas proposed by participants in the individual activity, as well as the areas where the debate took place in the groups' activity. They also show the progress that has occurred as a result of the debate in the group, and the considerations and arguments taken into account in this process.

Debates in the group activity evidence the way some colleagues have discussed and convinced others to accept certain ideas to which they were more reluctant. This is evidenced, for example, by the fact that some ideas are more accepted in individual activities, as in the case of "the advantages associated with interdisciplinary approaches," because some participants have changed their opinion.

Nevertheless, we noted how participants used certain external obstacles to justify the potential failure to apply these teaching approaches. This kind of facts has been reported by researchers as Watts & Jofili (1998), Pedretti et al. (2008) and McMinn, Kadbey, Dickson (2015). We also noted that beliefs associated with external obstacles posed less resistance to change. Evidence of the above is the consideration of the everyday and interdisciplinary knowledge and how it interacts with science subjects as an obstacle, the origin of which is in the division of the curriculum into separate disciplines, which might cause confusion both in students and their teachers.

On the other hand, in the context of the group, innovative ideas were better accepted and regarded as less revolutionary when they are supported by their colleagues. In this way, some innovative ideas made their way and gained more adepts. We observed a significant number of participants, from the beginning to the end of the process, looking for indicators in their progression of their ideas about teaching and learning science.

The above enables us to be aware that, by the debate among colleagues, there is a way to foster the overcoming of certain beliefs, which have been considered as barriers to progress, given that sometimes reluctance have not been absent from the process. This, for instance, is evidenced by our participants' concern about the lack of conceptual learning caused by certain teaching approaches. We can observe their hesitation and resistance to change. In these cases, the role played by pair work helps reduce the reluctance, allowing the adherence to new approaches.

The small group has been sometimes very favourable to the genesis of new ideas in an emerging context. In these cases, the group's work is very positive, given that new ideas, which otherwise would not have come to light, can be generated and assessed. In this regard, a very favourable progress appeared when the proposed deal was accompanied by specific action plans, in which participants could appreciate how to implement such ideas in the classroom.

We agree with authors as Carvalho et al. (2015) when they point out that reflection in a group is a good action to develop new conceptions and beliefs regarding science teaching, as it promotes situations in which pre-service science teachers acquire skills related to critical thinking and effective feedback. The results of this study are just an example.

In light with the above, Porlán et al. (2010) argued that, we, as trainers of science teachers, should contribute, in some way, to the encouragement of new knowledge in order to get over some stereotypes that are linked to the school culture.

We are also in line with Hewson & Hewson (1987) when they refer to making an extension in science teacher training approaches, which includes emotional and social risk associated with the design and development of new classroom' behaviours. In this sense, innovative teachers are usually seen as transgressors of what is considered normal and acceptable.

Our results are also in agreement with those obtained by Benarroch & Martin (2011), who assert that there are opportunities to improve the conceptions and beliefs about teaching and learning science in the pre-service science teachers, although we are still far from creating a common framework to influence and change their future practical action. In conclusion, it would be necessary to research how pre-service science teachers bring these approaches and objectives to the second part of the initial training programme in those centers where they carried out teaching practices. This will be our issue for further research.

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Views of Pre-service Biology Teachers on Structured Grid*

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ABSTRACT

Research was carried out to identify pre-service biology teachers' views on 'structured grid', one of the alternative assessment and evaluation tools available to teachers. A questionnaire form, consisting of four open-ended questions, was used as a data collection tool. Changes were made to the questionnaire to take into account the opinions of two faculty members and two teachers. The sampling of the study consisted of 29 pre-service biology teachers enrolled on a teacher training course at the Education Faculty at Ordu University during the 2014-2015 academic year. A case study was utilized in the study. The data obtained were examined by means of inductive content analysis. Based on the findings obtained from the open-ended questionnaire, the pre-service biology teachers stated that the use of structured grid, one of the alternative assessment and evaluation tools, in a biology course would contribute towards improved learning of the subject and would have a positive effect on the identification and elimination of misconceptions. Moreover, it was found that it eliminated students' weaknesses, raised students' curiosity and facilitated teachers' work. It allowed subjects to be taught in a fun way, it enabled student participation and it provided learning retention. Moreover, the findings highlighted that teachers did not adequately use alternative assessment and evaluation tools that these activities were not included in the course books to a sufficient degree and that teachers wanted to use these activities. It was suggested at the end of the study that all the teachers working for the Ministry of National Education should be introduced to alternative assessment and evaluation tools and that they should also be given in-service training on how to use them and how to evaluate students with these tools. Another finding of the study revealed that pre-service teachers must acquire knowledge, skills and understanding of alternative assessment and evaluation tools and activities in their educational process.

Keywords: Pre-service teachers, Structured, Assessment and Evaluation

INTRODUCTION

In addition to determining whether education has attained its goals or objectives, one of the important factors contributing to students' development is the role played by assessment and evaluation activities (Çeçen, 2011). Measurement and evaluation is an important process, which evaluates students' learning and offers feedback to students (Büyükturan & Demirtaşlı, 2012). In teaching-learning processes, assessment and evaluation identify whether the instruction is successful or not, to what extent and for whom the instruction is successful or unsuccessful, who needs extra support and what precautions need to be taken to improve teaching (Turgut, 1992). Some of the purposes of assessment and evaluation, particularly

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regarding students, teachers and instructional implementation, are as follows: to gather information about students and offer them a place in the education process; to reveal the difficulties, weaknesses and mistakes encountered in education by determining students' levels of learning; to evaluate the effectiveness of education; to guide students; and to determine the level of student performance (Bahar et al., 2009; Özdemir, 2010). The purpose of measurement and evaluation practices is not only to grade students or determine whether students pass or fail a course, but also to reveal students' skills considering their individual differences, to guide them considering their interests, needs and skills, to try to correct them and to prove the quality of the given education (Özdemir, 2010). In order to realize this purpose, alternative assessment and evaluation tools can be utilized. Alternative assessment and evaluation focus on how students construct their knowledge instead of their level of knowledge or performance and it also emphasizes their strengths instead of weaknesses (Ören Şaşmaz, 2014).

One of the alternative assessment and evaluation tools used by teachers is called 'structured grid'. The purpose of using this assessment tool is to identify students' level of knowledge, weaknesses and misconceptions. This assessment tool is formed of rows and columns in a way that creates boxes. A table consists of nine, 12 and 16 boxes depending on the level of the students and each box in the table is given a number. When creating a structured grid, a teacher prepares the first question about the subject and puts possible answers and the correct answer randomly in the boxes. The teacher then prepares the second question and possible answers are randomly distributed in the boxes. Some of the boxes containing the answers for the second question can be related to the first question. Students are asked to mark the correct boxes and put them in the correct logical and functional order. The students' responses reveal their level of knowledge, lack of knowledge, conceptual connections or misconceptions (Ünal, 2014). Therefore, structured grid offers an opportunity to determine the weaknesses and strengths of the cognitive structure existing in the students' minds (Hassan, Hill & Reid, 2004; Eroğlu& Kelecioğlu, 2011). The most important feature of the structured grid is that the boxes do not contain only one correct answer and the answers given in each box may be related to at least one question. As the students do not know the number of boxes for each question, they cannot reach the answer by chance. The wrong boxes selected by students reveal the misconceptions in their minds and the correct boxes identify the knowledge they have learned (Eroğlu & Kelecioğlu, 2011).

When science education national and international literature was reviewed, it was found that the studies on structured grid as an alternative assessment and evaluation tool in education began with Egan (1972) and it has been used successfully by many researchers since then (MacGuire & Johnstone, 1987; Neukom, 2000; Bahar, 2003; Durmuş & Karakırık, 2005; Karahan, 2007; Zimbicki, 2007; Bekiroğlu Ogan, 2008; Bahar et al., 2009; Tatar & Ören, 2009; Metin& Özmen, 2010; Eroğlu & Kelecioğlu, 2011; Vurkaya & Kırıkkaya, 2011; Büyükturan & Demirtaşlı, 2013; Özenç, 2013; Bektaş, 2014; Harman, 2014).

Büyükturan & Demirtaşlı (2013) in their study compared multiple choice test and structured grid, which were developed to assess the same behaviours regarding their psychometric properties. The findings obtained from the research revealed that the items of structured grid were much easier than the multiple choice items and the measurements obtained from the structured grid test were more reliable than the measurements obtained from the multiple choice test, but that there was no significant difference between the measurement reliability of the two tests. Özdemir (2010) examined the competencies of the pre-service teachers working in the primary schools towards alternative assessment and evaluation tools and their needs for in-service training. The findings obtained from the research study showed that, while the alternative assessment and evaluation tools that teachers felt most competent with were observation, performance tasks/homework, selfevaluation and presentation, the tools with which they felt less competent were structured grid, diagnostic branched tree, rubric (sum of the scores in a range of criteria) and attitude scales. At the end of the study, teachers stated that they needed in-service training on the tools with which they felt less competent. On the other hand, while Vurkaya & Kırıkkaya (2011) in their study taught students in the experimental group on the 'electricity in our life' unit in the science and technology course using structured grid and diagnostic branched tree activities, the control group did not receive any intervention. It was found at the end of the study that there was a significant difference between the students' academic achievement and their attitudes towards the science and technology course, in favour of the experimental group. Metin & Özmen (2010) in their study informed a total of 25 third-year students studying in the primary school teaching programme about how to develop teaching materials such as mind maps, concept maps and structured grid and at the end of the study they determined that these activities developed students' critical thinking skills. Karahan (2007) tried to determine the effects of alternative assessment and evaluation techniques on achievement in his study by using a structured grid, a conceptual map and a diagnostic branched tree. At the end of the study, it was found that alternative assessment and evaluation affected students' achievement positively. Eroğlu & Kelecioğlu (2011) in their study determined that structured grid was a reliable assessment tool. Arıbaş & Göktaş (2014) revealed as a result of the study carried out with mathematics teachers that mathematics teachers did not have adequate knowledge about alternative assessment and evaluation and they needed in-service training. İzci, Göktaş & Şad(2014) in their study examined pre-service teachers views about alternative assessment and evaluation with regard to some variables. As a result of their study, they found that although pre-service teachers had some limitations about alternative assessment and evaluation, it had a positive effect on learning and teaching process. Sağlam-Arslan, Devecioğlu-Kaymakçı & Arslan (2009) in their study explored how much teachers used alternative assessment and evaluation and the problems teachers encountered in this process. at the end of the study it was found that in addition to lack of opportunities provided by the school, because teachers did not have enough information about these methods, they had a negative effect on the effective use of alternative assessment and evaluation methods. Moreover, it is suggested that besides offering teachers theoretical information related to alternative assessment and evaluation, they should be given additional pedagogical formation including practical knowledge. Kuran & Kanatlı (2009) in their study tried to determine elementary teachers' views about alternative assessment and evaluation techniques, frequency of using these techniques and the problems they encountered while using these techniques. They found at the end of the study that teachers had problems about using alternative assessment and evaluation techniques and the reasons for this problem was found to be time, lack of sources, crowded classrooms, lack of parent and student interest, and teachers' lack of knowledge about alternative assessment and evaluation techniques.

In addition, when the national literature was reviewed, it was found that teachers and pre-service teachers in our country did not have adequate knowledge and skills about structured grid (Acat & Demir, 2007; Çalık, 2007; Doğan, Karakaya & Gelbal, 2007; Gelbal & Kelecioğlu, 2007; Karahan, 2007; Atikol, 2008; Tatar & Ören, 2009; Özdemir, 2010; Özenç, 2013). Therefore, this study was carried out to eliminate the weaknesses mentioned above, to have pre-service teachers gain the required knowledge and skills and to determine their views about these activities.

This research was carried out to identify pre-service biology teachers' views on structured grid. The study sought answers to the following questions given below:

1. What are the pre-service biology teachers' views about the use of structured grid, one of the alternative assessment and evaluation activities?

2. What are the pre-service biology teachers' views about their practice teachers using structured grid in their lessons in the schools they visited within the context of their teaching practice?
3. What are the pre-service biology teachers' views about the extent to which structured grid is included in biology course books?
4. What are the pre-service biology teachers' views and suggestions about the use of structured grid?

METHODS

a) Methodology of Research

A case study was used in this research. Case study is conducted in a natural environment such as a classroom, or an organization, aiming to produce aholistic interpretation of the environment or situations (Yıldırım & Şimşek, 2005). The research involves in-depth and detailed examination of a problem in a short time. The most important advantage of this method is that it gives the opportunity to focus on an instance of a problem (Çepni, 2007). This research emphasizes an instance of a class of phenomena and offers an opportunity to use different data collection tools together (Cohen & Manion, 1994).

b) Sample of Research

The sampling of this study consisted of 29 pre-service biology teachers enrolled on a teacher training course at the Faculty of Education at Ordu University in the 2014-2015 academic year. The study was carried out in the special teaching methods course. This is a four-hour course per week (two hours theoretical and two hours practice). The researcher explained and demonstrated alternative assessment and evaluation activities during the theoretical course hours. During the practice hours, the pre-service teachers performed these activities. The mistakes made by the pre-service teachers were corrected and the activities were reinforced.

c) Data Collection Tools

The questionnaire, consisting of open-ended questions, was used in the study as a data collection tool. The open-ended questionnaire was developed to identify pre-service teachers' views on structured grid. The validity of qualitative researches can be obtained through expert opinions, participant approval; whereas the reliability is ensured through a study of consistency and confirmation (Yıldırım & Şimşek, 2005). The first draft questions of the data collection tool, consisting of six questions, were composed by reviewing the relevant literature and necessary corrections were made taking into account the views of the two faculty members and two science and technology teachers who were experts in their fields. Considering these corrections, the number of questions was reduced to four. Two students in the implementation read these questions and it was determined that the questions were clear and understandable. It was verified by various experts in their field that these questions were suitable for the purpose of the study and they agreed that 25 minutes on average would be enough for the implementation. It was therefore approved that the time allocated for the questions would be 25 minutes. As the questions were explained in the findings section, they are not presented here.

d) Data Analysis

The open-ended questionnaires were distributed to the 29 pre-service teachers. The data obtained from the questions were analysed using content analysis. The researcher examined the data obtained from the teachers and created themes and codes. Based on the themes and codes, the frequency and percentages of each opinion were found. Necessary explanations and interpretations related to the pre-service teachers' views are presented below the tables.

FINDINGS

This research was carried out to identify pre-service biology teachers' views on structured grid. The findings obtained for each question asked to the teachers were presented in tables. Necessary interpretations were made below each table.

Question 1: The responses of the pre-service teachers to the question **'***What are your view about the use of structured grid, one of the alternative assessment and evaluation activities?* are presented in Table 1.

Table 1. *The Analysis Results of the Pre-service Biology Teachers' Responses to Question 1*

Theme	Code	Frequency	Percentage
Using structured grid in assessment and evaluation	It promotes improved learning of the subject	19	43
Positive Views	It identifies misconceptions	5	11
	It removes students' weaknesses	5	11
	It identifies students' weaknesses	5	11
	It fosters active participation of students	3	9
	It raises student curiosity	1	2
	It removes misconceptions	2	5
	It facilitates teachers' work	1	2
Negative Views	It was confusing for students	1	2
	It is difficult to evaluate it	1	2
	Its evaluation is disadvantageous for students	1	2

When Table 1 was examined, it was determined that the pre-service biology teachers had both negative and positive views about using structured grid activities. The results show that 94% of the students expressed positive views and 6% stated negative views. The following are some of the positive views stated by the pre-service teachers about using the activities: promoting better learning (43%), identifying misconceptions (11%), identifying students' weaknesses (11%), removing students' weaknesses (11%), raising curiosity of students (2%), eliminating misconceptions (5%) and facilitating teacher's work (2%). The following negative views were stated by the pre-service teachers: confusing for students (2%), difficult to evaluate (2%) and disadvantageous evaluation for students.

Question 2: The responses of the pre-service teachers to the question *"Do the practice teachers use structured grid in their lessons in the schools you visited within the context of teaching practice? How do you evaluate it?"* are presented in Table 2.

Table 2. *The Analysis Results of the Pre-service Biology Teachers' Responses to Question 2*

Theme	Code	Frequency	Percentage
Its use by the practice teacher in the lesson	Yes	12	41
	No	16	55
	Sometimes	1	4
The views related to the teachers who stated that it was used in the lesson	It has benefits in education	3	17
	The subject becomes more enjoyable	2	11
	The students participate in the lesson	1	6
	Teaching is effective and efficient	1	6
	It promotes permanent learning	1	6
	The subject taught is understood better and more clearly	1	6
	Students' weaknesses are eliminated	1	6
The views related to the teachers who stated that it was not used in the lesson	If it were used, concepts would be understood much better	1	6
	If it were used, students' weaknesses would be eliminated	1	6
	If it were used, students would revise the subject	2	11
	If it were used, students would actively participate in the lesson	1	6
	Students do not comprehend the subject	1	6
	It provides a very simple explanation	1	6
	It presents the subject better	1	6

When the data in Table 2 were examined, it was found that 41% of the guide teachers used structured grid in their lessons, 55% of them did not use it and 4% of them sometimes used it. The pre-service teachers who stated that the guide teachers used structured grid in their lessons stated that structured grid was effective in teaching the courses (17%), the subjects were taught in a more fun way (11%), it enabled students to participate in the lessons (6%), the instruction was efficient (6%), the subject was understood better and more clearly (6%), it removed students' weaknesses (6%) and it promoted permanent learning (6%). The pre-service teachers who stated that the guide teacher did not use structured grid in his/her lessons stated that, if it were used, the concepts would be understood better (6%), students' weaknesses would be eliminated (6%), it would allow students to revise their lessons (11%) and it would offer opportunities for student participation in the lesson (6%). They also mentioned that the students were not able to comprehend the subject (6%), a simple explanation was provided (6%) and the subject was presented better.

Question 3: The responses of the pre-service teachers to the question *"Do the biology course books involve structured grid? How do you evaluate it?"* are presented in Table 3.

Table 3. *The Analysis Results of the Pre-service Biology Teachers' Responses to Question 3*

Theme	Code	Frequency	Percentage
Its inclusion in the course books	Yes	26	90
	Very little	1	3
	Not enough	2	7
Students' state of evaluation			
Positive	It fosters active participation in the lesson	1	3
	It should always be used in education	2	7
	It facilitates learning	7	24
	It removes weaknesses	4	14
	It reinforces concepts	4	14
	It makes a difference	2	7
	It identifies the levels	1	3
	It promotes thinking	2	7
	It draws attention	1	3
Negative	There are only a few at the end of the units	3	10

When Table 3 was examined, 90% of the pre-service teachers stated that structured grid activities were included in the biology course book, 3% of them said that it covered very few activities and 7% of them said that there were not enough of the activities in the biology course book. Moreover, the pre-service teachers stated that the inclusion of structured grid in the course books had many benefits, such as promoting student participation in the lesson (3%), facilitating learning (24%), removing weaknesses (14%), reinforcing concepts (14%), making a difference (7%), promoting thinking (7%), drawing attention (3%), determining the level (3%) and should always be used in education (3%). In addition, 10% of the students stated that there were not enough structured grid activities and that they were only included at the end of the units.

Question 4. The responses of the pre-service teachers to the question *"Would you like to use a structured grid, an alternative assessment and evaluation tool? Explain your reason."* are presented in Table 4.

Table 4. *The Analysis Results of the Pre-service Biology Teachers' Responses to Question 4*

Theme	Code	Frequency	Percentage
Desire to use structured grid	I would like to use it	26	90
	I do not want to use it	3	10
Positive views	It helps the subject to be understood	11	29
	It promotes participation in the lesson	7	18
	It enables the identification of weaknesses	5	13
	It enables the removal of weaknesses	2	5
	It promotes retention	3	8
	It promotes the teaching of concepts	1	3
	It raises curiosity	2	5
	It enables reinforcement	1	3
Negative views	It is difficult to assess	2	5
	It is confusing	4	10

Regarding the findings obtained from the data analysis in Table 4, 90% of the pre-service biology teachers stated that they wanted to use structured grid in their lessons but 10% of them did not want to use it. In addition, the pre-service teachers stated that it enabled the subject to be understood (29%), it promoted student participation in the lesson (18%), it identified weaknesses (13%), it eliminated weaknesses (5%), it promoted knowledge retention (8%), it promoted learning of the concepts (3%), it raised student curiosity (5%) and it reinforced the subjects (3%). The pre-service teachers who expressed negative views remarked that it was difficult to assess structured grid (5%) and it was confusing (10%).

DISCUSSION

Assessment and evaluation in a constructivist curriculum must be a process that will consider students' individual differences and evaluate them in a multi-dimensional way. Moreover, it must be a process that will allow for the implementation of assessment and evaluation tools that will offer opportunities to students to use the knowledge, skills, attitudes, values and understanding that they have acquired during the learning process in their daily life. Therefore, it is expected that teachers who are the practitioners of the curriculum must acquire correct and sufficient information, skills and understanding about the constructivist approach to assessment and evaluation and alternative assessment and evaluation tools (Büyükturan & Demirtaşlı, 2012). One of these alternative assessment and evaluation tools is structured grid.

Structured grid is effective in identifying students' levels of knowledge, weaknesses and misconceptions and eliminating those misconceptions (Ünal, 2014). When national literature was reviewed, it was found that teachers and pre-service teachers in our country did not have enough information and skills about structured grid (Acat & Demir, 2007; Çalık, 2007; Doğan, Karakaya & Gelbal, 2007; Gelbal & Kelecioğlu, 2007; Karahan, 2007; Atikol, 2008; Kazu, Pullu & Demiralp'in, 2008; Tatar & Ören, 2009; Özdemir, 2010; Özenç, 2013). Thus, this study aims to eliminate this weakness, to enable teachers to acquire the necessary knowledge and skills and to determine their views about structured grid activities. Based on the findings obtained from the open-ended questionnaire, the pre-service biology teachers stated that the use of structured grid, one of the alternative assessment and evaluation tools, in a biology course would contribute towards improved learning of the subject and would have a positive effect on the identification and elimination of misconceptions. Karahan (2007) it was found that alternative assessment and evaluation affected students' achievement positively, While Eroğlu & Kelecioğlu (2011) in their study determined that structured grid was a reliable assessment tool. Moreover, it was found that it eliminated students' weaknesses, raised students' curiosity and facilitated teachers' work. It allowed subjects to be taught in a fun way, it enabled student participation and it provided learning retention. İzci, Göktaş & Şad(2014) determined that pre-service teachers supported alternative assessment and evaluation learning and teaching process positively. *Moreover*, the findings highlighted that teachers did not adequately use alternative assessment and evaluation tools that these activities were not included in the course books to a sufficient degree and that teachers wanted to use these activities. Özdemir (2010) stated that the alternative assessment and evaluation tools considered least effective by the teachers were structured grid, diagnostic branched tree, rubric (sum of the scores in a range of criteria) and attitude scales and added that they needed in-service training in these areas. Moreover, Okur (2008) stated in a study that the least-known alternative assessment and evaluation tools by the teachers were structured grid and diagnostic branched tree and determined that the teachers should be offered in-service training about these alternative assessment and evaluation tools. Arıbaş & Göktaş (2014) found that mathematics teachers did not have enough knowledge about alternative assessment and evaluation techniques and they required in-service training about this topic. Sağlam arslan,Devecioğlu-Kaymakçı & Arslan (2009) revealed that because teachers did not have enough knowledge about alternative assessment and evaluation techniques they should be given both theoretical knowledge about knowledge about alternative assessment and evaluation methods and additional pedagogical formation involving practical knowledge. In addition, Kuran & Kanatlı (2009) identified that teachers had problems about using knowledge about alternative assessment and evaluation techniques..In addition, in the studies conducted by Acat &Demir, 2007; Çalık, 2007; Doğan, Karakaya & Gelbal, 2007; Gelbal & Kelecioğlu, 2007; Atikol, 2008), teachers stated that they did not feel themselves qualified regarding alternative assessment and evaluation tools. The studies conducted by Kazu, Pullu & Demiralp'in (2008) revealed that 60% of the teachers did not know in detail the assessment and evaluation tools that were included in the new primary education curriculum (as cited in Özdemir, 2010).

CONCLUSION and RECOMMENDATIONS

Regarding the data obtained at the end of the research, it was concluded that using structured grid contributed towards pre-service biology teachers better understanding of the subject, it had positive effects on eliminating misconceptions after determining them, it removed students' weaknesses, it raised student curiosity, it facilitated teachers' work, the subjects were taught and learned in a fun way and it promoted student participation and permanent learning. Moreover, the pre-service teachers' statements led us to conclude that these alternative assessment and evaluation activities were not used adequately by their guide teachers, the activities were not sufficiently included in the course books and the teachers wanted to use these activities. The results obtained from this study are compatible with the research results of Metin & Özmen 2010; Eroğlu & Kelecioğlu, 2011; Vurkaya & Kırıkkaya, 2011; Büyükturan & Demirtaşlı, 2013; Özenç, 2013; Bektaş, 2014).

Considering these results, all of the teachers working for the Ministry of National Education must be given in-service training seminars to introduce alternative assessment and evaluation tools, how to use them and how to evaluate students by using these tools. Neukom (2000) determined in a study that the achievement obtained from alternative assessment and evaluation techniques was dependent on both teachers and students and that teachers in particular must be given in-service training before using such techniques (as cited in Şenel et al., 2009). Moreover, Zimbicki (2007) revealed that teachers should be trained properly for the desired efficiency and that they would gain knowledge with the support they were given (as cited in Şenel et al., 2009). In addition to this, pre-service teachers must gain knowledge, skills and understanding of alternative assessment and evaluation tools and activities during their education. In order to achieve this, special teaching methods and assessment and evaluation courses taken by the students in their undergraduate studies must be taught by qualified and well-equipped instructors in this field. Moreover, practice instructors and practice teachers must guide pre-service teachers about alternative assessment and evaluation tools within the context of teaching practices and they must help pre-service teachers to develop in this area. Finally, structured grid, an alternative assessment and evaluation tool, must be given more prominence in the course books of the Ministry of National Education.

The following recommendations can be made regarding the study:

1. Students' views about structured grid should be investigated.
2. Pre-service teachers' views studying in different majors should be examined.
3. Teachers' views about structured grid should be investigated.

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Effects of the Inquiry-Based Learning Method on Students' Achievement, Science Process Skills and Attitudes towards Science: A Meta-Analysis Science

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ABSTRACT

The effectiveness of inquiry-based learning method was discussed for a long time. However, inquiry-based learning method was not discussed and compared with traditional learning before in terms of students' academic achievement, science process skills and attitudes towards science in a meta-analysis study. This study aimed to cover the effects of the inquiry-based science education on students' academic achievement, science process skills and attitudes towards science comparing with traditional learning. The study reviews the findings of the studies on the effectiveness of the inquiry-based science education comparing with traditional learning. In other words, meta-analysis method was used to combine statistically the numerical data of the studies and to reach a general conclusion using the results of these studies. The study reviewed a total of nineteen studies (37 comparisons in terms of achievement, science process skills and attitudes towards science) about the effects of the inquiry-based science education on the students' academic achievement, science process skills and attitudes towards science comparing with traditional learning carried out in Turkey between 2005 and 2015. Meta-analysis results showed that the inquiry-based science education had a positive and higher levels of effects of students' academic achievement (Cohen's d=1.029). It was also found that this specific teaching and learning method had a positive and medium level of effect on their science process skills (Cohen's d=0.742) and attitudes towards science (Cohen's d=0.558). It was found that the inquiry-based learning method used in science education had much more significant effects on student achievement rather than on their science process skills and their attitudes towards science in contrast to the traditional teaching method.

Keywords: Academic achievement, attitudes towards science, inquiry, meta-analysis, science process skills.

INTRODUCTION

Improvements in science and technology have significant effects on science education like in other fields. Therefore, given that science education has become an important field the educational systems of different countries aimed at educating individuals who are scientific literacy. Countries have tried to improve the science course and to make it possible to educate individuals who can reach the necessary information, interpret the newly acquired information

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based on experiences and have problem-solving skills (AAAS, 1990; NRC, 1996, 2000; MEB 2013). The national educational program for the course of science which became effective in 2013 has the major goal of "educating scientifically literate individuals" (MEB, 2013). The program makes use of the inquiry-based method as a primary learning and teaching method for educating scientifically literate individuals. Similarly, National Research Council (NRC) published a series of standards and reported that inquiry is the basis for science education (NRC, 1996; 2000). The inquiry-based learning method is a student-centered method in which students discover everything in their near environment, develop strong arguments about the natural and physical world surround them based on strong justifications, become those individuals who are aware of the significance of science, and construct information about doing, living and thinking (MEB, 2013; Wallace, 1997; Wood, 2003).

Although inquiry-based science teaching commonly could not be identified by scientists, scientists determine common characteristics of inquiry-based science teaching for participants. National Research Council (1996) expressed national science standards to define inquiry-based teaching in different aspects (content, process skills or instructional strategies). In 2000, Inquiry and the national science education standards declared five main characteristics of inquiry-based science teaching without any classification (NRC, 2000; Tatar, 2006; Ulu, 2011);

1. Learners are engaged by scientifically oriented questions.
2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.
3. Learners formulate explanations from evidence to address scientifically oriented questions.
4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
5. Learners communicate and justify their proposed explanations.

Using of traditional teaching cause to rote learning of science topics. Traditional teaching is concerned with the teacher being the controller of the learning environment. Power and responsibility are held by the teacher and they play the role of instructor (in the form of lectures) and decision maker (in regards to curriculum content and specific outcomes). They regard students as having knowledge holes that need to be filled with information. In short, the traditional teacher views that it is the teacher that causes learning to occur (Novak, 1998). In the eyes of reformers, traditional teacher-centered methods focused on rote learning and memorization must be abandoned in favor of student-centered and task-based approaches to learning. In recent years, reforms in science education proposed methods which are not based on route memorization, and encourage students' mental and scientific reasoning skills. These methods are strongly based on inquiry and aimed to improve their interest in science (NRC, 1996; 2000). In numerous studies, it was found that the inquiry-based teaching is much more efficient in improving student performance than traditional teaching methods (Gabel, Ruba & Franz, 1977; Hal & McCurdy, 1990; Geban, Askar & Ozkan, 1992; Gencturk & Turkmen, 2007; Celik & Cavas, 2012), their laboratory skills or science process skills (Tobin & Capie, 1982; Matheis & Nakayama, 1988; Basaga, Geban & Tekkaya, 1994; Ergul et al., 2011; Ozdemir & Isık, 2015; Yalcın, 2014), their ability to remember the content of the course (Schneider & Rener, 1980), gender (Gencturk & Turkmen, 2007; Inaltekin & Akcay, 2012) and their attitudes towards science or their scientific activities (Gabel, Ruba & Franz, 1977; Shepardson & Pizini, 1992; Turkmen, 2009; Arslan et al., 2014). Ergul, Simsekli, Calıs, Ozdilek, Gocmencelebi and Sanlı (2011) carried out the study with elementary students about how inquiry-based science learning change their science process skills and attitudes towards science and had reached the conclusion that inquiry-based science learning significantly influenced on their science process skills and attitudes towards science.

Although there are plenty of studies to investigate about the effect of inquiry-based science learning on students' achievement, science process skills and attitudes towards science, there is no clear conclusion about whether inquiry-based science learning influence students achievement, science process skills and attitudes towards science positively or negatively compared with traditional learning. In all these studies, there seems to be no consistent conclusion. Some studies showed a result that inquiry-based science learning increased students' science process skills, achievement and attitudes towards science and technology than traditional learning (Celik & Cavas, 2012; Hickey et al., 1999; Hickey, Wolfe & Kindfeld, 2000; Hmelo-Silver, Duncan & Chinn, 2007; Guthrie et al., 2004; Langer, 2001; Lynch et al., 2005; Tatar, 2012; Wu & Tsai, 2005) with statistical significance, whereas others found that there is no statistical effect of inquiry-based science learning on students' science process skills, achievement and attitudes towards science and technology compared with traditional learning (Bagcaz, 2009; Yıldırım & Berberoğlu; 2012).

Such studies may or may not reach different conclusions. Given that the number of studies has been increasing, it is hard to access the information needed. Therefore, a comprehensive research approach should be used in order to make use of the findings of these studies. One of such comprehensive research approaches is meta-analysis (Hedges & Olkin, 1985; Borenstein et al., 2009). There are both national and international studies about the use of the inquiry-based teaching method in science education. However, in these studies, the correlations among the variables which have significant effects on inquiry-based teaching method in science education generally have not been fully revealed. Therefore, a meta-analysis is needed to reveal the effects of these variables in science education.

This study aimed at covering the effects of the inquiry-based science education on students' academic achievement, science process skills and attitudes towards science comparing with traditional learning. In addition, the study reviewed the findings of the studies on the effectiveness of the inquiry-based science education comparing with traditional learning. In other words, it contains a meta-analysis which is a method to combine statistically the numerical data of the studies and to reach a general conclusion using the results of these studies. According to the aim of the study, the following research questions try to be answered. In contrast to traditional teaching methods:

1) At which level does the inquiry-based learning method affect students' academic achievement?
2) At which level does the inquiry-based learning method affect students' science process skills?
3) At which level does the inquiry-based learning method affect their attitudes towards science?

METHODS

a) Research Design

In the study, meta-analysis method was employed to cover the effects of the inquiry-based learning method on students' academic achievement, their science process skills and their attitudes towards science comparing with traditional learning in science education. Meta-analysis is a method to combine statistically the numerical data of the studies which were carried out on the same topic and to reach a general conclusion using the results of these studies (Lipsey & Wilson 2001; Saglam & Yuksel, 2007; Kablan, Topan & Erkan, 2013). In general, meta-analysis is carried out in the following three steps: 1) identification and selection of eligible studies, 2) the coding of the data of studies and calculation of effect size and 3) statistical analysis of the effect size and interpretation of the findings of the studies (Hoffler & Leutner, 2007).

b) Data Collection Tools

The studies were reviewed if they contained a comparison between traditional teaching methods and the inquiry-based learning method used in science education in terms of the effects on students' academic achievement, their scientific process skills and their attitudes towards science. More specifically, the following criteria were employed in selecting the studies to be reviewed (Camnalbur & Erdogan, 2008; Springer, Stanne & Donovan, 1999; Topcu, 2009; Kablan, Topan & Erkan, 2013):

Publication dates: Those studies which were carried out between 2005 and 2015 were included in the study.

Publication type: Master theses, Ph.D. theses, articles published in scientific journals or in e-journals, databases (ERIC, YOK thesis catalog, Google scholar, Springer, Science Direct) were reviewed in the study.

Method employed in the studies: In order to establish the effect size of each method, namely traditional teaching method and the inquiry-based learning method, those studies which included both an experimental group and a control group were selected. In addition, the traditional method should be implemented in the control groups and the inquiry-based method should be employed in the experiment groups. The study data included statistics that could be transformed in an effect size. The study was available in Turkish or English. The sample was from Turkey only.

Use of the appropriate teaching method: In the study, it was required that the inquiry-based method was employed in the experiment groups and traditional learning was implemented in the control groups.

Sufficient numerical data: In meta-analysis, the effect size should be covered. Therefore, descriptive numerical data about the control group and the experiment group are needed to reveal the effect size. Therefore, those studies which contained the data on the number of the sample, mean and standard deviation for the control group and the experiment group were included in the study.

In order to find all potential studies for inclusion in the quantitative synthesis, a comprehensive systematic search strategy was used. These articles published in international journals and national journals, which met the criteria given above, were accessible through the YOK theses catalog, and proceedings were reviewed. The stems of following identifiers or keywords in the title or abstract were used in the separate or combined searches: (In Turkish) Sorgulama, Araştırma, Sorgulamaya Dayalı Öğretim, Araştırmaya Dayalı Öğretim, (In English) Inquiry, Inquiry-based, Inquiry-based Teaching. At the end, a total of 58 studies were identified.

Then, these studies were reviewed in terms of containing the control group and the experiment group. Those with no such sampling design were excluded from the study. Those studies with no numerical data were also excluded. When it was clear that multiple sources (e.g., dissertations and journal manuscript) reported about the same data set, the source with more information was included in the analysis. After these reviews, a total of nineteen studies were included in the sample of the study.

c) Coding of the Data

In the study, the data collected were grouped into two categories. In the first category, there were eight sub-categories which are all about the publication information and the content of the studies. These sub-categories were the author(s), publication date, type of the publication, academic semester, materials used in the study, dependent variables, target educational level and type of the course. The second category includes information about sampling size, arithmetical mean, and standard deviation. In order to establish the reliability of the coding, the data were coded by the authors for two times independently.

Dependent variables: The dependent variables of the study were the effects of the inquiry-based learning method on the students' academic achievement, their science process skills and their attitudes towards science comparing with traditional learning. The effect size is a standardized value for the data analysis tools used in each study (Bernard et al., 2004).

d) Data Analysis

The data collected in the study were analyzed using treatment effectiveness meta-analysis. This method is reported to be employed when the arithmetical means of the dependent variables was found using different data collection tools (Camnalbur & Erdogan, 2008). The statistical data obtained in different studies should be transformed into a common form which is called the effect size.

The calculation of the effect size was realized using the Standardized Mean Difference (SMD) also known as Cohen's d in the literature and in the statistical analyses the significance was set at 95%. To calculate SMD and to get possible moderators, the following information was extracted from each study: sample size (experiment and control groups), the title of participants (traditional and inquiry-based science education attendance) and quantitative data to calculate effect sizes (r, t, F statistics and X2), p values, or means and standard deviations. Calculations were based on fixed and random effect model. However, in social studies, random was recommended (Cumming, 2012). Heterogeneity of effect sizes was assessed using Q and I2 statistics. When these statistics indicate the lack of homogeneity, the meta-analytic procedures are repeated in the moderator sub-groups. Therefore, in the study the effect size classification developed by Cohen (1992) was used. In the meta-analysis, the effect size is interpreted using a coefficient classification. This classification states that if the effect size is between .20 and .50 it is small-size. If it occurs between .50 and .80, it is called medium effect size and if it is higher than .80, it is called large effect size. In the study, the CMA and the Microsoft Excel 2010 Office program were used for the group comparisons.

Publication Bias

Publication bias is mostly stated in the studies which contain positive and statistical significance. However, it is rarely stated in the studies which contain negative and no statistical significance. Publication bias at a certain level affects the mean effect size and makes it larger than its actual size (Kıs & Konan, 2014). In the study in order to control the effect of publication bias on the effect size the funnel plot and Orwin's Fail-Safe N value were employed.

A funnel plot is a graph designed to check the existence of publication bias. It shows standard error in the study on the Y axis and effect size on the X axis. Those studies with smaller standard error occur at the top of the funnel and near to the line of the effect size. Those studies with higher standard error occur at the bottom of the funnel (Dincer, 2013). Because those studies with smaller sampling rate have a larger sampling variance than the expectation of effect size. Publication bias was controlled for each dependent variable independently below.

RESULTS

a) Descriptive Data

In the study, a total of nineteen studies comparing the traditional method and the inquiry-based method used in the secondary school science education were reviewed.

These studies were carried out on 1521 students, 778 of whom were in the experiment groups and 743 of whom were in the control groups. The following table shows the type of the studies, publication dates, and the dependent variables included:

Table 1. *Included Studies*

	Academic Achievement		Science Process Skill		Attitudes Towards Science	
Included Studies	Article	Thesis	Article	Thesis	Article	Thesis
Celik & Cavas, 2012	X		X		X	
Bagcaz, 2009		X				X
Kula, 2009		X		X		X
Kaya, 2009		X				
Akpullukcu & Gunay, 2013	X				X	
Fansa, 2012		X		X		X
Gencturk & Turkmen, 2007	X					
Colak, 2014		X		X		
Koksal & Berberoglu, 2012	X		X		X	
Karamanoglu, 2006		X				
Taskoyan, 2008		X				X
Yildirim, 2012		X		X		
Ulu, 2009		X		X		
Tatar, 2006		X		X		X
Sahin & Saglamer Yazgan, 2013	X					
Parim, 2009		X		X		
Turkmen, 2009					X	
Yalcın, 2013				X		
Ergul et al., 2011			X		X	
Total (n=19)	5	11	3	8	5	5

The studies reviewed were categorized into three groups: the effects of the inquiry-based learning method on students' academic achievement, the effects of the inquiry-based learning method on students' science process skills and the effects of the inquiry-based learning method on students' attitudes towards science (Table 1). It was found that there were eleven theses and five articles on the effects of the inquiry-based learning method on students' academic achievement. There were eight theses and three articles on the effects of the inquiry-based learning method on students' science process skills. There were five theses and five articles on the effects of the inquiry-based learning method on students' attitudes towards science. On the other hand, these studies were also found to be related to the effects of other variables which were not included in the study.

b) Effects of the Inquiry-Based Learning Method on Students' Academic Achievement Based on the Random Effects Model

As given in Table 2, the results of the random effects models about the effects of the traditional teaching model and the inquiry-based learning method on the student achievement used in the studies reviewed.

Table 2. *Effectiveness of inquiry-based learning method according to random effects model*

Model Type	N	Z	Q	ES	95% confidence interval	
					Lower	Upper
Random Effects Model	16	6.488	87.358	1.029	.718	1.340

As can be seen in Table 2, there is a large effect size on student achievement. Therefore, it can be argued that the students' academic achievement in the groups where the inquiry-based learning method is employed is much higher than in the groups where the traditional learning method is employed.

The results of the z test which was employed for statistical significance purposes showed the following z value: z= 6.488. It is statistically significant with p= 0.000 ($p<0.05$).

In the chi-square table, the critical value is stated to be nearly 24.996 with a significance level of 95% and a degree of freedom of 15. Given that Q value found in the study is 87.358 and that it is higher than the critical value of 24.996, the hypothesis of homogeneity about the distribution of the effect size was used in the random effects model.

In the study, the effect size was found as 1.029. As can be seen in Figure 1 the effect sizes of the studies reviewed are symmetrically distributed on two sides of the vertical axis and they are all near to this axis. The Orwin's Fail-Safe N analysis showed that the effect size of 1.029 could only be near to zero if 848 studies were included in the meta-analysis. However, there were only sixteen studies which met the necessary inclusion criteria. In short, it can be argued that there was no publication bias in the studies reviewed.

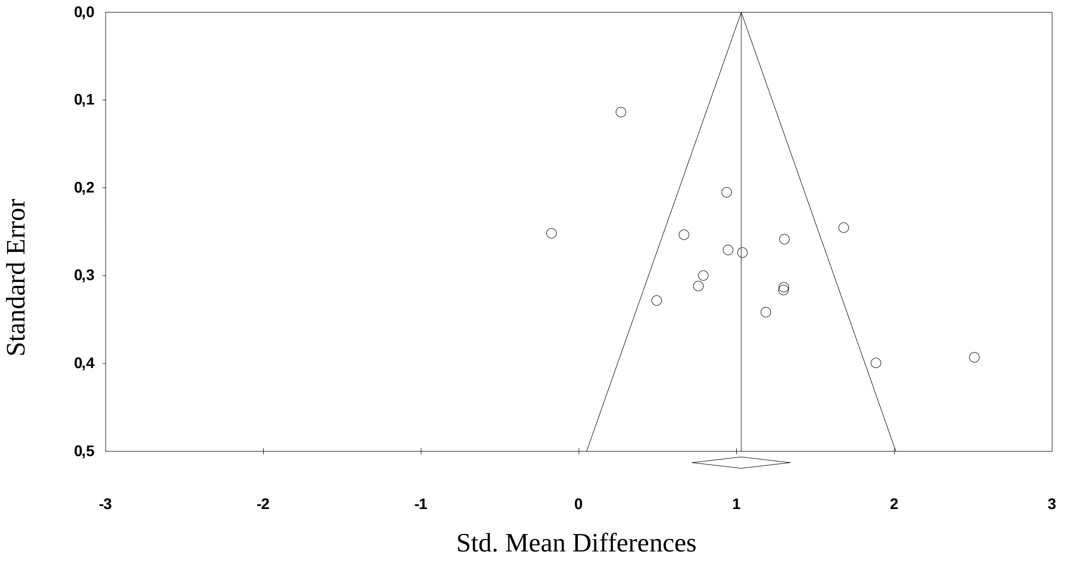

Figure 1. *Funnel plot for effectiveness of inquiry-based learning on academic achievement*

c) Effects of the Inquiry-Based Learning Method on Students' Science Process Skill Based on the Random Effects Model

As given in Table 3, the results of the random effects models about the effects of the traditional teaching method and the inquiry-based learning method on students' science process skills used in the studies reviewed.

Table 3. *Effectiveness of inquiry-based learning method according to random effects model*

Model Type	N	Z	Q	ES	95% confidence interval	
					Lower	Upper
Random Effects Model	11	5.074	37.816	.742	.455	1.028

As it can be seen in Table 3, the effect size is at the medium level according to the classification developed by Cohen (1988). It is safe to argue that the students' science process skill in the groups where the inquiry-based learning method is employed is much better than in the groups where the traditional teaching method is employed.

The results of the z test which was employed for statistical significance purposes showed the following z value: z= 5.074. It is statistically significant with p=0.000 ($p<0.05$).

In the chi-square table, the critical value is stated to be nearly 18.31 with a significance level of 95% and a degree of freedom of 10. Given that Q value found in the study is 37.816 and that it is higher than the critical value of 18.31, the hypothesis of homogeneity about the distribution of the effect size was used in the random effects model.

In the study, the effect size was found as 0.742. As can be seen in Figure 2, the effect sizes of the studies reviewed are symmetrically distributed on two sides of the vertical axis and they are all near to this axis. The Orwin's Fail-Safe N analysis showed that the effect size of 0.742 could only be near to zero if 266 studies were included in the meta-analysis. However, there were only eleven studies which met the necessary inclusion criteria. In short, it can be argued that there was no publication bias in the studies reviewed.

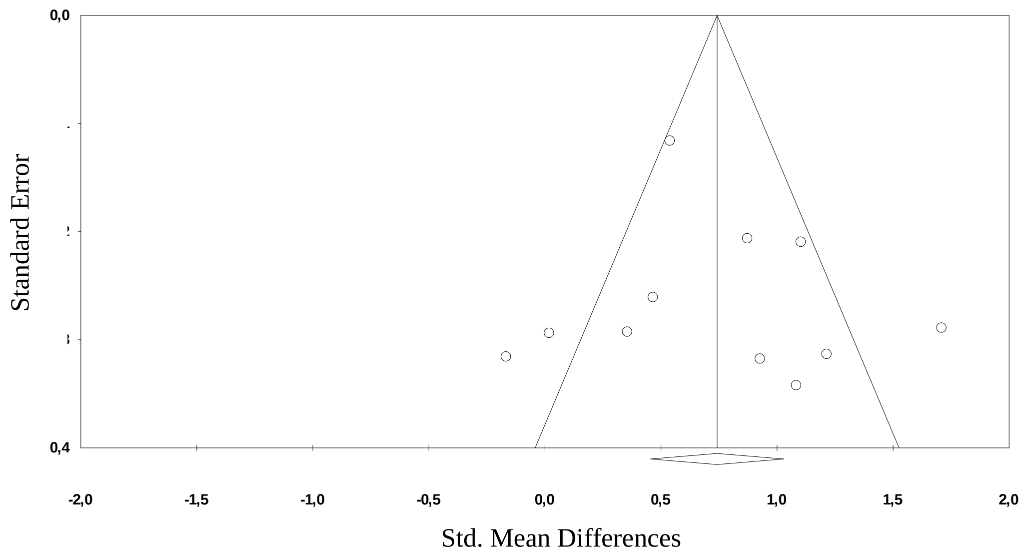

Figure 2. *Funnel plot for effectiveness of inquiry-based learning on science process skills*

d) Effects of the Inquiry-Based Learning Method on Students' Attitudes Towards Science Based on the Random Effects Model

Table 4 shows the results of the random effects models about the effects of the traditional teaching model and the inquiry-based learning method on students' attitudes towards science used in the studies reviewed.

Table 4. *Effectiveness of inquiry-based learning method according to random effects model*

Model Type	N	Z	Q	ES	95 % confidence interval	
					Lower	Upper
Random Effects Model	10	3.832	36.631	.558	.273	.843

As it can be seen in Table 4, the effect size is at the medium level according to the classification developed by Cohen (1988). It is safe to argue that the students' attitude towards science in the groups where the inquiry-based learning method is employed is much more positive than in the groups where the traditional teaching method is employed.

The results of the z test which was employed for statistical significance purposes showed the following z value: z= 3.832. It is statistically significant with p=0.000 (p<0.05).

In the chi-square table, the critical value is stated to be nearly 16.92 with a significance level of 95% and a degree of freedom of 9. Given that Q value found in the study is 36.631 and that it is higher than the critical value of 16.92, the hypothesis of homogeneity about the distribution of the effect size was used in the random effects model.

In the study, the effect size was found as 0.558. As can be seen in Figure 3 the effect sizes of the studies reviewed are symmetrically distributed on two sides of the vertical axis and they are all near to this axis. The Orwin's Fail-Safe N analysis showed that the effect size of 0.742 could only be near to zero if 127 studies were included in the meta-analysis. However, there were only ten studies which met the necessary inclusion criteria. In short, it can be argued that there was no publication bias in the studies reviewed.

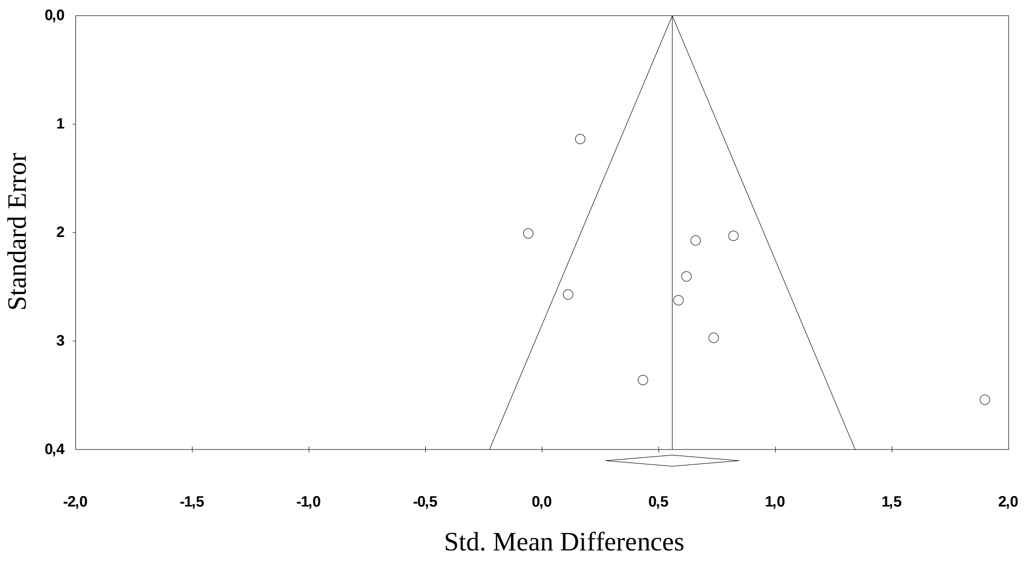

Figure 3. *Funnel plot for effectiveness of inquiry-based learning on attitudes towards science*

DISCUSSION and CONCLUSION

Discussion

In the study, a total of nineteen studies were reviewed in terms of the effects of the traditional teaching method and the inquiry-based learning method on student achievement, their science process skills and their attitudes towards science in the context of primary education science courses.

Of these nineteen studies, sixteen studies compared the effects of the traditional teaching method and the inquiry-based learning method on students' academic achievement. The meta-analysis showed that in fifteen studies there was a positive effect size in favor of the inquiry-based learning method. The national findings (Timur & Kincal, 2010) about the effects of the inquiry-based learning method are mostly consistent with the international findings (Schroeder et al., 2007). Minner, Levy & Century (2009) reviewed a total of 138 studies on the effects of the inquiry-based learning method used in science education on student achievement and their conceptual comprehension. These studies were published between 1984 and 2002. They found that the inquiry-based learning method used in science education had significant effects on the students' academic achievement and their conceptual comprehension. On the other hand, based on the findings of the current meta-analysis and the previous findings it is safe to argue that the inquiry-based learning method used in science education had significant effects on the primary education students' academic achievement in contrast to the traditional teaching method (Celik & Cavas, 2012).

In the current meta-analysis, eleven studies were reviewed in terms of the effects of the traditional teaching method and the inquiry-based learning method on students' scientific process. Of these eleven studies in ten studies, the inquiry-based learning method was found to have much more positive effects on students' science process skills in contrast to the traditional teaching method. In the previous studies carried out in Turkey about the effects of the inquiry-based learning method on primary education students' science process skills inconclusive findings were found. For instance, Yıldırım and Berberoglu (2012) concluded that the inquiry-based learning method had no significant effect on the eight-grade students' academic achievement and science process skills in regard to the unit of force and movement. However, Yasar and Duban (2009) concluded that the science activities which were carried out using the inquiry-based learning method increased the number and type of the science process skills used by the fifth-grade students. Based on the findings of the current meta-analysis it is possible to argue that the inquiry-based learning method improved the use of the science process skills by primary education students in terms of the number of these skills.

Among ten studies reviewed in eight studies the inquiry-based learning, method was found to have much more positive effects on the attitudes of the students towards science in contrast to the traditional teaching method. Similarly, Gibson and Chase (2002) concluded that the attitudes of the students towards science who were taking courses in an inquiry-based learning method. Duban (2008) also argued that the inquiry-based learning method used in science education has positive and significant effects on student achievement, their science process skills and their attitudes towards science.

Conclusion

Experimental studies were included to meta-analysis study so results should be interpreted according to nature of experimental studies. In experimental studies, it was possible that variables out of the independent variables influence on dependent variables. Especially, when participants' attitudes toward being involved in a study affect the way they behave, a Hawthorne effect has occurred. When participants are given increased attention and recognition because they are participating in a study, their responses may be affected. This is known as the Hawthorne effect, some changes in teaching method by researchers cause that participants can give different responses unusually (Fraenkel & Wallen, 2006). Therefore, experimental groups can take higher scores than control groups. Sometimes teachers and researchers can be influenced by Hawthorne effect. For this reason, it can be said that increasing of academic achievement could not be resulted from only inquiry-based science teaching in experimental studies.

In the current study, it was found that in contrast to the traditional teaching method the inquiry-based learning method used in science education had much more significant effects on student achievement rather than on their science process skills and their attitudes towards science.

Recommendations

Therefore, it can be suggested that the inquiry-based learning method should be preferred in primary education science courses in order to improve student achievement, science process skills and attitudes towards science.

Future studies may also employ the meta-analysis technique to reveal the effects of the inquiry-based learning method used in science education on misconceptions and on students' future careers.

In the study only quantitative studies were reviewed. Therefore, future studies may review the qualitative studies. Another limitation of the current study is that it reviewed those studies carried out in Turkey. Future studies may review other studies carried out in different countries. Such studies will provide an opportunity to make comparisons at a larger scale.

Given that the studies on the inquiry-based learning method have become common, similar meta-analysis based studies should be made to make comparisons in terms of the effect size.

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Examination of Science Learning Equity by Argumentation Instruction between Students Having Different Socio-Economic Status and Attending Different Achievement Level Schools

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ABSTRACT

We investigated if argumentation instruction provides equal science learning opportunities to students who have different socio-economic status (SES) and attend different achievement level schools. We selected a disadvantaged school and an advantaged school for this aim. 46 low-SES 8th graders in the disadvantaged school formed the experimental group. 35 low-SES 8th graders in the disadvantaged school formed the control group and 29 high-SES 8th graders in the advantaged school formed the comparison group. While experimental group received argumentation instruction on science topics during one semester, control and comparison groups did not. We compared group performances on conceptual knowledge, utility value of science, beliefs on theory and data, and views on student-centered teaching. Results showed that students of experimental and comparison groups outperformed students of control group on all measures after instruction. In addition, no difference was found between experimental and comparison group after instruction except from beliefs on theory and data measure.

Keywords: Achievement; Argumentation; Equity; Socio-economic status; Middle school.

INTRODUCTION

The importance of student evidence-based reasoning and reasoning between different alternative theories/explanations have been emphasized in science education and cognitive psychology research (Driver, Newton, & Osborne, 2000; Kuhn, Schauble, & Garcia-Mila, 1992; Zeidler, 1997). Studies mostly show that students have difficulty in evidence-based reasoning and reasoning between alternatives (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Kelly, Druker, & Chen, 1998; Kuhn et al. 1992; Watson, Swain, & McRobbie, 2004; Zeidler, 1997). From this perspective, providing contexts to students where they can construct evidence-based arguments and reason between alternatives is recommended (Fleming, 1986; Kuhn, 1993).

Researchers have focused on teaching students how to construct a qualified argument and make a good argumentation in science classes. Encouraging results were obtained regarding the improvement of quantity and quality of evidence and these results warrant students use in their arguments (McNeill, Lizotte, & Krajcik, 2006; Sandoval & Milwood,

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2005). Moreover, it is demonstrated that students' arguments for other alternatives can be enhanced in science classrooms where students are provided with opportunities for counter-argument and rebuttal construction (Acar, 2008; Osborne, Erduran, & Simon, 2004a). In addition, studies showed that important variables in science education such as conceptual knowledge (Gültepe & Kılıç, 2013; McNeill et al., 2006; Zohar & Nemet, 2002), nature of science understanding (McDonald, 2010; Walker & Zeidler, 2007), and scientific reasoning (Acar, 2015) may be enhanced by fostering argumentation in science classes.

From the perspective of raising scientifically literate citizens, the focus of any student-centered instruction is changing from examination of effectiveness to achieving equity among students (National Research Council [NRC], 1996; Organisation for Economic Co-operation and Development [OECD], 2013). Recent studies have also focused on comparison of performances of low achieving students (LAS) and high achieving students (HAS) during inquiry instruction (Akkus, Gunel, & Hand, 2007; Lewis & Lewis, 2008). Encouraging results were obtained with regard to closure of achievement gap by gender and race (Geier et al., 2008; Huppert, Lomask, & Lazarowitz, 2002; Johnson, 2009; Wilson, Taylor, Kowalski, & Carlson, 2010). However, there is paucity of study examined this issue in the context of argumentation instruction. More specifically, Zohar and Dori (2003) compared reasoning and Akkus et al. (2007) compared achievement of LAS and HAS during argumentation instruction. These researchers sought whether argumentation instruction provided equal learning opportunities for both groups. However large-scale assessments show that socio-economic status (SES) and school type are also important variables for explaining students' science achievement (Martin, Mullis, Foy, & Stanco, 2012; OECD, 2013). Thus, researchers need to consider these variables for the examination of achieving equity among students in detail. Moreover, Acar (2015) compared conceptual knowledge and scientific reasoning of students in a disadvantaged school who received argumentation instruction with students in a comparatively advantaged school who received traditional instruction. In addition, a study by Chen, Hand, and McDowell (2013) examined the relative conceptual knowledge performances of low-SES students who received argumentation instruction and low-SES students who received traditional instruction. However, Acar (2015) did not pay attention to SES of students and Chen et al. (2013) did not compare the experimental group with high-SES students in an advantaged school. Furthermore, no research in argumentation literature have examined the equity among students for important variables in science education such as students' attitudes towards science, epistemological beliefs, and views on science teaching. This study aims to close these gaps in the literature. Following research questions were sought in this study:

Research Question 1: Is there any conceptual knowledge difference between control and experimental group low-SES students in disadvantaged school and comparison group high SES students in advantaged school after instruction?

Research Question 2: Is there any utility value of science and beliefs on theory and data difference between control and experimental group low-SES students in disadvantaged school, and comparison group high SES students in advantaged school after instruction?

Research Question 3: Is there any difference of views on student-centered teaching between control and experimental group low-SES students in disadvantaged school, and comparison group high SES students in advantaged school after instruction?

Argument and Argumentation

Argument and argumentation refer to different constructs in the literature. That is to say, argument is a product of one's attempt to support a claim about an issue (Kuhn, 1993; Kuhn & Udell, 2003). Thus, there need not to be alternative explanations or theories when one is constructing an argument. On the other hand, argumentation is a reasoning process by which advantages and disadvantages of alternative explanations or theories are examined (Kuhn 1993).

Toulmin (1958) offered a framework which can be used to construct model and assess arguments in practical situations (Toulmin, Rieke, & Janik, 1984). According to Toulmin (1958), a simple layout of an argument consists of data, warrant, backing, and claim. Data are the observations or facts that can be used to support a claim. A warrant is a reasoning that serves as a connection between data and the claim. A backing is a basic assumption in a domain that serves as a justification for the warrant. Finally, a claim is a conclusion stating one's stance on an issue. In more advanced arguments, qualifiers and rebuttals can also be used (Toulmin 1958). A qualifier is a statement that specifies the conditions under which the claim is true and a rebuttal is a statement that indicates the circumstances under which the claim is wrong.

Toulmin's argumentation pattern (TAP) was used both as an assessment technique for student arguments and as an instructional tool to teach evidence-based reasoning in science classrooms in the literature. Although several limitations of TAP was found for tracking student written and oral arguments in science classes (see Erduran, 2007 and Sampson & Clark 2008 for review), it has been widely used in science education literature to assess student arguments (e.g., Bell & Linn 2000; Jimenez-Aleixandre et al. 2000; Kelly et al. 1998, Watson et al. 2004). On the other hand, studies showed that explicating the components of TAP to students help students improve their written and oral arguments (Osborne et al., 2004a; Sandoval & Millwood, 2005; Zohar & Nemet, 2002).

As for argumentation, studies in cognitive psychology and science education show that subjects who are dependent on their theoretical beliefs demonstrate reasoning flaws when they argue among different alternative theories (Kuhn, 1991; Kuhn et al., 1988; Kuhn et al., 1992; Zeidler, 1997). Mostly they have difficulty in differentiation between theory and evidence (Kuhn, 1993). However, subjects who can offer evidence that is not theory oriented are more able to coordinate their theories with evidence (Kuhn, 1993; Kuhn et al., 1992). Accordingly, these latter subjects are more competent in arguing between different alternatives (Kuhn, 1991; Kuhn et al., 1988; Kuhn et al., 1992). Studies in science education also show that students mostly rely on their beliefs when they argue among alternative theories (Sadler, Chambers, & Zeidler, 2004; Zeidler, Walker, Ackett, & Simmons, 2002). In addition, they solely rely on scientific authorities without scrutinizing the data in their arguments when they argue between alternatives (Kolsto, 2001). As a remedy to these problems, providing students contexts where they can argue among different alternatives is recommended (Acar, 2008; Kuhn, 1993; Osborne et al., 2004a).

Effect of Argumentation Instructions on Student Related Variables

Studies show that students use rare evidence and justifications to support their claims in inquiry learning environments (Jimenez-Aleixandre et al., 2000; Kelly et al., 1998; Watson et al., 2004). Furthermore studies reveal that students are reluctant to consider other alternatives about an issue (Sadler et al., 2004; Zeidler, 1997; Zeidler et al., 2002). This is problematic in terms of inquiry learning because students are expected to construct and test evidence-based arguments in these settings (NRC, 1996). From this point of view, teaching argument and argumentation are seen as a remedy to these problems.

Several argumentation studies focused on if this kind of instruction helps students develop their argument and argumentation quality. Results demonstrate that student evidence and justification use can be enhanced through teaching the components of an argument (McNeill et al., 2006; Zohar & Nemet, 2002). Besides, it is found that students' skills related to arguing for the other alternatives can be enhanced (Acar, 2008; Nussbaum & Sinatra, 2003; Osborne et al., 2004a). Moreover, studies focus on the effect of argumentation instruction on important variables in science education such as conceptual knowledge, epistemological beliefs, nature of science, and attitudes towards science. Results of these studies suggest that students' conceptual knowledge and nature of science understanding may be enhanced through argumentation instruction (Aydeniz, Pabuccu, Cetin, & Kaya, 2012; Günel, Memiş, & Büyükkasap, 2010; McDonald, 2010; Zohar & Nemet, 2002). On the other hand, equivocal results are reported for the effect of argumentation instruction on students' epistemological beliefs (Osborne, Simon, Christodoulou, Howell-Richardson, & Richardson, 2013; Sandoval & Morrison, 2003) and attitudes towards science (Osborne et al., 2013).

Achieving Equity in Science Classrooms and Argumentation Instruction

Science achievement gap among students has been a concern among policy makers (Eğitimi Araştırma ve Geliştirme Dairesi Başkanlığı, 2010; NRC, 1996; OECD, 2013). This gap can be attributed to the differences in student-level factors such as students' resources at home, self-efficacy, attitudes towards science, gender and their parents' SES and education level (Acar, Türkmen, & Bilgin, 2015; Engin-Demir, 2009; Martin et al., 2012; Sun, Bradley, & Akers, 2012; Yetişir, 2014); school-level factors such as program type, school climate (Dinçer & Uysal, 2010; Engin-Demir, 2009); classroom-level factors such as type of instructional method, class average engagement, and collaboration among teachers (Atar, 2014; Aypay, Erdoğan, & Sözer, 2007; Ceylan & Akerson, 2014; Yetişir, 2014). However, this issue is problematic with the movements of *science for all* and raising scientifically literate students who would participate in complex problems in the future as citizens (NRC, 1996).

Although addressing all of these factors in an education system for approaching achievement equity among students require large-scale policy efforts, several initiatives can be undertaken by researchers to reduce the achievement gap. Among one of these initiatives, studies examined if reform-based inquiry instruction leads to reduction of achievement gap in science classes. It is suggested that inquiry teaching is effective in eliminating the achievement gap by race (Johnson, 2009; Wilson et al., 2010), and gender (Geier et al., 2008; Huppert et al., 2002). On the other hand, it is also reported that traditional instruction results in a detectable achievement gap (Wilson et al., 2010). Contrary to these encouraging results, Lewis and Lewis (2008) found that students' prior Scholastic Aptitude Test scores explained a significant portion of their achievement in inquiry instruction which suggests that preexisting achievement gaps among students still did not close after inquiry. In another study, Von Secker and Lissitz (1999) examined data from a national study for the effect of instructional practices on eliminating the achievement gaps among students. More specifically, authors compared science achievement of several LAS groups based on gender, race, and SES in reform-based instruction. Authors found that achievement gap between LAS and HAS reduced in learning environments that focused on laboratory inquiry but widened in environments where critical thinking was fostered.

In case of argumentation instruction, four studies found in the literature which examined conceptual knowledge, reasoning, and achievement gaps between student groups during argumentation instruction. To begin with, Zohar and Dori (2003) examined thinking scores of high and middle school LAS and HAS during argumentation instruction. Actually, this study was an overall report of the four studies conducted previously. Students were grouped under LAS and HAS based on their previous science academic achievement. Mostly students in this study were required to develop their arguments with using evidence and consider alternative perspectives about contemporary science and society problems like bioethical dilemmas and diminishing of ozone layer. Overall, results suggested that both LAS and HAS developed their thinking skills. However, no consistent result was found for the closure of thinking scores between these groups. In another study, Akkus et al. (2007) investigated achievement of middle and high school LAS and HAS during argumentation instruction. Students' laboratory work was organized in this study in a way that students wrote their ideas, observations, claims, and reflections during the investigations. On the other hand, teachers monitored student learning during these processes. Researchers grouped students under achievement levels based on their performance on a baseline science test. Results showed that argumentation instruction helped to reduce the achievement gap between LAS and HAS in this study. In another study, Acar (2015) investigated the relative scientific reasoning and conceptual knowledge scores of students who were taught by argumentation instruction in a disadvantaged school and students who were taught by traditional instruction in an advantaged school. Competing theories and predict-observe-explain (POE) teaching strategies were used to foster student argument and argumentation during the study. Neither conceptual knowledge nor scientific reasoning difference was found between students in disadvantaged school and students in advantaged school. Finally, Chen et al. (2013) compared achievement of low-SES students who received argumentation instruction with other low-SES students who received traditional instruction. Students in the experimental group in this study wrote letters containing evidence-based arguments about force and motion to the questions posed by their older peers. Results showed that low-SES students in the experimental group outperformed low-SES students in the control group on force and motion achievement test.

As can be seen, Zohar and Dori (2003) and Akkus et al. (2007) examined whether argumentation instruction provides equal learning opportunities for LAS and HAS. However, for the investigation of science learning equity on a large scale, students' SES and their school type should be taken into account. Although Acar (2015) examined if students in a disadvantaged school taught by argumentation can close the scientific reasoning and conceptual knowledge gap with students in an advantaged school, he did not pay attention to students' SES. Furthermore, no control group from a disadvantaged school was included in that study. On the other hand, although Chen (2013) considered students' SES, this study did not compare low-SES and high- SES students and did not take school type into account. Addressing limitations of these studies is important for getting a clear picture for science learning equity. Therefore we aimed to address these gaps in the present study.

METHODOLOGY

Sample and Research Context

This research took place in an industrial city in Turkey in the spring academic semester. Quasi-experimental research design was utilized. More specifically, we selected a disadvantaged and an advantaged school for examining if argumentation instruction taught to students in the disadvantaged school helps to close the learning gap between these students and the students in the advantaged school. We selected these two schools based on their previous science achievement on a state-wide exam called passing from primary to middle school education exam (i.e., *Temel Eğitimden Ortaöğretime Geçiş sınavı* (TEOG) in Turkish). Specifically, disadvantaged and advantaged schools' means in science on this exam, that is used to place students in high schools and administered one semester before the study, were 58.16 and 78 out of 100 respectively. Families of the students' in the former school were mostly immigrants and had low-SES. On the other hand, families in the latter school mostly had high-SES. We focused our attention to 8th grade classes because we had developed argumentation activities and conceptual knowledge test for 8th grades in our previous work (see Acar, 2015). We did validity checks for both argumentation activities and conceptual knowledge test, and this enabled us to spend our effort on other methodological issues. Then we selected two 8th grade science classes as experimental and two 8th grade science classes as control group from disadvantaged school. Science teachers in this school who participated in this study said that four classes have same science achievement levels. In addition, an 8th

grade science class from the advantaged school was selected to compare other groups' performances. Although there were a total of 109 8th grade students in the disadvantaged school, 46 students remained in the experimental group, 35 students remained in the control group from the disadvantaged school and 29 students remained in the comparison group from the advantaged school after a list-wise deletion of four of the dependent variables used in this study. As can be seen, we had 28 students missing from the study sample in the disadvantaged school. Since we administered our instruments in two different days after TEOG exam after which student attendance rates usually get lower especially in disadvantaged schools, this high rate of missing data may be tolerable. However, the problem of whether missing students have different characteristics, e.g., initial conceptual knowledge, than the students remained in the study for disadvantaged school is a considerable one. To examine this problem, we performed ANOVA on students' conceptual knowledge pretest scores in the disadvantaged school. Result demonstrated that missing students (n = 28; M = 6.44) did not have different conceptual knowledge pretest scores than their peers (n = 81; M = 6.48) who remained in the study sample ($F_{(1, 107)} = 0.06$; $p > .05$). Therefore we do not have evidence for the claim that study sample is different than the students who were excluded from the sample.

We tested the assumptions related to student families' SES for each group and science achievement of control and experimental group in the disadvantaged school. To test the assumption regarding the SES of student families, we administered a questionnaire to students in which we asked education level of students' fathers and mothers, and monthly income of their families. We performed analysis of variance (ANOVA) on this overall SES measure. Result revealed that there is a significant difference between groups ($F_{(2, 107)} = 158.26$; $p < .001$). Then, we performed post-hoc comparisons with *Sidak* adjustment to experiment-wise alpha. Result showed that control (M = 6.40) and experimental groups (M = 6.15) in the disadvantaged school did not differ ($p > .05$). However, comparison group in the advantaged school (M = 10.03) had higher SES than control and experimental groups in the disadvantaged school ($p < .001$ for each comparison). Since the experimental and the control groups were in disadvantaged school, we expected similar science academic achievement between these groups. To test this hypothesis, we performed ANOVA on students' previous semester, i.e., fall semester, science academic grades. Result showed that experimental (M = 57.43) and the control group (M = 58.19) did not differ on their previous semester science grades ($F_{(1, 79)} = 0.06$; $p > .05$).

Three science teachers participated in this study. Two of them were in disadvantaged school and the other was in advantaged school. Although it might have been good for an experimental design to select one science teacher who could teach control and experimental groups as well as comparison group, it would be very difficult to find a science teacher who teaches at an advantaged and also disadvantaged school because of teacher appointment system in Turkey. However we could have selected two teachers one who had taught both control and experimental groups in disadvantaged school and the other who had taught comparison group in the advantaged school. On the other hand, Osborne et al. (2004) precaution other researchers that experimental group teachers can transfer their argumentation pedagogy to control groups unintentionally which may be undesirable for experimental design. In fact, our results regarding similar previous semester science achievement of control and experimental groups may confirm that control and experimental group teachers have similar pedagogical content knowledge because these teachers taught respective science classes in the previous academic semester. Experimental group's teacher attended to a professional development course on argumentation pedagogy before the study took place. To put it more clearly, components of TAP and argumentation were presented in the first session of this course. Additionally, examples of sound and fallacious argument and argumentation were presented and discussed in this session. Then, strategies to foster student argument and argumentation were presented in the second session. Finally, strategies for how to form small groups and how to scaffold students' argument and argumentation were presented and discussed in the final session. Each session lasted approximately half day period. In addition to the professional development course, the author gave feedback to this teacher about how to scaffold student argumentation in argumentation lessons better when he visited the class regularly throughout the semester. Control and comparison groups' science teachers taught the same science topics without argumentation.

The author visited and observed each group's science classes regularly during the semester. The author took field notes about the pedagogies teachers implemented during these observations. More clearly, the author paid particular attention to whether teachers used any argumentation strategies and any student-centered teaching approaches during these classroom observations.

Instruction

Experimental group's teacher explained TAP, argumentation and their components by examples in the first two class sessions of the spring semester. Then, experimental group did 6 argumentation activities during the semester and spent 6 lessons during these activities. There were sound, matter states and heat, living things and energy relation, electricity in our life and natural processes units covered in the spring semester of 8th grades. We used concept cartoons (Naylor & Keogh, 2013), competing theories, POE, six hats thinking techniques (de Bono, 1985) to develop argumentation activities. More specifically, two snowmen were presented as supporting alternative explanations about which one will melt first under sun shine in the concept cartoon activity (Osborne, Erduran, & Simon, 2004b) which was used in matter states and heat unit. Students first discussed this controversy in small groups and then wrote arguments on their worksheets. Competing theories strategy was used to develop two activities about how sound travels in a medium and how seasons form which were used in sound and natural processes units respectively. That is to say, two hypothetical students were presented for each topic as supporting alternative explanations. Another hypothetical student was also presented who provided data about the controversy. More clearly, a hypothetical student was presented as supporting the view that sound travels through the space of atoms and molecules of the medium in the first activity. Another hypothetical student was presented as arguing that sound waves moves by their effect on the particles of the medium. A third hypothetical student was presented as providing several everyday observations about the discussion such as sound waves are reflected as they encounter another medium and sound travels faster in the iron than it travels in the air. In the second activity, one of the hypothetical students was presented as claiming that seasons form due to the change of earth's distance from the sun. The other one was presented as claiming that the slope of the earth's orbit causes seasons. Finally, third hypothetical student was presented as showing data related to the controversy such as earth's having an elliptical orbit when rotating around the sun and when it is winter in northern hemisphere, there is summer in southern hemisphere. Students first discussed the controversy in small groups and then constructed their arguments, counter-arguments, and rebuttals in their worksheets for these two activities.

Two of the activities about the factors affecting the transformation of electric energy to heat energy and factors affecting the strength of an electro-magnet were developed using POE strategy which were used in electricity in our life unit. More clearly, students were asked to state dependent, independent, and controlling variables and predict which variables affect the water temperature in a beaker shown in Figure 1 for the first activity. Similar to the first activity, students were again asked to state dependent, independent, and controlling variables and predict which variables affect attraction force of electromagnet on clothespins. Then each group did the experiments and recorded the result of the investigations in their worksheets.

Finally, students explained their observations in the light of their predictions in their worksheets. Finally, six hats thinking technique was utilized to develop an argumentation activity which was about advantages and disadvantages about using nuclear energy which was used in living things and energy relation unit. More clearly, a scenario that explained the history of nuclear energy usage and evidence that is both for and against the nuclear energy usage was presented to students. For example nuclear power plant accidents in Three Mile Island and Chernobyl were presented as evidence against the usage of nuclear energy. On the other hand, scientists' view that nuclear power plants are safer for causing global warming than other power plants that use coal and petroleum which emit greenhouse gases was presented as evidence for supporting nuclear energy usage. First, each small group discussed this controversy in their groups. Then each student stated the facts (white hat), their emotions (red hat), advantages (yellow hat), disadvantages (black hat), innovative ideas (green hat), and finally their evaluation (blue hat) about the issue in their worksheets. Experimental group teacher guided student discussion in small groups. A transcript of a small group discussion can be seen in Table 1. As can be seen from this transcript, experimental group teacher fostered student argumentation in small groups for both sides of the controversy. Furthermore, he gave each student a chance in the small group to express his/her idea about the issue.

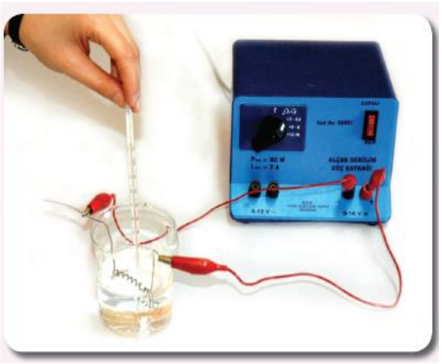


Figure 1. *Electric to Heat Energy Activity.*

Table 1. *Teacher-Student Interaction Transcript from an Argumentation Activity*

Teacher	Zeynep, what do you feel about (using) nuclear energy?
Zeynep	I think there are advantages and disadvantages (about using nuclear energy). I am really scared of its bad effects. If an accident happens, all of us can suffer.
Teacher	Ahmet (what do you feel)?
Ahmet	(a little pause) Nuclear energy is good for using (as an energy source) but it is bad for its negative effects (to environment).
Teacher	Ok, what about its advantages?
Sude	It is used for energy need.
Akın	It does not cause emission of greenhouse gases which contribute to global warming.
Teacher	Good, and what would you say about its disadvantages?
Zeynep	If an accident happens, people can suffer from it.
Ahmet	Furthermore, since its waste is dangerous for the environment, there is a problem with the waste disposal.
Teacher	All right, Akın do you have any innovative idea (about this issue)?
Akın	(hımmm) I think, (nuclear) power plants can be constructed far away from the cities.
Teacher	Sude (do you have any innovative idea)?
Sude	Its usage is good for our country if all the cautions can be undertaken (for an accident).
Teacher	Zeynep, can you give a summary of your stance about the issue?
Zeynep	I think nuclear energy is an important discovery because its positive effect on the economy. An accident can happen in a small probability if all the necessary cautions are undertaken. Therefore the probability of dangerous radiation coming from a nuclear power plant is as small as this probability.

Control and comparison groups' students were taught the same topics without argumentation. Male teacher in disadvantaged school taught science to control group mostly by lecturing. He did not even create a class environment for discussion during these occasions. In addition, he did not create a student-centered lesson that students can participate. Furthermore, he did not use the science laboratory for his lessons. On the other hand, female teacher in the advantaged school taught science to the comparison group by frequently using a laptop and a projector connected to it. Besides, she used smart board in each science lesson. Furthermore, she used science laboratory almost every week during the study. Thus, we cannot conclude that the latter group received traditional instruction because several elements of student-centered instruction were in place. Rather we can conclude that they did not receive argumentation instruction because these students neither argued between different alternatives nor constructed evidence-based arguments during the study.

Instruments

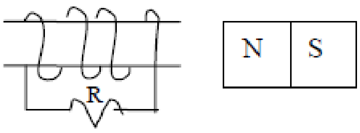
Conceptual Knowledge Test: This test was developed to measure 8th graders' conceptual understanding related to sound, heat and temperature, states of matter and heat, electricity in our life, and natural processes. There were 17 multiple-choice items in the test. Content validity of the test for 8th graders was established by Acar (2015). A student response was coded as 1 if he/she answered an item correct otherwise it was coded as 0. Cronbach's alpha estimate of the internal consistency was computed as .72 (n = 110) for the posttest administration of this test. Two example items of this test can be seen in Figure 2.

Matter	SpecificHeat (J/g °C)
Water	4,18
Lead	0,13
Iron	0,46
Olive oil	1,96

Same quantity of heat is given to the matters that have same temperature and mass initially and have specific heats indicated at the table. Which matter would have the highest temperature after the experiment is over?

a. Water b. Iron

c. Lead d. Olive oil



Which of the following situations cannot create electric current in the circuit shown on left?

a. Removing away the magnet from the circuit.
b. Bringing circuit closer to the magnet.
c. Moving the magnet and circuit in the same direction with the same velocity.
d. Rotating the magnet around N-S poles constantly.

Figure 2. *Two Example Items From Conceptual Knowledge Test.*

Utility Value of Science: Four Likert-type items were selected from PISA 2006 student questionnaire (OECD, 2006). These items were presented to a science education faculty to establish content validity. After examination of the questions, he stated that items were about a person's perception of science practical value in his/her daily life. Therefore, we named this questionnaire as utility value of science. Turkish translation of the questionnaire was done by the author and an English Language expert from Teaching English as a Second Language

Department edited any vague statement. All the items were in positive direction so if a student selected strongly agree, it was coded as 4 and if he selected strongly disagree, it was coded as 1. We computed Cronbach alpha as .55 (n = 110). Then we examined each items' contribution to the overall alpha. We recognized that an item was not contributing to the scale. After deletion of this item, we computed the alpha as .77 (n = 110). Accordingly, we performed statistical analyses with the remaining 3 items. Statements of these three items can be seen in Table 2.

Table 2. *Utility Value of Science Scale Items*

Advances in broad science and technology usually improve people's living conditions.
Broad science is important for helping us to understand the natural world.
I find that broad science helps me to understand the things around me.

Beliefs on Theory and Data: Leach, Millar, Ryder, & Sere (2000) developed this questionnaire to assess student epistemological beliefs about theory and data. There were 7 pairs of written statements which were about opposing philosophical stances on theory and data. Turkish translation of this questionnaire was done by the author and the English Language expert edited this translation. We coded each pair for representing contemporary view of theory and data or not. Then same categorization was done by a science education faculty. Both coding were consistent. For example "Scientists' theoretical assumptions influence their interpretation of data" was coded as representing contemporary view because it is related to theory-laden nature of science. On the other hand, "Scientists interpret data without being influenced by their theoretical assumptions" was coded as not representing contemporary view. Students were asked which statement they agree with for each pair of statements. If a student agreed with the contemporary view, his/her response was coded as 2 otherwise it was coded as 1. Then we examined internal consistency and found Cronbach's alpha as .52. Then we examined each item for their contribution to the scale. After this examination, we recognized that 3 items were not contributing to the scale. After deleting these items, Cronbach' alpha increased to .64 (n = 110). Thus, we used the remaining 4 items for statistical analyses. These statement pairs can be seen in Table 3.

Table 3. *Statements of Four Item Pairs in the Beliefs on Theory and Data Questionnaire*

The design of an experiment is dependent on theory about the thing that is being investigated.	An experiment is designed to see what happens, and does not depend on theory about the thing that is being investigated
Scientists interpret data without being influenced by their theoretical assumptions.	Scientists' theoretical assumptions influence their interpretation of data.
Scientists' ideas and theories influence their planning of data collection in experiments.	Scientists' put their ideas and theories to one side when they are planning data collection in experiments.
Scientists plan their data analysis based on the ideas and theories that they had when designing the experiment.	Scientists plan their data analysis without reference to the theories that they may have had when designing the experiment.

Views on Student-Centered Teaching: Four Likert-type items were selected from PISA 2006 student questionnaire (OECD, 2006) for examination of student views on student-centered teaching in their science classes. A science education faculty was also asked to examine items for content validity. He stated that items were assessing students' perception of science teaching in their science classes. We translated the items into Turkish and the English Language expert edited any vague statement. Meaning of each item was in positive direction.

Therefore we coded 4 for a response of in all lessons and 1 for a response of never or hardly ever. Internal consistency of Cronbach's alpha yielded to a score of .58 (n = 110). Each item in this questionnaire was contributing to the scale. Items in this scale can be seen in Table 4.

Table 4. *Items in the Views on Student-Centered Teaching Scale*

Students are given opportunities to explain their ideas.
Students spend time in the laboratory doing practical experiments.
Students are required to design how a school science question could be investigated in the laboratory.
The students are asked to apply a school science concept to everyday problems.

Data Analyses

For the first research question, we performed analysis of covariance (ANCOVA) on post conceptual knowledge scores of experimental and control groups. We checked normality, linearity of covariate over dependent variable and homogeneity of regression slopes assumptions for ANCOVA. Shapiro Wilk test showed post conceptual knowledge scores were normally distributed in experimental and control groups (W = .95, $p > .05$; W = .94, $p > .05$ respectively). Then we computed Pearson product-moment correlations between covariate and post conceptual knowledge scores. Result showed that there was a significant relationship between two variables (r = .24, $p < .05$). From this result, we concluded that linearity assumption was met. Finally we computed the *F* statistic for examining the homogeneity of regression slopes assumption. Result showed that this assumption was also met ($F_{(1, 77)} = 3.29$; $p > .05$).

Then, we performed ANOVA on post conceptual knowledge scores to examine any differences among the experimental, control, and comparison groups. We checked normality and homogeneity of variances assumptions. As reported previously, post conceptual knowledge scores were normally distributed in the former two groups. Result of the Shapiro Wilk test also showed this was the case for the comparison group (W = .94, $p > .05$). We examined Levene's statistic for homogeneity of variances assumption. Result showed that groups' variances for this variable were not same ($F_{(2, 107)} = 8.32$, $p < .001$). However, Lindman (1974) stated that F statistic is robust against the violation of homogeneity of variances assumption.

For the second and third research questions, we examined normality assumption for the remaining dependent variables. Results of the Shapiro Wilk tests showed that utility value of science scores were not normally distributed over the control, experimental, and comparison groups (W = .90, $p < .01$; W = .87, $p < .001$; W = .80, $p < .001$, respectively). Similar results were obtained for beliefs on theory and data scores (W = .78, $p < .001$; W = .85, $p < .001$; W = .81, $p < .001$, respectively). Finally, Shapiro-Wilk test showed while views on student centered teaching scores were normality distributed in comparison group (W = .95, $p > .05$), they were not normally distributed in control and experimental groups (W = .89, $p < .01$; W = .92, $p < .01$, respectively). Therefore, we used non-parametric tests to compare control, experimental, and comparison groups for these three dependent variables.

FINDINGS

Conceptual Knowledge Difference between Groups after Instruction

Means and standard deviations of pre and post conceptual knowledge scores of the three groups can be seen in Table 5. We performed ANCOVA for comparing post conceptual knowledge scores of low-SES students in the control group and low-SES students in the experimental group. Students' initial conceptual knowledge scores were the covariate in this analysis. Result of the ANCOVA showed that experimental group outperformed the control group controlling over initial conceptual knowledge scores ($F_{(1, 78)} = 35.21$; p < .001).

Table 5. *Descriptive Statistics of Groups' Conceptual Knowledge before and after Instruction*

		Pre Conceptual Knowledge		Post Conceptual Knowledge	
	n	M	SD	M	SD
Low-SES Students in Experimental Group	46	6.73	2.23	11.93	1.87
Low-SES Students in Control Group	35	6.17	1.20	8.40	3.24
High-SES Students in Comparison Group	29			12.31	3.01

Then we performed ANOVA to compare posttest conceptual knowledge scores of experimental, control, and comparison groups. The result showed that groups differed on this measure ($F_{(2, 107)} = 22.71$; $p < .001$). Post-hoc comparisons with Sidak adjustment showed that conceptual knowledge scores of low-SES students in the experimental group and high-SES students in the comparison group were similar ($p > .05$). On the other hand, high-SES students in the comparison group scored higher than low-SES students in the control group ($p < .001$).

Utility Value of Science and Beliefs on Theory and Data Difference between Groups after Instruction

For comparing groups' rank on utility value of science scores, we performed Kruskal-Wallis test. Then we did Mann-Whitney U-test to compare pairs of groups. Result of the Kruskal-Wallis test showed that groups differed on this measure, H = 65.85 (2, N = 110), $p < .001$. Mann-Whitney U-test's result showed high-SES students in the comparison group (Median = 11) outperformed low-SES students in the control group (Median = 7, U = 36.50, $p < .001$). In addition, low-SES students in the experimental group (Median = 10) outperformed low-SES students in the control group (U = 42, $p < .001$). However, no significant difference was observed between low-SES students in the experimental group and high-SES students in the comparison group (U = 508, $p > .05$).

Same analyses were performed for beliefs on theory and data scores. Kruskal-Wallis test result demonstrated groups' ranks were significantly different from each other H = 36.66 (2, N = 110), $p < .001$. Results related to Mann-Whitney U-tests showed low-SES students in the experimental group (Median = 6) scored higher than low-SES students in the control group (Median = 5, U = 471, $p < .01$), high-SES students in the comparison group (Median = 7) scored higher than low-SES students in the control group (U = 78, $p < .001$), and low-SES students in the experimental group (U = 359.5, $p < .01$).

Views on Student-Centered Teaching Difference between Groups after Instruction

Similarly we performed Kruskal-Wallis and then Mann-Whitney U-tests for views on student-centered teaching scores. Result of the Kruskal-Wallis test showed groups differed on this measure H = 18.57 (2, N = 110), $p < .001$. Mann-Whitney U-tests' results showed low-SES students in the experimental group (Median = 10) scored higher than low-SES students in the control group (Median = 8, U = 516, $p < .01$) but not high-SES students in the comparison group (Median = 12, U = 505.50, $p > .05$). Furthermore high-SES students in the comparison group scored higher than low-SES students in the control group (U = 191.50, $p < .001$).

To gain more insight on these differences, we performed separate Mann-Whitney U-tests on views on student-centered teaching items to compare low-SES students' views in the experimental group with that of low-SES students in the control and high-SES students in the comparison groups. Results showed low-SES students in the experimental group (Median = 4) scored higher than low-SES students in the control group on item 1 (Median = 2, U = 370.50, $p < .001$) and item 4 ($Median_{exp} = 3$, $Median_{cont} = 2$, U = 536.00, $p < .01$). More clearly, items 1 and 4 were about if students find chances to explain their ideas and if they find chances to apply school science to everyday problems in science classes respectively. However, no difference between these groups was found for item 2 ($Median_{exp} = 1.5$, $Median_{cont} = 1$, U = 728.50, $p > .05$) and 3 ($Median_{exp} = 1$, $Median_{cont} = 1$, U = 789.50, $p > .05$). Specifically, items 2 and 3 were about if students do practical experiments and if they investigate school science questions in their science labs respectively. Furthermore, results showed low-SES students in the experimental group (Median = 4) scored higher than high-SES students in the comparison group on item 1 (Median = 3, U = 497.00, $p < .05$). However, high-SES students in the comparison group outperformed low-SES students in the experimental group on item 2 ($Median_{exp} = 1.5$, $Median_{comp} = 2$, U = 412.50, $p < .01$) and 3 ($Median_{exp} = 1$, $Median_{comp} = 2$, U = 386.50, $p < .01$). On the other hand, no difference between these groups was observed for item 4 ($Median_{exp} = 3$, $Median_{comp} = 3$, U = 634.00, $p > .05$).

DISCUSSION

Our main aim in this study was to examine if argumentation instruction helps to achieve equity in science learning for different SES students attending low and high performing schools. For this aim, we formed experimental group consisting of low-SES students in a disadvantaged school who were taught science by argumentation, control group consisting of low-SES students in the same school and comparison group with high-SES students in an advantaged school who were not taught science by argumentation. Then we compared these groups' conceptual knowledge, utility value of science, views on theory and data, and views on student-centered teaching after instruction.

Our results suggest that low-SES students in the experimental group outperformed low-SES students in the control group on all of the measures. Furthermore, we did not find any difference between low-SES students in the experimental group and high-SES students in the comparison group on conceptual knowledge, utility value of science, and views on student-centered teaching total scores. Moreover, high-SES students in the comparison group outperformed low-SES students in the control group on all measures. These results are encouraging for researchers and educators who are concerned with equity issue among different student groups. More specifically, these results should be interpreted within the context of the gaps between different achievement schools because it is documented that students in high performing schools have more positive attitudes towards science and they understand science topics well conceptually than their peers in low performing schools (Aypay et al., 2007; Ceylan & Akerson, 2014). What our results suggest is then argumentation instruction may help in reducing the gaps between students who have low-SES and attend low achieving schools with their peers who have high-SES and attend high achieving schools. However, it should be kept in mind that method of instruction is only a factor, which we addressed, among others, i.e., student-level, classroom-level, and school-level factors, which contribute science achievement gap between student groups (Acar et al., 2015; Dinçer & Uysal, 2010; Martin et al., 2012). Nevertheless, the results are in alignment with previous research finding that instructional opportunities can compensate other factors that result in achievement gap (Von Secker, 2004; Von Secker & Lissitz, 1999). On the contrary, we found that traditional instruction resulted in science learning gap between low-SES students in low achieving school and high-SES students in high achieving school. Similar to these results, Acar (2015) found that the students who received argumentation instruction in a low achieving school closed conceptual knowledge and scientific reasoning gaps with their peers who received traditional instruction in a high achieving school. However, this study was limited in that it did not pay attention to students' SES. Furthermore, no control group consisting of low-SES students was included in that study. Chen et al. (2013) also found that low-SES students who received argumentation instruction had higher achievement scores than low-SES students who received traditional instruction. However, this study did not take school type into account and make a control group including high-SES students. Addressing these limitations is crucial for the examination of science learning equity because school type and students' SES are influential in explaining students' science achievement (Martin et al., 2012; OECD, 2013). We aimed to address these gaps in the literature. However, science learning gap cannot be limited to students who have different SES and attend schools which differ in science achievement. For instance, studies emphasized that other factors such as gender and race can cause science learning gap (Geier et al., 2008; Johnson, 2009; Wilson et al., 2010). Therefore, our results should be viewed as a part of a continuing endeavor to address science learning equity among different student groups.

Contrary to our expectation, high SES students in the comparison group outperformed low-SES students in the experimental group on beliefs on theory and data. An interpretation of this finding might be that development of low-SES students' beliefs on theory and data may require longer period of instruction. However, Osborne and his colleagues (2013) found no significant change of student epistemological beliefs after two year of argumentation instruction. Therefore, inspired by Sandoval and Morrison (2003), we suggest that nature of science issues should explicitly be taught to students in argumentation instruction to develop their epistemological beliefs.

When we analyzed students' views on student-centered teaching scores at item level, we found that low-SES students in the experimental group outperformed low-students in the control group on items 1 and 4 which were about if students find chances to explain their ideas and if they find chances to apply school science to everyday problems in science classes respectively. However, there was no difference between these groups on items 2 and 3 which were about science laboratory activities. Although students in the experimental group did two of the argumentation activities which were POE experiments, they did these activities in class but not in the lab. Therefore, this result is tolerable from this point of view. Low-SES students in the experimental group also outperformed high-SES students in the comparison group on item 1. This result also confirms that students in the experimental group had more opportunities than other groups for explaining their ideas in argumentation instruction. Although students in the experimental group had chances to apply school science to everyday problems such as how seasons form, and advantages and disadvantages of nuclear energy usage, there was not any difference between low-SES students in the experimental group and high-SES students in the comparison group on item 4. We interpret this result as a consequence of the science instruction that latter group received which had several elements of student-centered teaching. On the other hand, high-SES students in the comparison group outperformed low-SES students in the experimental group on items 2 and 3. This result is not surprising in that former group students frequently used their science lab during the instruction. However, latter group students had rare equipments and supplies in their science lab which was an obstacle for performing science classes in the lab. This result also raises an important problem for achieving equity among students. Achievement of equity would be possible if disadvantaged schools have equal science class and laboratory facilities and equipments with those in advantaged schools (Dincer & Uysal, 2010; Martin et al., 2012). One way to do this can be by clarifying class and laboratory standards nation-wide. Then each school needs can first be determined and then supplied by the use of these standards (Von Secker & Lissitz, 1999).

Limitations

There are several limitations in this study. First, our main aim in this study was to examine if argumentation instruction provides equal learning opportunities to students in a disadvantaged school with their peers in an advantaged school. However, our study may be limited in giving a full spectrum of examining of learning equity because we did not have an experimental group in the advantaged school. Thus, our results regarding learning equity should be interpreted within this limitation. Second, we used two science teachers in the disadvantaged school. We could have used a science teacher who teaches both control and experimental groups in the disadvantaged school to establish the experimental design in this study carefully. On the other hand, our finding regarding similar previous semester science achievement of control and experimental groups suggests that we do not have evidence that these two teachers were different in terms of their pedagogical content knowledge because same teachers had taught these groups in the previous semester before the study took place. Third, the period of professional development course given to the experimental group teacher may be viewed as relatively short according to longer periods of courses implemented in previous argumentation research (e.g., Erduran, Ardac, & Yakmaci-Guzel, 2006; Tümay and Köseoğlu, 2011; Simon, Erduran, & Osborne, 2006). However no time was devoted for training this teacher constructing materials and lesson plans for argumentation activities in the course because these activities were constructed by the author of this study. Therefore, this considerably shorter professional development course time should be evaluated within this context. In fact, there are pioneering studies in argumentation literature with having similar or shorter periods of teacher training and also have observed the effect of argumentation instruction (e.g., Akkus et al., 2007; Zohar & Nemet, 2002). Finally, we do not know each group's initial scores for utility value of science, beliefs on theory and data, and views on student-centered teaching. Therefore, we cannot claim any change for these variables during instruction. Future work is necessary which would assess each group's initial scores on these variables for examining the change from the beginning to the end of the instruction.

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The Reconstruction of Society Indigenous Science into Scientific Knowledge in the Production Process of Palm Sugar

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ABSTRACT

This research was aimed to reconstruct society indigenous science into scientific knowledge in the production process of palm sugar that was conducted on the people of Lendoh Hamlet, Leban Village, Boja Subdistrict, Kendal Regency, Central Java, Indonesia. The outform of this research were numbers of scientific knowledge from the result of society indigenous science reconstruction that was based on Javanese Culture about the production of palm sugar. The expected benefit of this research was to be the contextual educational resource for teacher of science on the school. The method of this research was qualitative descriptive through visceral interview, direct observation and document study about traditional production of palm sugar, and also scientific literature about nira and palm sugar. The research focus was the tradition of palm sugar production especially on knowledge of traditional sugar craftsman related to the raw materials palm nira and palm sugar production process. The obtained data were analyzed, verified, and constructed into scientific knowledge and were interpreted to get meaningful information. The conclusion was that there were five ten indigenous science from the palm sugar production which could be reconstructed into scientific knowledge.

Keywords: Palm sugar, palm nira, contextual learning, society knowledge, scientific knowledge.

INTRODUCTION

The rapid development of knowledge and technology have pushed the development of science education that produce specific formal science or what usually called as Western Modern Science (WMS) which is taught in school. While in traditional society environment, original science (indigenous science) is built in the form of symbolic message, custom and social culture. Indigenous science or traditional knowledge is a heritage knowledge from ancestors. This kind of traditional knowledge is a holistic or comprehensive understanding towards traditional society in daily practice according to their nature interaction live experience during centuries. According to (Duit, 2007), if it is inspected and studied accurately, that original science often contains of various concept, principle or scientific knowledge that have not been formalized. However, most of these traditional knowledge

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have been forgotten and gone because the lack of understanding of conservation and preservation importance of that various traditional knowledge (Halim, Jawan, Ismail, Othman, & Masnin, 2013).

Result of semi-structured interviews collected by (Yavuz Topaloğlu & Balkan Kıyıcı, 2015), from 36 science and technology teachers in the Gölcük district of Kocaeli province in 2011-2012 academic year revealed that the teachers stated that out-of-school learning environments have a positive effect on students' cognitive and affective development. Science learning need to be attempted so that there are balance or harmony between science knowledge itself by investing scientific attitude, also existed and developed local wise values in the society. Science teachers ought to provide students with opportunities to develop their own understanding of nature of science in order to enable them to critically analyze the intertwined relationship between science, technology and society, which is the basic requirement for scientific literacy (İrez & Çakır, 2006). The students not only learn about western (modern) science that has objective, universal, and value-free process characteristic as culture that come from West (Chaudhuri, 2015), but also learn about their own indigenous science that has contextual, ethics and wisdom characteristic which is their cultural heritage from Eastern people (Irzik, 2001) . And if science learning in school does not pay attention to students' culture, the consequence is that students will deny or accept only most of the science concepts developed in the learning. So, the students' social-culture environment seriously need to be paid attention to in developing science knowledge in the school because inside it there is an original science that is useful in their lives.

Science knowledge curriculum is develop from local culture and grows strong nationalism attitude (Michell, Vizina, Augustus, & Sawyer, 2008). In addition (Jegede & Okebukola, 1989) say that the combination of indigenous science with science knowledge in the school actually can increase students' achievement. Local culture exploration is important to understand local knowledge that is integrated in the school, so cross culture approaching is used if science knowledge in the school can be balanced between western science (modern science) and traditional science (indigenous science) ((McKinley & Stewart, 2012) (Mercer, Kelman, Suchet-Pearson, & Lloyd, 2009) . Similar opinion is also stated by (Aikenhead & Elliott, 2010), they state that if modern science harmonically taught in the school along with students' daily life, science learning leanly will strengthen students' perspective about universe and the result is enculturation. If enculturation occurred, students' scientifically way of thinking about daily live will increase. In other word, the success of science learning process in the school highly influenced by the cultural background that students have or the society where the school is placed (Sudarmin, 2014).

Indigenous science as ethno science, that is explained as educational knowledge system which is developed from the local cultural perspective related to the objects classification and activities of natural phenomenon (Rist & Dahdouh-Guebas, 2006). Indigenous Science only explains science and culture that come from cultural traditional supreme values, used to organize the social order of society in order to reach the community advancement both peace creating and people prosperity increasing (Suastra I. , 2005) (Aikenhead & Elliott, 2010) (Cajete, 2000). That culture is still an indigenous ancestors' heritage and has not been influenced by other culture and can be in form of local knowledge, local skill, local aptness, local resources, local social process, local norms and ethics and local customs.

Indigenous science often called as folk knowledge, traditional knowledge, western science or traditional ecological knowledge ((Battiste, 2005) (Duit, 2007). Indigenous science is still in the form of concrete experience knowledge, while scientific knowledge has already in the form of concept, principle, theory or reproducible laws (experimentally tested in laboratory) based on scientific work, has been avowed by scientific community, objective, universal, value-free process and can be responsible (Suastra I. , 2005). The range of indigenous science knowledge includes chemistry, biology, physics, agriculture, ecology, and medical (Battiste, 2005). For medical and medicines, society indigenous science knowledge can be seen in the use of traditional medicine and simplicia production from plants to cure specific disease, Joglo House Philosophy and tobacco planting culture (Sudarmin; Sumarni, W.; Hartono, 2009), traditional therapy system (Winkelman, 2009) (Hollenburg, Zakus, Cook, & Xu, 2008) (Robbins, 2011) for agriculture can be seen on the Sundanesse people's understanding about photosynthesis cycle and plant respiration (Djulia, 2005).

The knowledge of palm nira production into palm sugar is one of the culture that is owned by people of Lendoh, Kendal Subdistrict, Central Java. That production of palm sugar indigenous science contains of values that is full of wisdom and professed by local people all this time have been forgotten in many learning, including science learning. This statement is appropriate to (Suastra I. , 2005) which say that the values full of local genius and profess by original society has been ignored in the learning especially in science learning in the school. In conclusion, science learning become "arid" and lack of meaning for students.

The encountered obstacles, until now there have not been much efforts to discover the production of palm sugar original science potential both content or context of its pedagogic. Indigenous Science usually is only stated orally, according to experience and symbolic, the consequence is the limitation of knowledge delivery through modern model. If this kind of living knowledge in society has not been formalized and reconstructed and become scientific knowledge, it can be used in the learning process as alternative learning resource (Sudarmin; Asyhar, R., 2012). According to thinking framework and background above, the problem inspected is how palm sugar production process doing by people of Lendoh until now has the relation to scientific knowledge concepts?

The purposes of this study are to identify and describe the original science of palm sugar production process which is believed the existence and practiced by people of Lendoh, and to identify scientific knowledge concepts related to palm sugar production process. If the indigenous science of palm sugar production process which live in people of Lendoh and has not been formalized, reconstructed and become scientific knowledge, it can be used in the learning process as contextually alternative learning resource.

It is hoped in the future that by including the local culture aspects into the science learning process, so science learning will drive students to attentively develop their local potential and can get profit for their own life and for their surrounding people's prosperity. The learning process can be started from the learning material that is adapted to local culture, learning method that demands students to be able to combine local culture with learning concept they learn, and various learning media which indirectly can combine local cultural science with the material given in the school.

METHODS

This research was conducted in Lendoh Hamlet, Leban Village, Boja Subdistrict, Kendal Regency by including three traditional palm sugar maker (M_1, M_2, M_3). This location was chosen because this village is occupied only by among 150 families which are categorized as poor family, most livelihood at this village rely on the crop of fields, gardens and forests. One of the occupation that become an old tradition is palm sugar maker. This kind of occupation going so well because there are lots of palm growing wildly both in the gardens or forests. People of Lendoh are used to make palm sugar beside the main occupation as farmers or breeders.

This research used the qualitative research approach through ethno science, a study about knowledge system which organized from culture that is exist in society (Battiste, 2005). In this reconstruction, it focused on the culture of Lendoh's people which were already been organized in their knowledge system and were believed by local society in the long specific time where that knowledge was built according to the geography condition of that place. During the time of collecting the data, researcher directly influenced in many life activities of the palm sugar maker which were observed. Primer data collection technic was through observation, visceral interview, discussion, and direct observation on the field. While, secondary data were achieved by cultural documents study about palm sugar production. In this research, researcher become the main instrument in order to collect data of society original science as many as possible, doing verification, reconstruction, formulation, and conceptualization to become a scientific knowledge. To ensure the criteria of confidence in the data obtained, the researchers made several efforts, among others, (1) conduct research in the field with intensive observations, (2) triangulate the data and methods, (3) provide adequacy of reference, and (4) conduct a study case negative. To increase levels of dependence and the certainty of the results of research conducted by the efforts of a review of all traces of activity of Research and informant review (Suastra I. W., 2010). Data analysis process was conducted continuously and intensively investigated, categorized and then constructed into scientific knowledge. Interpretation of the data is done through discussions with experts who are competent in local culture. After analyzing the data, the study continued to reconstruct the original findings in the form of science in order to develop local culture-based science education in schools.

RESULT AND DISCUSSION

From the observation result and visceral interview towards palm sugar maker, it was obtained an information that the people's knowledge in daily life is a knowledge that came from their own experience and had not been influenced western knowledge or science. Responders' knowledge about the way and system of traditional palm sugar production is a hereditary knowledge from their ancestors.

Figure 1. One of the responder is Mr. Kemadi and his family.

Figure 2. Palm Trees which grow much in Leban Village


Figure 3. Nira Heating Process,


Figure 4. Molding Process


Figure 5. Produced molded-sugar

The result of society original science exploration about palm sugar production that has been reconstructed into scientific knowledge can be seen on Table. 1

Table 1. *Indigenous Science and Scientific knowledge about Palm Sugar Production*

No	Research Question Contains of Scientific Concepts	Indigenous Science	Scientific knowledge
1	What is palm tree?	M_1 , M_2 , M_3 : A tree that can produce KOLING and BADHEG	Aren (*arenga pinnata*) is categorized in family *Arecaceae* (pinang-pinangan), is a **Closed-Seed Plants** (*Angiospermae*). . The Aren Taxonomy as follows: Kingdom : *Plantae* Division : *Magnoliophyta* Class : *Liliopsida* Ordo : *Arecales* Family : *Arecaceae* Genus : *Arenga* Species : *arenga pinnata* (Heyne, 1987) Science concept: types, plants taxonomy
2	What is NIRA (palm juice)?	M_1 , M_2 : Liquid that comes from Palm flower stem, usually called as BADHEG which is the raw material of palm sugar production. M_3 : called as LEGEN	Nira (palm juice) is a transparent **solution/** liquid that is obtained by tapping the aren flower stem. Nira is sugar as the result of **photosynthesis reaction**. In fresh condition, nira has good aroma, sweet taste, relatively transparent to clearly yellow, and the **acidity level (pH)** is almost neutral. Nira liquid is usually tapped from the **masculine flower**, even though the **feminine flower** can also be tapped, but the amount and the quality tapped result of the masculine flower are more satisfying than the female one. Generally, Nira contains high level of sugar, approximately 7,5% until 15%. Main sugar that compose nira is **sucrose,** around 13-17%. Nira also contains of **glucose and fructose**, but in a very little amount. Nira (palm juice) has composition of 88,5% **water** degree, 10,2% sugar degree, 0,23% **Protein**, 0,02% **Fat**, and

			0,03% **ash** content. Source : *www.kebunaren.com/* Science concept : mixture, solution, physical properties, chemical properties, compounds, levels of substance, the male flowers, female flowers
3	What will be done to nira after it is tapped?	M_1 , M_2 , M_3 : It is immediately processed into sugar, because it will be sour if it is left for a long time. M_2, M_3 : if the amount is not sufficient, it can be preserved by way heated to boiling. Once heated, the badheg can hold up to 1 day at room temperature.	This nira liquid which is the raw material of palm sugar must be processed quickly because if it is not quickly processed into sugar, nira liquid will change into tuak beverage or *saguer* that has **ethanol** degree of 4%, it can be seen by the **colour** of nira that changes into turbid yellowish, sour **taste** and stingy **scent** (physic characteristic) Nira detriment process is started by sucrose **inversion process**, the **fermentation process** and it is ended by **oxidation process** that produce **Acetate acid (chemistry process)**. The reaction occurred as follows $C_{12}H_{22}O_{11(aq)} + H_2O_{(l)} \rightarrow C_6H_{12}O_{6(aq)} + C_6H_{12}O_{6(aq)}$ Sucrose glucose fructose In this reaction, it is occurred inversion if nira is less sour or there is **enzyme** β- fructofuranosidasion. $2C_6H_{12}O_{6(aq)} \rightarrow 4CO_{2(g)} + 4C_2H_5OH_{(l)}$ Glucose/fructose ethanol There is fermentation process in this reaction. $4C_2H_5OH_{(aq)} + 4O_{2(g)} \rightarrow 4CH_3COOH_{(aq)} + 4H_2O_{(l)}$ Ethanol acetate acid There is oxidation process in this reaction. Science concepts: acid, fermentation, oxidation, inversion, enzyme, leaven, sugar reduction, monosaccharide, disaccharide, alcohol, acetate acid
4	Why does the sweet nira can turn into sour?	M_1 , M_2 , M_3 : No idea	Fresh nira if it is left will through **fermentation** process because there is **yeast** cells *Saccharomyces tuac*. If that fermentation process is being left continuously, there will be vinegar acid that tastes very sour. **Vinegar acid fermentation or acetate acid** is basically an advanced fermentation product of **alcohol fermentation**. The reaction occurred is **aerob** reaction as follows: $CH_3CH_2OH_{(aq)} + O_{2(g)} \rightarrow CH_3CHO_{(aq)} + H_2O_{(l)}$ Ethanol acetaldehyde $CH_3CHO_{(aq)} + O_{2(g)} \rightarrow CH_3COOH_{(aq)}$ acetaldehyde acetat acid Science concept: aerob bacteria, fermentation, alcohol, vinegar.
5	Is there any chemicals that can be used as preservative to maintain nira quality?	M_1 , M_2 , M_3 : There is a preservative chemicals, but it has not been used yet. .	According to the rule that is attached in the attachment of Agriculture Ministry Regulation Number 133/Permentan/OT.140/12/2013 about a good Palm Cultivation Orientation (*Arengapinnata Merr*) that it should be put some **additive material** before tapping into the saving container, which are the mangosteen stalk peel or coconut husk fiber as much as 10g per saving container to maintain the nira quality (pH of nira is not quickly down), ideal pH is 5,6 – 6,8;. In many places, the farmers add “laru” to prevent fermentation/ as **natural preservative** which is lime, pith pieces of jackfruit wood, young mangosteen or its leaf. The function of this “laru” is not only for preventing nira to be sour, but also for helping sugar **agglomeration process** right after nira is boiled. Science concept: additive material, preservative, sugar

			agglomeration.
6.	What is the effect if broken nira is made into sugar?	M_1 , M_2 , M_3 : Palm sugar cannot be formed in the mold	If broken nira is produced, it will become a brown sugar that cannot be formed or taffy like, although nira can be formed into brown sugar but the result cannot harden on for too long and it will be low quality of brown sugar in the form of soft texture sugar. Sucrose inversion occurs because of high **temperature** and highly alkaline pH (Estiasih, 2009); (Dewi, et al., 2014) Science concept : alkaline, brown sugar
7	Why does nira can be damaged so it cannot be formed into sugar ?	M_1 , M_2 , M_3 : Because it is stated	Nira is broken because the microbe fertilization. Microbe which takes part in sucrose **hydrolysis** process into reducing sugar is the **leaven** group and **bacteria**. This kind of leaven that dominantly desecrate nira are *Saccharomyces cereviceae* and *Monillia* **yeast**. While the kind of bacteria that is dominant are *Enterobacter aerogenes, Leuconostoc mesenteroides* and *Lactobacillus plantarum* (they cause essence like line on nira), *Pseudomonas flourescens, Alcaligenes* and *Flavobacterium* (they cause turbid, hazy and greenish colour), *Micrococeus, Escherichia* and *Acetobacter sp.* (they cause acid). Science concept: leaven, bacteria.
8	How to make the cooking process to be efficient?	M_1 , M_2 , M_3 : Cooking process should use solid firewood/ hardly so it become ashes .	To get efficient cooking process, it must use **high** temperature and stable **heat**. Solid/ hardly firewood is choosen because it become ashes slowly in nira cooking so that there will be high heat and it does not take so much time in cooking. The traditional production of brown sugar has not been accompanied with cooking temperature control, so it can cause over **caramelization** that make the brown sugar has too much dark color. Uncontrolled cooking temperature can damage the sucrose. Science concept: caramelization, temperature, heat.
9	Why in the cooking process of palm sugar sometimes liquid/ forth overflow during boiling?	M_1 , M_2 , M_3 : No idea	When cooking nira, both frying pan and nira water will **expand**. The effect is the frying pan or nira water **volume** will be bigger. However, because the water volume increasing is bigger than the frying pan volume increasing, and liquid essence volume expanding related to **pressure** expanding because of temperature increasing, so the nira liquid still overflow in **boiling**. That process shows that expanding on **liquid essence** is bigger than **solid essence** expanding. Science concepts: essence expanding, essence form.
10	How to solve the overflowing foam/nira water when cooking?	M_1 : By adding coconut oil M_2 , M_3 : By adding coconut oil or scraped coconut, stirring, or by leaving long-handled spoon in the frying pan.	Nira solution is the same as water, when **boiled** the liquid will **overflow**. But the left sugar concentrate and **protein** cause the appearance of thick layer and make the ascended water steam cannot be emerged and stuck. Water steam finally gathered and try to emerge by giving stronger urges so the **foam** sprayed out from the frying pan (**irregular boiling**). Oil addition can be used to get rid of that **irregular boiling**. This is possible by adding oil, the molecule movement will be slower, the pulling energy between the **molecules** will be stronger and the gap between the molecules will be tighter. The consequence is the tinnier essence volume, in other word that essence is decreasing and the previous nira which through the irregular boiling will back to the regular ones. By letting a long-handled spoon in the frying pan, the spoon handle will provide a tunnel that make the steam out to the air

			so it prevent nira foam to spray out of the frying pan. Science concept: foam (koloid), boiling, expanding, steaming.
11	What chemical is added in the nira cooking process?	M_1 , M_2 , M_3 : Only a little amount of oil and scraped coconut when the foam is getting overflowed.	According to literature, there are two kinds of nira cooking which are with the lime addition and without lime addition. Lime addition is used to purify the nira (to omit **organic essence** and **inorganic essence** which is not sugar so it can be obtained maximum and clear degree of sucrose), to obstruct the microbe activity and growing, to arrange nira pH in the level of 6-7 pH. Science concept: organic essence, inorganic essence, oil.
12	Why are there solid and soft kind of brown sugar in the market?	M_1 , M_2 , M_3 : The quality of the sugar is decided by the quality of nira, whether is there any usage of mixture/filler or not.	Sugar quality is decided by sucrose degree that is contained in it. The higher sucrose, the better sugar quality. Non-sucrose components like **fat**, **protein**, sugar reduction, water and **organic material which cannot be fused in the water** that is contained in some kind of formed-sugar will influence the kind of formed-sugar produced, so the formed-sugar can be divided into three types: solid, medium and soft texture. This non-sucrose component will increase the softness of formed-sugar. Fat is estimated takes a crucial part in deciding the sugar softness, because fat molecules that cannot fuse in water form fat globules that were spread between sugar **crystals**. Science concept: essence form, biomolecule.
13	What should be done to prevent the sugar not to fail in the production process?	M_1 , M_2 , M_3 : By adding some sugar in the cooking process.	To fasten the **crystal** form in sugar solution production and to increase the ability that can be **granulated**, it is needed some smooth sugar as **germ/starter**. This crystal core addition usually implement on **Saturated Past Coefficient (SPC)** reaching 1,0 – 1,2. To reach the same level of saturation in all parts, it is needed to stir when the **crystallization** occurred that can be seen from the appearance of white color in the surface of the cook. Or by taking that dense mass example then put it in the water, if it is hardened so that dense is already cooked, and the cooking can be finished. Science concept: crystallization, granulated, starter.
14	What is the characteristic of good palm sugar?	M_1 , M_2 , M_3 : Solid, smooth texture, dry, moldy-free, does not make any impurity when it is disolved.	A good original palm sugar, **organoleptically** can be known with not so soft nor hard characteristic, inner side is not very dry, has bright brown color (evenly spread), has quality according to SNI standardization, does not been mixed white sugar (whitish in the middle part), there is one that is soft and easily broken because it mixed with cassava, there is one with hard texture because it is mixed with coconut dregs. Science concept: organoleptic test, Indonesian National Standardization (INS)
15	Why does palm sugar has a browncolour?	M_1 , M_2 , M_3 : No idea M_1 : because of high heat	Palm sugar has brown reddish color because there is **browning reaction** during the production, both from **Maillard reaction** or **Caramelization**. Caramelization on sugar occur when sucrose solution is heated until the temperature is reached its melted point (> 160^{o}C) so there will be sucrose caramelization that produce brown color. There are three types of caramel, they are **karamelan ($C_{24}H_{36}O_{18}$),, karamelen ($C_{38}H_{50}O_{25}$), dan karamelin ($C_{125}H_{188}O_{80}$)** (De Man, 1998) and each of it has different weight molecule . Maillard reaction occur between amine groups (amino acid) and reducing sugar (**ketones** or its **aldehydes**) form glucosamine. The rate of browning increase fast because temperature increasing and pH is above 6,8. (Damasceno, Fernandes, Magalhães, & Brito, 2008)

			Science concept: browning reaction, Maillard reaction, caramelization, weight molecule, pH, amine, ketone, aldehyde
16	How does the steps to make sugar is durable in storage?	M_1 , M_2 , M_3 : It should keep it in the dry place.	Brown sugar has characteristic that attract water (**hygroscopic**) because contains of high sugar reduction (± 10%) so that cause brown sugar relatively cannot be durable. The damage of brown sugar can occur because the water steam absorption from its environment. Science concept: Hygroscopic, compound, absorption.

From Table 1, it can be seen that palm sugar indigenous science could be reconstructed into scientific knowledge. It was found there were 16 indigenous science that could be explained by scientific knowledge which were divided into 48 science concepts. If this indigenous science will be integrated for example on junior high school's science learning, this traditional palm sugar production culture will at least can be related to 4 Standard Competence that are relevant as it is written on Table 2.

Table 2. *The relation of Palm Sugar Production Culture with Junior High School Science Standard Competence*

No	Standard Competence	Science Concepts of Palm Sugar Production
1	Comprehending essence characteristic, and physical and chemical change on the compound that can be used in daily life (e.g mixture separation)	Name of compound and element Character's difference of element, compound and mixture Physical character and chemicals character Separation based on physical character
2	Comprehending concept of temperature, expanding of heat, heat movement, and its appliance on maintaining the stability of body temperature mechanism on human and animals and also in daily life.	Heat and temperature concept on expanding process of solid and liquid compound Heat and temperature concept on solvent evaporation process.
3	Comprehending the use of chemicals in daily life.	Additive materials in palm sugar production
4.	Knowing energy concept, various energy resources, food energy, energy transformation, respiration, food digestion system and photosynthesis.	Sugar synthesis on aren tree through photosynthesis reaction

If it will be integrated on senior high school's chemistry learning, this traditional palm sugar production culture will be related to some Standard Competence on Table 3.

Table 3. *The relation of Palm Sugar Production Culture with Junior High School Chemistry Core Competence*

No	Standard Competence	Science Concepts of Palm Sugar Production
1	3.10 Applying the rule of IUPAC for name giving of simple organic and inorganic compound.	The name of inorganic and organic compound
2	3.11 Applying the concept of relative mass atom and relative mass molecule, reaction equation, chemistry basic laws, and mole concept to solve chemistry calculation.	Essence level Reaction equation
3	3.1 Analyzing structure and character of hydrocarbon compound based on the	Isomer Hydrocarbon compound classification

	understanding of atom carbon characteristic and compound classification.	
4	3.10 Analyzing the character of solution based on alkali acid concept and/or pH solution.	Alkali acid concept pH solution
5	3.14 Analyzing the use of colloid in life according to its characters.	Dispersion phase and dispersant medium of colloid system The character of colloid solution
6	3.1 Analyzing the cause of solution colligative character phenomenon on steam tension, boiling point increasing, forzen point decreasing and osmosis tension.	Solution colligative character Boiling point increasing
8	3.9 Analyzing structre, names, character and macromolecule classification (polymer, carbohydrate, and protein)	Structure, names, character and macromolecule classification The use of protein, fat, carbohydrate

The analysis result of indigenous science that had been found on traditional palm sugar production in Lendoh village, it was found that Lendoh society indigenous science has still been preserved and it is believed the existence is appropriate if it will be integrated into science learning. This statement is an indicator that indigenous science still being preserve by people then it will be a learning source if it is discovered and have the relation to scientific knowledge. The research result of (Suastra I. W., 2010) state that an appropriate learning source in science learning for students' ability of creative thinking development is natural environment and social culture beside text book/ lesson book, audio visual and internet. .

Why does the people still preserve it? It is because they have seen and experienced the truth by themselves according to life experience (scientific experiment) for years from one generation to the next generation through trial and error process. This indigenous science knowledge was transformed through oral tradition from their parents for the next generation and concrete experience in their environment interacting. During the process of time, it is possible that the new culture come according to the development of technology and science, but the way of thinking (belief) that is a heritage from the previous generation is still preserved.

This invention like was stated by (Suastra I. W., 2010) can be the base of science curriculum reformation based on traditional knowledge (indigenous science) and beliefs that is disseminated in the society. It is expected from the reformation result that it can produce a good quality of syllabus and learning material and care about surrounding culture, which can help student in comprehending science without leaving their source culture in the end.

Natural and social environment are learning source that are exist around the students and can be used by teachers in arranging learning according to learning material given. From natural learning source and social culture, it will be easier for students to relate the material they are learning to their daily life. On the contrary, the better understanding of students about a science concept or principle in the school, the better students' way of thinking about daily life. And vice versa if the students 'understanding of a concept or principle of science at school is better, then the students' ability to think about their daily life will be better anyway. Therefore, the upcoming science learning should be pursued in order to obtain a balance between knowledge of science itself to the cultivation of scientific attitudes, and values of local wisdom and develop in society. Socio-cultural environment of students need to be given serious attention in developing science education in schools because it is integrated pent scientific knowledge that can be useful for life and for the wider community (Suardana, 2010).

CONCLUSIONS

Based on the result of research, it can be concluded that from process of the palm sugar production which is a heritage knowledge from ancestors, there are lots of society science knowledge that can be reconstructed into scientific knowledge which can be the science learning source for students. Thus, in the process of science learning, teachers are expected to pay attention to local culture spread in society and to relate between concepts, process and contexts so science understanding of student about natural phenomenon will be more meaningful and contextual. The process of making palm sugar in Lendoh village, Kendal regency, Central Java, which is the ancestral knowledge can be reconstructed into a science that can be used as a source of science learning for students. Recommended further research on the development of student activity sheet and science teaching materials based on local wisdom in an effort to make science learning resource for students.

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Assessment on How Pre-Service Science Teachers View the Nature of Science

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ABSTRACT

This study presents the results of a pedagogical activity developed with a group of pre-service science teachers from a Brazilian Federal University. The activity was designed so that the pre-service teachers (PSTs) could express their conceptions about the nature of science through several ways of representation by means of drawing, writing, or diagrams. The PSTs were asked to describe their thoughts about five themes: science in human life, the construction of scientific knowledge, the work of a scientist, the relationship between science and technology, and science and society. Our findings brought to light very important points about the nature of science as well as further discussions with the group. Indeed, activities such as the proposed one can lead PSTs to a meta-reflection about their conceptions about the nature of scientific knowledge by aiding them in the construction of new models and strategies for science teaching in their classroom practices.

Keywords: Nature of science, scientific knowledge, teacher training.

INTRODUCTION

While planning educational activities to be developed with their students, natural science teachers generally aim at a specific goal, which is to assist students in understanding the so-called "scientific situations" in chemistry, physics, and biology. These situations correspond to different scientific events happening throughout human history and in different contexts, which make up part of the curriculum's areas of knowledge, for instance, atomic models, the study of force and motion, and the evolution of living beings. However, such knowledge is presented in science textbooks as concepts that are often "ready-made," "finished," and "true." As a matter of fact, if teachers do not think about the nature of scientific knowledge and teach their students solely what is ready-made, they can foster misconceptions about science.

Teachers' beliefs about science as a way of knowing include the understanding of the nature of science. As highlighted by Lederman (2007), understanding of the nature of science

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is a critical point of scientific literacy. Daily behaviors and scientific activities are influenced by people's views of the nature of science.

In the context of this paper, it is important to highlight what is accepted by the authors as views, conceptions, and beliefs. The view refers to a superficial part of the idea, stereotype observed by the individual. The conception is elaborated from the view and the concepts that the individual knows and establishes a relationship between them. Belief corresponds to the deeper, internal level of the individual; it is a representation built by the individual from experience and learning in his or her life and is what he or she supposes to be true.

An understanding of pre-service teachers' (PSTs') conceptions and beliefs about the nature of science is important to improving the actions and activities developed in the PSTs' training courses.

This research is part of an ongoing doctoral thesis, which presents an activity of reflection conducted with a group of 21 PSTs from the Federal University of São Paulo - Diadema in Brazil and is aimed to investigate the PSTs' conceptions about the construction of scientific knowledge, the work of scientists, and the relationship between science and society.

This activity was made part of the main research and the aim was to understand whether activities planned to encourage the explication of thoughts about these issues could favor the understanding of the nature of science by the pre-service science teachers investigated. The activity was applied at the start of an elective subject offered in the science teachers' training course. The information gained from this activity can contribute to an understanding of the PSTs' conceptions about the nature of science. Generally, the data from research that investigates conceptions about the nature of science are obtained from questionnaires and interviews. The activity was intended to obtain the data by encouraging other ways of expression by PSTs, such as drawing or diagrams.

Literature Review

For decades, numerous academic researchers have been debating how views, conceptions, and beliefs about the nature of science, of both students and teachers, may influence educational activities (Abd-El-Khalick, 2001; Abd-El-Khalick & Akerson, 2004, 2009; Abd-El-Khalick & Lederman, 2000; Acevedo Días, 2010; Almeida & Farias, 2011; Harres, 1999; Lederman, 1992; Lederman, 2006; Lederman et al., 2001; Matthews, 1995; Osborne et al., 2003; Sarieddine & Boujaoude, 2014; Rubba & Harkness, 1993; Tobaldini et al., 2011; Torres et al., 2015; Vázquez et al., 2008; Wellington & Lakin, 1994). There is no specific definition for the "nature of science." The understanding about it involves different conceptions regarding the development of science. According to Acevedo Días (2009), some researchers understand nature of science (NOS) as the epistemology of science. Other researchers also emphasize the sociological and psychological aspects of science, with scientific activities and characteristics of the knowledge produced (p. 356). Lederman (1992) indicates that "the nature of science refers to values and assumptions inherent to the development of scientific knowledge" (p. 331).

According to Comas, Clough, and Almazroa (1998),

> [...] the phrase "nature of science" is used to describe the intersection of issues addressed by the philosophy, history, sociology, and psychology of science as they apply to and potentially impact science teaching and learning. As such, the nature of science is a fundamental domain for guiding science educators in accurately portraying science to students. (p.5)

Abd-El-Khalick (2001) asserts that the conceptions of NOS have changed throughout the development of science. The dynamic character of science, the imagination and creativity of those who develop science, and the observations of the scientist influenced by theories present in their minds are important aspects of NOS. The study of NOS, based upon contributions from the history, philosophy, and sociology of science, plays a very important role by which PSTs can deepen their reflections on the management and construction of scientific knowledge. Therefore, preparing PSTs through activities that promote a deep reflection on how science has been built, given its dynamic character, becomes essential to enable such teachers to adequately interpret scientific situations and concepts in their classroom practices so that their students can develop their own networks of meanings.

The activity applied in this study was carried out based on an explicit and reflective approach as reported in the studies of Fouad Abd-El-Khalick and other researchers (Abd-El-Khalick & Lederman, 2000; Khishfe & Abd-El-Khalick, 2002; Abd-El-Khalick & Akerson, 2009) that is aimed at studying the nature of science with PSTs.

According to Abd-El-Khalick and Akerson (2009), the explicit-reflective approach "represents an overarching framework intended to guide instruction about NOS" (p.2163). According to the researchers, the term "explicit" is curricular in nature, and the term "reflective" is instructional in nature. Abd-El-Khalick and Akerson (2009) explain that an "explicit" approach entails planning instructional sequences for teaching NOS in an intentional way, encouraging students to understand NOS, and the "reflective" approach entails giving opportunities designed to encourage learners to examine their science learning experiences from within an epistemological framework. Acevedo Días (2009) asserts that the reflective component in the planned activities can be identified throughout reflective essays written by students or answers to planned questions about NOS. Irez and Çakir (2006), in their study about strategies of teaching NOS, highlighted the following:

> [T]he reflection orientation in science teacher education is characterized by asking students to describe their ideas, beliefs, and values about science teaching and learning and by offering experiences that help them clarify, confront, and possible change in their personal theories. (p. 9)

In this sense and based on a theoretical framework, the activity was aimed at promoting a meta-reflection on the construction of scientific knowledge so that these future teachers could express both their ideas and conceptions about NOS, which will certainly influence and frame their classroom practices.

THE METHODOLOGY OF RESEARCH

The research was carried out in the first semester of 2015 within an elective subject of a science teacher training course at the Federal University of São Paulo, Diadema, São Paulo, Brazil. Such research is part of a university program called "Projeto Zero," which addresses the initial and continuing education of science and mathematics teachers by articulating projects and educational actions aided by researchers from different research areas in order to improve the quality of teaching and teacher education.

In this university and specifically in the science teacher training course, the first two years comprise the basic cycle in accordance with general subjects and disciplines in specific educational areas; within these two years, the PTSs select their future area of teaching from among physics, chemistry, biology, and mathematics.

The research is interpretative in nature. The activity recounted in this paper was applied in the initial stage of the elective subject, which presented an exploratory character. The methodology was performed to identify the views of the PSTs about NOS at the start of the research. In the first meeting of the elective subject, the PSTs were asked about various aspects of NOS through different instruments of data collection, of which this activity was made a part.

The sampling

In this phase, 21 pre-service science teachers with ages ranging between 19 and 30 years (mean 24.5) were enrolled in an elective subject. Each individual who voluntarily participated in the study signed a written consent form after receiving information about the study goals.

Data collection

The PSTs were asked to express their conceptions about NOS in several different ways, thus sharing tacit knowledge about it. In this stage of the research, we began by asking participants for their thoughts on five themes: science in human life, the construction of scientific knowledge, the work of a scientist, the relationship between science and technology, and science and society. The PSTs could perform their representation by drawing, diagrams, or even writing in order to preserve each individual's skill.

Our pedagogical activity was designed in accordance with previous studies in order to meet the goals of this study, in which we adopted an "explicit" approach, given the sequence of purposely planned activities, for discussions about the construction of scientific knowledge as well as a "reflective" approach so that the PSTs could reflect and analyze (in different ways) their ideas about NOS. We also encouraged them to share those ideas with the other participants. A similar study was carried out by Sevim and Pekbay (2012), in which teaching activities were designed with an explicit and reflective approach to induce insights in PSTs, and, according to the researchers, the results showed that the self-reflections encouraged in the activities promoted an improvement in the views about the nature of science.

Data analysis

The analysis of the results was carried out through content analysis, according to Bardin (2011), by the creation of categories of analysis, which emerged from each proposed theme based upon the responses of the PSTs. It should be noted that such categorization has the subjective views of the study's authors, and it was created from the answers of this specific group. The categorization was based on similar elements in the representations of the PSTs, and they were grouped by common characteristics identified. Thus, the tables were built with categories and the frequencies of answers. These categories represent data that is important to the understanding of the initial PSTs' conceptions about NOS.

FINDINGS

In the first part of the study, 21 pre-service science teachers responded to a questionnaire about their school education backgrounds and academic profiles. Figure 1 shows the type of institution (private or public) that each individual attended for their basic education. Such data suggest different backgrounds in terms of educational levels based upon the number of classes, syllabi, textbooks, and materials used in the classes among other factors conditioned by the educational system adopted by each institution.

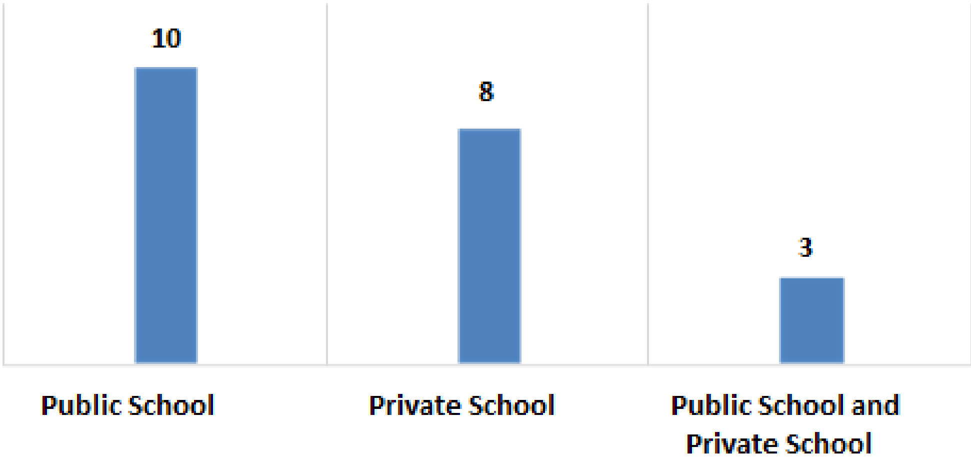

Figure 1. *Training of basic-education teachers.*

Two-thirds of the respondents are in the final stage of the course. The group of PSTs was comprised of five participants in the area of physics, two in chemistry, 13 in biology, and one in mathematics, which brought diversity to the discussions during our study. Two-thirds of the group had never worked as teachers before.

Throughout the activity, the 21 PSTs used more than one form of representation, as follows: three students used drawings and diagrams, five students used diagrams and writing, eight students used drawing and writing, and one student used solely writing, but none of them chose only to draw. Nevertheless, by the end of the activity, they reported that it was quite difficult to perform the activity since they had no “script” to follow, leading them to more deeply reflection on how to express themselves. However, they highlighted a positive side of the activity, which enabled them to express their thoughts on the subject in several different ways. Tables 1–5 show the categories created.

Theme 1 - science in human life

The objective of Theme 1 was to assess the PSTs views concerning the role of science in human life. The frequency of responses shown in Table 1 indicates that eight PSTs understand that science is aimed at providing benefits for humans.

Table 1. *Categories for Theme 1*

Category	Frequency
Science is everything	4
Science as a way to explain the world	2
Science used for human benefit	8
Science as human development product	5
Other responses	2

Theme 2 - the construction of scientific knowledge

The objective of Theme 2 was to understand the views of PSTs on how scientific knowledge is built. Based upon the frequency of responses shown in Table 2, it is possible to conclude that seven PSTs believe that the construction of knowledge takes place through scientific methods (defined steps and linear sequence of procedures). Conversely, seven other PSTs believe that it takes place by questioning the phenomena of the world around us.

Table 2. *Categories for Theme 2*

Category	Frequency
It occurs by the scientific method.	7
It occurs by questioning the phenomena of the world.	7
It occurs by the interaction between human beings and the world.	4
Other responses	3

Theme 3 - the work of a scientist

The objective of Theme 3 was to identify how PSTs view the work of scientists. The frequency (Table 3) shows five answers as “Scientists make discoveries and prove theories, which is in alignment with the views presented in Theme 2, highlighting the sequential and linear scientific methods.

Table 3. *Categories for Theme 3*

Category	Frequency
Scientists make discoveries and prove theories.	5
Scientists are influenced by the social environment.	2
Scientists study the phenomena of the world around us.	6
Scientists seek for answers.	3
Other responses	5

Theme 4 - the relationship between science and technology

The objective of Theme 4 was to identify the views of PSTs on this matter, given the rapid technological advances currently present in our society due to scientific studies, which affect the daily life of citizens.

Table 4. *Categories for Theme 4*

Category	Frequency
Technology facilitates the study of science.	5
Science produces technology.	8
Science & technology linkages as they depend on one another	4
Other responses	4

Theme 5 - science and society

The objective of Theme 5 was to identify how PSTs view scientists, as they are society members and therefore might be influenced by a variety of factors involving scientific concepts and cultural and social issues.

Table 5. *Categories for Theme 5*

Category	Frequency
Science meets the needs of the society.	11
Science influences the actions of society.	4
Science is the product of society's aspirations.	2
Other responses	4

DISCUSSION

For each proposed theme, PSTs' views are presented herewith along with forms of representation, which were briefly described according to each PST´s response (from PST 1 to PST 21). Some examples of representations were selected and presented as follows.

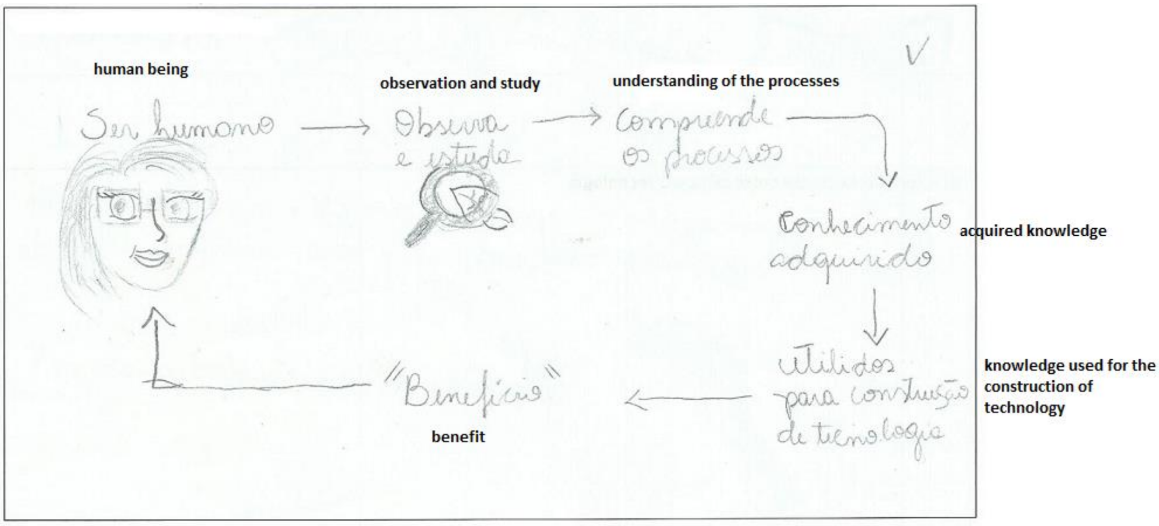

Figure 2. *Response of PST 17 about Theme 1.*

The main idea of Figure 2 is related to knowledge providing benefits to humans. The social values implicit in this representation can be noted. Only two PSTs pointed out that science can explain the phenomena around us (Table 1). On the other hand, five PSTs pointed out that science is the direct result of human development throughout time in accordance with one of the NOS aspects that refers to scientific knowledge as partly the product of human imagination and creativity (Khishfe & Abd-El-Khalick, 2002; Lederman, 2007; Sevim & Pekbay, 2012). The discussion about the limitations and dynamic character of science is important.

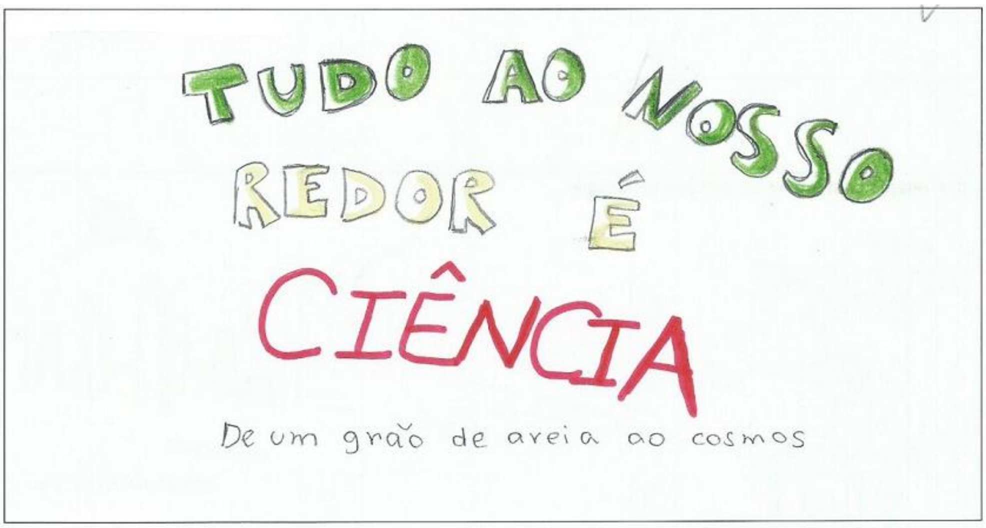

Figure 3. *Response of PST 7 about Theme 1. Legend reads: Everything around us is science, from a grain of sand to the whole universe.*

PST 7 states that he/she believes that everything around us is science without explaining or detailing his/her own views (Figure 3). This implies the importance of sharing ideas and thoughts as well as analyzing other points of view by means of debates and discussions with the other participants because there are different conceptions about the question "What is science?" and the debates can encourage more reflection about it, including, for instance, discussions on the ideas of Karl Popper, who established the criteria to identify science and non-science (contributions of philosophy of science).

Figure 4 shows the sequence of scientific methods, from observing the phenomena to the development of theories. This view of the scientific method as a sequence of pre-established steps was also identified in the study of Sarieddine and Boujaoude (2014), from questionnaires and interviews. In this representation (Figure 4), it can be noted that the role of experimentation is essential for a theory to be accepted or discounted.

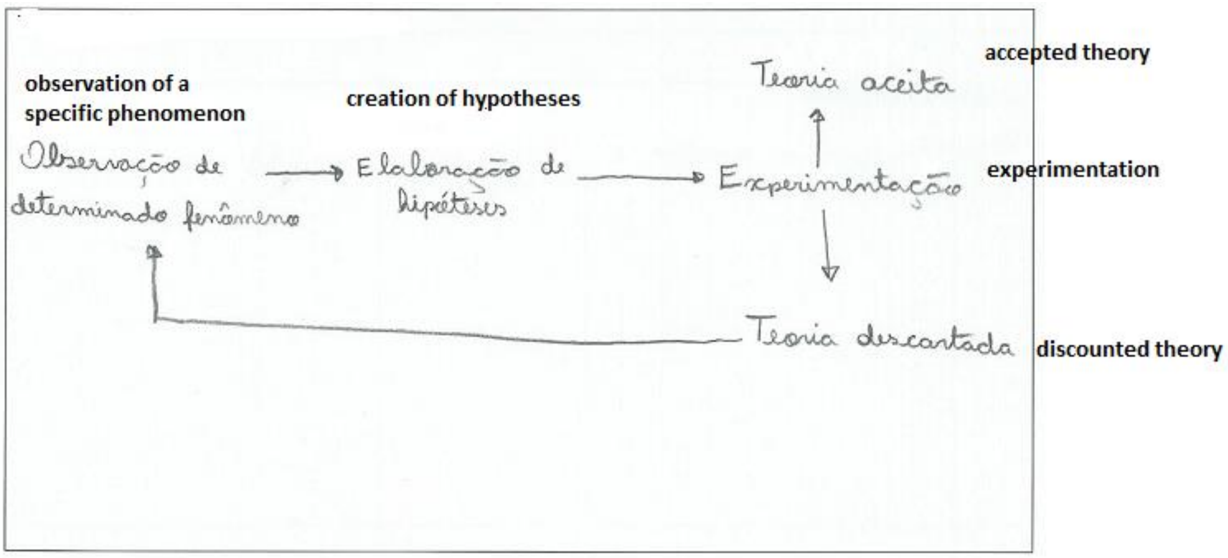

Figure 4. *Response of PST 6 about Theme 2.*

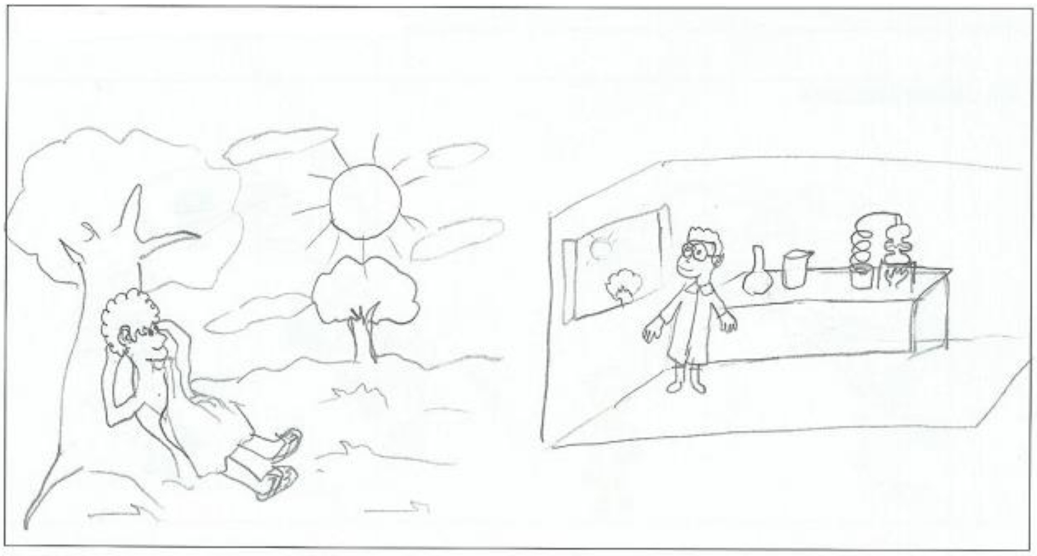

Figure 5. *Response of PST 4 about Theme 2*

This drawing (Figure 5) suggests that the environment interferes with how each human being observes science and scientific situations. When asked what the design was all about, PST 4 reported that the construction of scientific knowledge does not only take place in laboratory facilities. Also, according to PST 4, a certain phenomenon can be explained based on study and reflection.

Figure 6. *Response of PST 17 about Theme 2. Legend reads: to study, to think, to observe, to understand, to behold, to experience, to dedicate, not give up, to respect, to rethink, to be resilient, to dare, to make a mistake, to make a mistake again, to make connections, to pay attention, to make it right, and to have a breakthrough.*

Moreover, the response of PST 17 (Figure 6) expresses the idea of scientists as human beings, subject to making mistakes. It also points out the resilience needed to find ways to understand a certain phenomenon. When asked what the design was all about, PST 17 reported that scientific work is full of mistakes, which are not “bad” but rather “necessary” to obtain the scientific knowledge we currently have. Furthermore, many scientific theories dating from other periods in history were discredited, probably due to the “poor” technology available in such periods.

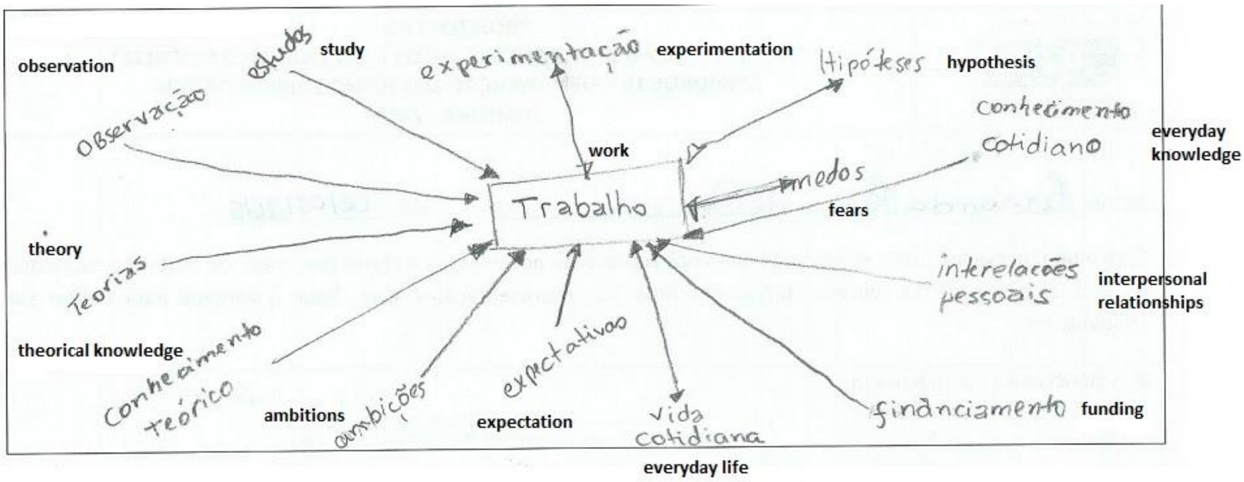

Figure 7. *Response of PST 9 about Theme 3.*

Based upon the illustrated response seen in Figure 7, PST 9 shows the influence of the social environment on the work of scientists, showing important factors that exert this influence, such as the study, theories, expectations, and personal and interpersonal relations as well as research funding, which play an important role in the continuity of scientific work. Vázquez et al. (2007) argued that science arose in society and scientists share uses, values and established interpersonal relationships with each other. In this sense, science is a human enterprise. This issues can be discussed from the contributions of history and the sociology of science.

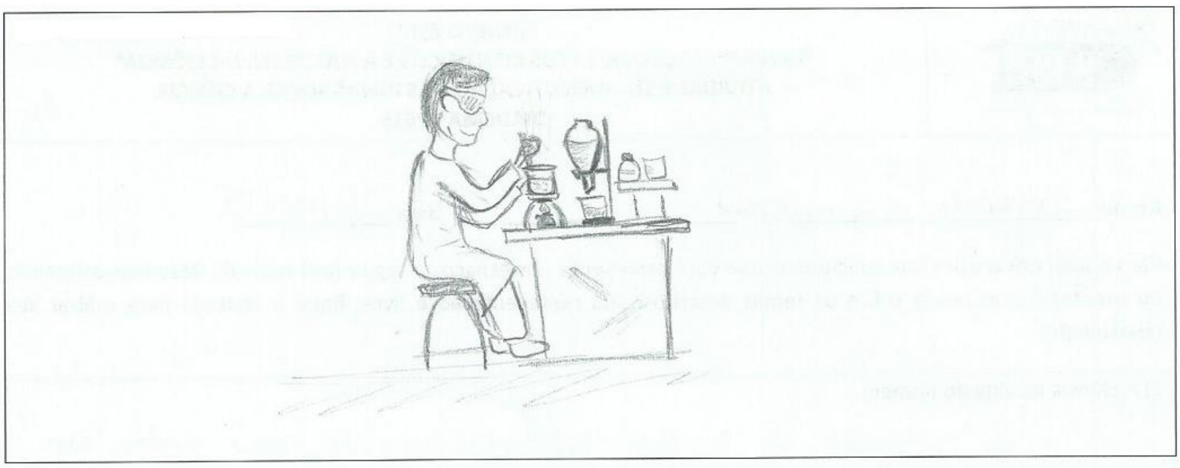

Figure 8. *Response of PST 16 about Theme 3*

The response shown in Figure 8 suggests that the work of scientists takes place within laboratory facilities. This kind of representation is quite common in other studies dealing with the same subject, such as Kosminsky and Giordan (2002) and Zanon and Machado (2013). Similar designs also appear in other parts of the world, such as the study of pre-service Israeli teachers by Koren and Bar (2009), in which data collection for image analysis of PSTs' views about the scientists and their scientific work are based on drawings. Likewise, in our study, scientists are generally represented within laboratories.

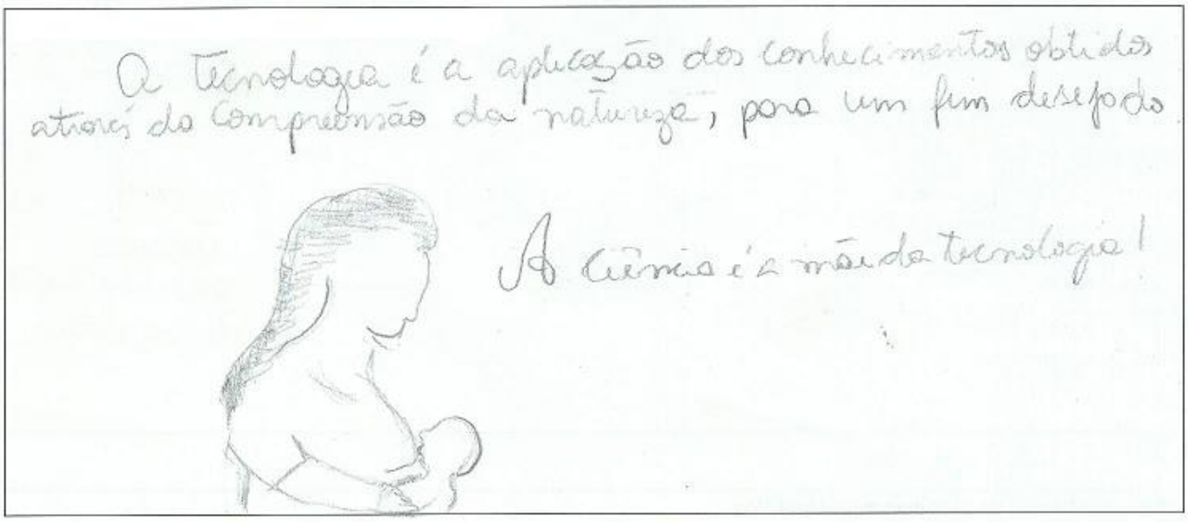

Figure 9. *Response of PST 17 about Theme 4. Legend reads: Technology is the application of knowledge obtained through the understanding of nature for the desired end-use. Science is the mother of technology!*

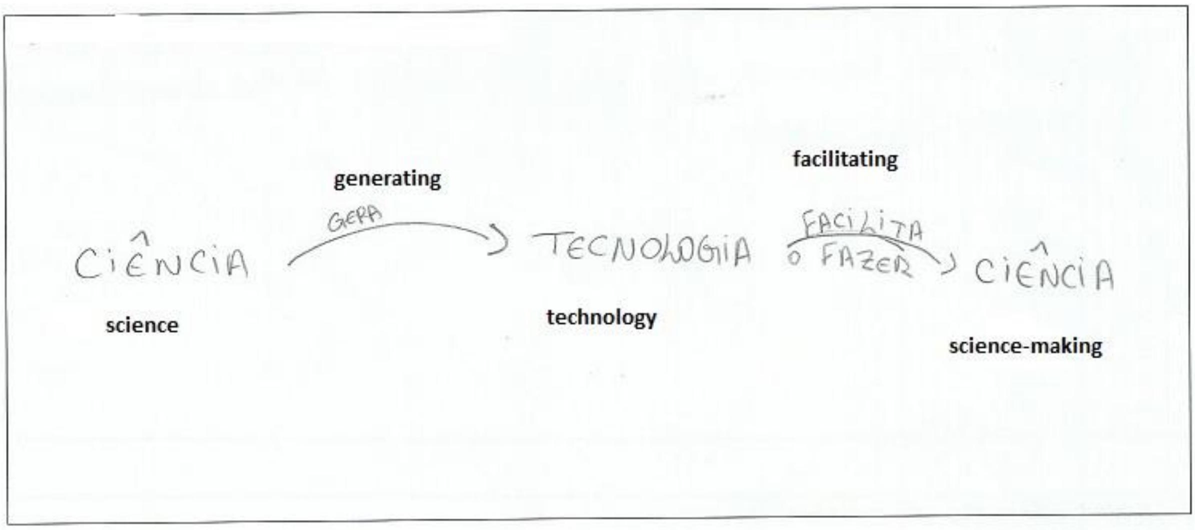

Figure 10. *Response of PST 21 about Theme 4.*

Both the responses of PST 17 (Figure 9) and PST 21 (Figure 10) suggest that technology has arisen from science. Thirteen PSTs understand that science produces technology, as technology facilitates scientific studies. In fact, this view may have been influenced by textbooks, which often feature technology as an application of the knowledge produced by science. According to Ferreira-Gáuchia, Vilches, and Gil Pérez (2012), throughout history, the advances in technology did not necessarily mean that technology had ties to science since the technology has existed for much longer than science. For instance, the Early Stone Age includes the most basic stone toolkits made by early humans, perhaps based solely on observation without any scientific knowledge. This idea rules out the concept of technology as a byproduct of science. Moreover, according to Ferreira-Gáuchia, Vilches, and Gil Pérez (2012), it is quite important that more recently, science has become dependent on technology to build its body of knowledge in such a way that we can call it “techno-science” (Ferreira-Gáuchia et al., 2012). Indeed, technology evolves and develops new tools rapidly and efficiently, whereas science uses them to build new knowledge.

Regarding Theme 5, all participants chose to respond by the written method. The frequencies shown on Table 5 indicate that more than half of the PSTs understand that science meets the needs of society. Examples of responses:

PT 12: *Science should focus on benefits for society and seek for improvements, greater good solutions, and lower social impact.*

PT 1: *Science is to serve society through discoveries and help in understanding the laws of nature*.

Again, it can be seen that science is expected to be useful for society according to the described answers. However, the essential role of science is not only to produce benefits for society but also to provide knowledge and accessible explanations for the phenomena observed by human beings. As a matter of fact, society itself is not always in complete agreement with science. Further discussions regarding this issue are required in order to facilitate the formation of pre-service teachers' pedagogical competence.

CONCLUSIONS AND SUGGESTIONS

There is no single way of thinking about science and discussion about different views on science with PSTs is important. The study of the nature of science, by means of knowledge of history, philosophy, and sociology of science, offers relevant contributions to the understanding of the construction of scientific knowledge. The activity, developed in an explicit and reflective approach, contributed to encourage reflection about this issue by the PSTs investigated.

Throughout this pedagogical activity, the 21 pre-service science teachers expressed their thoughts and views about science and its construction. At the end of the activity, the PSTs were asked to share their impressions and feelings. The group reported that the activity itself was much more difficult than answering the questions on their views about science since they had no “script” or “rule” to follow but were just told to express their thoughts, beliefs, and values regarding the five proposed themes.

On the other hand, their speeches corroborated that the activity was quite productive and successful since they were able to show their views in several different ways besides simply writing, which will certainly aid these PSTs in their classroom practices. Our findings suggest that the PSTs made an effort to organize their thoughts and views about the nature of science, which promoted a meta-reflection on their own ideas about such issues. Consequently, the activity showed an explicit and reflective approach as discussed in the methodology.

It is important to mention that there was no interference of any kind by the researchers while the activity was carried out. The answers to the questions expressed the initial ideas of the PSTs and were an important model of their views about science. This was not the only tool used to understand the views of the pre-service teachers, but from it, important points have arisen for the next steps of the study. Activities such as this may promote opportunities for reflection on the issues involving the nature of science and can be used for debates and discussions within basic-education teacher training.

Finally, our results showed the ongoing need for further studies and activities, such as the proposed herewith, within natural science graduation courses, based upon the engagement of the PSTs who performed the activity. As it is an important field of research, we suggest the establishment of study groups within universities for discussions about the nature of science in order to enhance pre-service teachers` training as well as in-service teachers' continuous formation.

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