Improving Deaf and Hard of Hearing Students' Achievements Using STS Approach: A Literature Review

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ABSTRACT

Science for all indicates that science should be accessible to all learners including deaf and hard of hearing (DHH) students, but they tend to struggle with developing abstract concepts of science optimally. Science, Technology, and Society (STS) approach is an interdisciplinary approach to science learning which is integrating science with technology and society aspects. Through STS approach, students become more interested in learning abstract concepts of science because they can apply the concepts throughout their daily living. The purpose of this study was to investigate whether DHH students improve their achievement levels of science specifically in the aspects of cognitive and affective via STS approach. A total of five journal articles from 2008-2016 written in English on the topic of science learning using STS approach were reviewed. This literature was collected via ERIC database. Then they were analyzed and interpreted in accordance with the objectives of the study. Based on the literature reviews, students experiencing STS instruction improve their achievements according to five STS domains in science learning. Due to learning via STS approach, students not only memorize the science concepts, but also enable to analyze scientific information as well as to apply it in their real-life situations, and set them on a path of life-long learning in science.

Keywords: Achievements; Science Learning; Deaf and Hard-of-Hearing; STS Approach

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INTRODUCTION

Science refers to a systematic process of acquiring knowledge. It is the most important subject that is taught in schools (Akram, Mehboob, Ajaz, & Bashir 2013). Science gives satisfaction and answers to questions arising in the learners' minds and it helps to adjust them to their environment. It enables to facilitate us to think about our self and others and how to relate the world around us. Science could develop as a result of an interaction between technology as the application of theoretical knowledge and requirements created by social needs (Yörük, Morgil, & Seçken, 2010). Development of science is always related to society (social and natural environment) and associated with the development of technology. Science, Technology, and Society (STS) is an interdisciplinary field of study (Mansour, 2009) by connecting science and technology related to its use in the community (Pudjiadi, 2010 in Muzari, 2015). Based on Aikenhead (1994) in Yörük (2010) the aims of STS are to enable individuals to understand science better, to encourage students with creativity and critical thinking, and to make boring and abstract topics more interesting and fun. STS emphasizes the importance of human experiences and personal involvement for real learning to occur (Yager, 1992); the learning process using STS approach provides students to learn concepts in science and connections science concepts with their daily life.

In Science for All, there should be concepts and approaches that contribute to different dimensions of science education (UNESCO, 2010). It indicates that science should be accessible to all learners including special needs children. Deaf and hard of hearing (DHH) students, one type of special need children who have limitation to obtain information through their hearing sense need special methods to fulfill their rights in education. Haenudin (2013) mentioned the low learning achievements of children with hearing impairment does not come from their low cognitive abilities. Instead, their learning difficulties are due to the cognitive aspects that did not receive a chance to develop optimally. Roald and Mikalsen (2000) showed that younger deaf children who are deaf have conceptions of scientific facts similar to those of their hearing peers. However, the scientific knowledge of deaf high school students tends to deviate significantly from hearing students. Those differences follow, at least in part, from deaf students' lack of experience with scientific reasoning and the mental models necessary for understanding and integrating new scientific facts (Hammer, 1996 in Akram et al., 2013).

Science education should help students in developing an understanding and habits of thinking, which is needed to solve problems in life (Mundilarto, 2002). DHH students need appropriate learning strategies that can strengthen learning process through their visual sense to gain information. Chand (2006) in Akram et al. (2013) told that science makes a significant contribution to the learning experiences of deaf children not only in the development of scientific knowledge, concepts and skills but also increase their self-esteem and self-concept. Yager and McCormack (1989) have broadened the view of appropriate science for all learners. There are five STS domains that are important as science for all, such as applications and connections, attitudinal, creativity, process, and concept domain. STS approach provides students to connect the science with technology and society that related to their daily life.

Based on literature reviews of some research publications about STS, STS instruction can develop achievements of the hearing students in accordance with five STS domains. STS approach through experimental activities is important in providing hands-on/ mind-on of science as well as supporting science process skill not only for hearing students but also for DHH students. Based on the study by North Central Regional Educational Laboratory (1995) in Patalano (2015) showed that there was a significant change in the level of categorization by the deaf children through the experimental group. STS approach also provides active learning and focuses on student-centered learning, which is important to provide direct and meaningful experience in science learning. Active learning in scientific topics produced positive results among profoundly deaf secondary school students (Rumjanek et al., 2012; Pinto-Silva, Martins, & Rumjanek, 2013 in Flores & Rumjanek, 2015). STS approach can be applied in the learning process to train and improve deaf students' achievements in science especially in five STS domains (i.e. applications and connections domain, attitude domain, creativity domain, process domain, and concept domain). In this paper, it is assumed that through STS approach, DHH students can optimize their ability to improve their achievements in science learning related to five domains of STS and characteristics of DHH students.

Therefore, the purpose of the current study was to know how STS approach influences both hearing and DHH students' achievements in science learning. Then the research questions in this literature review were:

1. How does STS approach influence hearing students' achievements in science learning?
2. Does STS approach improve DHH students' achievements in science learning?

METHOD

In order to provide an overview of available and convincing research, literature reviews were selected to recent (an arbitrarily chosen 8-year period) peer-reviewed articles published in research journals via the Education Resources Information Centre (ERIC) database, which is by far the most popular and complete indexing system for educational research. Then in order to obtain other resources needed in the current study, this review also used some journal articles that were accessed in Hiroshima University library. Most articles that were not written in English excluded from this review. Five relevant peer-reviewed articles have been chosen in the current study and focused on science, technology, and society (STS) and that effect to hearing students' achievements at the elementary and secondary levels.

Selection of the Articles

Articles selection started by using the website http://www.eric.ed.gov/ for peer-reviewed or journal articles from 2008 to 2016. With titles that contained one or more words of 'science', 'technology', 'society'. At the beginning, a total of 1,874 full texts were available on ERIC fell within these criteria. To limit the search of match articles which were appropriate with keywords, only peer-reviewed research articles were selected. The number of articles was 392 on ERIC database.

At the second screening phase, the corpus articles that were not published in journals specific to science and technology (S&T) education and for which the journal titles had no mention of science (biology, physics, etc.), technology (considered as title keywords), or 'general education' keywords, such as 'learning', 'instruction', or 'teaching' were excluded; for example articles from Higher Education Journal and Teacher College Record. Other articles excluded at this stage were selected based on the abstracts and a quick examination of each article, such as any articles that concerned pre-schoolers or very early elementary students, and post-secondary level; articles that exclusively deal with teacher training (where teachers were the main focus instead of students); and articles exclusively about 'technology' when this label was used to designate information and communication technology (ICT).

At this stage of the selection process of articles or relevant journals, there were no article related STS approach to the 'deaf' and 'hard of hearing' (DHH) criteria. Therefore, the authors focused in accordance with STS approach for normal students, then connected with other journal articles related to the science education for DHH students. Five articles were identified for thorough analysis according to the research questions.

Analysis

The literature reviews were conducted utilizing a best-evidence approach, based on analysis of the five journal articles selected according to the research question. Each article was analyzed by two people and one-verification. In this process, the authors used the same criteria that were mentioned above, according to research questions.

Categorization

Each article was reviewed in light of the developing set of research questions until the entire set of data was treated. We also ensured that each article had the potential to fit into more than one finding (and sometimes many more). For example, some articles show different types of achievements. Therefore, the study divided the results based on five STS domains (i.e. applications and connections domain, attitude domain, creativity domain, process domain, and concept domain).

RESULTS

The General Information of STS Approach

Many definitions of Science, Technology, and Society (STS) are available especially in the area of education. STS uses the constructivist perspective for learning and knowing; its emphasis is on current issues, local situations and personal relevance (Yager & Ackay, 2008). Akcay and Akcay (2015) showed that STS addresses emerging questions about effective strategies for improving students' understanding of the nature of science. Teaching science subjects through STS links would enable students to understand the fact that the topics they learn are not independent of their real lives and can lead them to learn about occupations on science fields (Yörük, Morgil, & Seçken, 2009). Some studies showed that STS instructional approaches have characteristics in student-centered (Yager, Chol, Yager, & Ackay, 2009; Akcay & Akcay, 2015), make students active in the learning process and gain more knowledge. Furthermore, the significance of STS approach provided students with opportunities to engage in real-life, contextualized, and exploratory science experiences. Those opportunities are important to develop students' skills such as argumentation, critical thinking, reasoning and decision-making (Autieri, Amirshokoohi, & Kazempour, 2016).

In summary, STS approach in science education aims to meet the goal of scientific literacy by promoting teaching and learning of science related to the real-life context in society. Thus, the students gain essential science skills and abilities to think critically, make informed decisions, solve problems, work collaboratively, and be technologically efficient (Yager, 2007; Mansour, 2009).

Data Sources that Were Used to Assess STS Approach

STS as the teaching and learning science and technology in the context of human experience (NSTA, 2006) can be applied in the class to improve students' achievements. The five STS domains are found separately in the fifth journal articles; in other words, all articles did not explain all of the five STS domains and the similar findings based on these journal articles were classified. This section provided an overview of the data source and research method, corresponding instruments (when available) that were used in the selected articles. Four of the five articles were using comparison study (Yager & Ackay, 2008; Yörük, Morgil, & Seçken, 2009; Yager, Chol, Yager, & Ackay, 2009; Akcay & Akcay, 2015) to know the effectiveness of STS approach comparing with traditional learning. The other one used literature review to collect the information (Autieri, Amirshokoohi, & Kazempour, 2016).

To assess the students' understanding of science concepts, the studies were utilizing pre-post assessments study (Yager & Ackay, 2008; Yörük, Morgil, & Seçken, 2009; Yager, Chol, Yager, & Ackay, 2009; Akcay & Akcay, 2015) and Assessment Battery for the Concept Domain (ABCD) (Autieri, Amirshokoohi, & Kazempour, 2016). The findings related to applications domain of concepts used in new situations were encouraged and collected routinely by using students' suggestions for analogies (Yager & Ackay, 2008; Yager, Chol, Yager, & Ackay, 2009). The students' attitude toward science learning was checked periodically in connection with material which has resulted in the major examination. Two journal articles (Yager & Ackay, 2008; Yager, Chol, Yager, & Ackay, 2009) used Third Assessment of Science by the National Assessment of Educational Programs (NAEP, 1977); the other used questionnaire Likert-type five point scale strongly agree to strongly disagree (Akcay & Akcay, 2015) to assess students' attitudes toward science in terms of science, science class and science career; and the other one assessed by Attitudes, Preferences, and Understanding Test (Autieri, Amirshokoohi, & Kazempour, 2016). Creativity and interest aspect were observed by research assistants during the lesson (Yager & Ackay, 2008; Yörük, Morgil, & Seçken, 2009; Yager, Chol, Yager, & Ackay, 2009) and creativity test as part of the Iowa Assessment Package (Autieri, Amirshokoohi, & Kazempour, 2016). And the last about the understanding of the scientific processes was assessed utilizing the Welch Science Process Inventory (SPI) (Autieri, Amirshokoohi, & Kazempour, 2016).

Articles Contents about the Existence Links between Effects of Using STS Approach with Hearing Students' Achievements

This question can be answered by reviewing the result of these five research studies. All the results of STS approach showed the positive impact on the students' achievements according to five domains of STS by Yager and McCormack (1989). Major findings indicated that middle school students experiencing the STS approach gained better understanding of natural of science (NOS) and concept mastery (Yörük, Morgil, & Seçken, 2009; Ackay & Ackay, 2015; Autieri, Amirshokoohi, & Kazempour, 2016) and applied science concepts in new situations better than students who studied science in a more traditional way and developed more positive attitudes towards science (Yager & Ackay, 2008; Yager, Chol, Yager, & Ackay, 2009; Autieri, Amirshokoohi, & Kazempour, 2016). Based on Yörük, Morgil and Seçken (2009) STS approach increased students' interests in science learning. Other findings showed that STS approach exhibited better process skills (Yager, Chol, Yager, & Ackay, 2009; Akcay & Akcay, 2015; Autieri, Amirshokoohi, & Kazempour, 2016) and creativity skills (Yager & Ackay, 2008; Yager, Chol, Yager, & Ackay, 2009; Autieri, Amirshokoohi, & Kazempour, 2016).

Articles Contents about the Best Ways to Improve STS Approach

There are many ways to improve STS approach in science learning, such as by improving teachers' conceptions in science and teaching practices (Akcay & Akcay, 2015; Autieri, Amirshokoohi, & Kazempour, 2016) as well as teaching materials related to daily life context (Yörük, Morgil, & Seçken, 2009). Science learning with STS approach can be linked to social issues to include a social science perspective; to focus on careers and practical courses; and to improve many communication skills, including reading, speaking, reporting, and writing (Yager & Ackay, 2008). STS approach provides a meaningful learning experience, moreover by relating the science concepts to the real-world contexts (Yager, Chol, Yager, & Ackay, 2009).

Things that should be done with the STS Approach in Accordance with Education and Science for All

Through STS approach, students can associate the science concepts that they have already known from life experiences into new situations. The STS approach characterizes student-centered instruction (Yager & Ackay, 2008; Yörük, Morgil, & Seçken, 2009; Akcay & Akcay, 2015) and related with real-life problems (Yager & Ackay, 2008; Yörük, Morgil, & Seçken, 2009; Yager, Chol, Yager, & Ackay, 2009; Autieri, Amirshokoohi, & Kazempour, 2016). STS which lead to a more meaningful learning (Yörük, Morgil, & Seçken, 2009; Akcay & Akcay, 2015) could make students noticed to be more willing to participate in social responsibility studies. Such efforts promise to add excitement, new trials, new information, and greater mind engagement among students as more seek to improve science education for the middle years for all students (Yager & Ackay, 2008). Related to science for all students which indicated science education must be fulfilled by all students including deaf students; STS approach can become a strategy in science learning to deaf students so that deaf students can learn the abstract concepts of science more easily with linking it in their daily life.

DISCUSSION

STS Approach Influencing Hearing Students' Achievements in Science Learning

Education mandated that science teaching and learning should bring to the forefront consideration of the impacts of science on society and environment, and include environmental education; topics that are particularly pertinent given the location(s) of the study in logging and mining towns (Steele, 2013). Based on National Science Teachers Association (1993) in Lee (2007), Science–Technology–Society (STS) is defined as the teaching and learning of science-technology in the context of human experience. It implies that with STS related to science education, students recognize the effects of technology in social life. It is more important for students to learn how they could acquire and use knowledge rather than memorizing it directly. Therefore, they should be aware of how science courses they take at school could be related to technology and society in terms of their uses.

The view of students in the STS approach is very different from what it is in traditional teaching. In traditional teaching, the teacher decides which topics to include, in what sequence, and in what ways. The teacher is the authority and students are the passive recipients. Conversely, students are central in the STS approach, which is congruent with the philosophy recommended for most middle schools (Yager & Ackay, 2008). Based on their own questions, students view their previous understanding of the problem and suggest possible explanations based upon their initial conceptions and experiences. This makes science more meaningful, exciting, and appropriate to the real life.

Yager and McCormack (1989) have identified five STS domains that are important as science for all (i.e. applications and connections domain, attitude domain, creativity domain, process domain, and concept domain). Based on a literature review of five journal articles, through STS approach students could gain a better understanding of nature of science (NOS) and concept mastery (Yörük, Morgil, & Seçken, 2009; Akcay & Akcay, 2015) it was accordance with concept domain of STS. In other findings, it was shown that students experiencing with STS-vision could apply science concepts in new situations better than students who studied science in a more traditional way (Yager & Ackay, 2008; Yager, Chol, Yager, & Ackay, 2009; Autieri, Amirshokoohi, & Kazempour, 2016), in this result section, it mainly involved the applications and connections domain. The other findings accordance with the attitude domain showed that STS approach could develop more positive attitudes towards science (Yager & Ackay, 2008; Yager, Chol, Yager, & Ackay, 2009; Autieri, Amirshokoohi, & Kazempour, 2016) and increase interest in science (Yörük, Morgil, & Seçken, 2009). Then the process domain of STS which was achieved by students exhibited better process skill (Yager, Chol, Yager, & Ackay, 2009; Akcay & Akcay, 2015; Autieri, Amirshokoohi, & Kazempour, 2016) and the last is the creativity domain, which was shown with better creativity skills (Yager & Ackay, 2008; Yager, Chol, Yager, & Ackay, 2009; Autieri, Amirshokoohi, & Kazempour, 2016) by using STS approach in science learning.

Based on the findings of the five journal articles, the STS approach could reach the five domains. However, in the all of five articles, the implementations were still limited to normal students of high grade of elementary school and middle school level. Based on education for all learners, the implementation of education is the right of all students without exception. Moreover, there is science for all students, which shows that all students have equal opportunities in learning science.

STS Approach to Improve DHH Students' Achievements in Science Learning

Nowadays, the development of education has established inclusive schools and special schools that allow students with special needs obtain appropriate educational services. One of the special needs children is deaf and hard of hearing (DHH) students. Erting (2001) explains that deaf students arrive at school without the same background knowledge and linguistic skills as their hearing peer. This often leads to an educational focus on language instruction. Lane-Outlaw (2009) explains that too often deaf education programs focus on teaching a language other than science which is also an important life skill in understanding how science works around us in the world. Without integrating content knowledge and language instruction, deaf students fall further behind in content knowledge (McIntosh, Sulzen, Reeder, & Kidd, 1994). Sunal and Burch (1982) suggest that the deaf education programs build science knowledge on top of teaching language, cognitive and developmental skills (Kurz, Peter, & Brenda, 2015).

There is not much research on science education with deaf students (Mangrubang, 2004; Moores, Jathro, & Creech, 2001). The research that has been conducted related to science education with deaf students, in general, has not looked specifically at science instruction or language use, yet many of the recommendations for future research are highly appreciated include investigating the use of sign language in science instruction (Molander, Pedersen, & Norell, 2001; Roald, 2002; Roald & Mikalsen, 2000). While there have been numerous studies conducted related to reading and language instruction with deaf students, little research has been conducted on deaf students' language, literacy, or instruction in content areas (Lane-Outlaw, 2009). Nevertheless, DHH students need competent interpreters as some of them might choose science as their chosen career (Kurz, Peter, & Brenda, 2015), so it is important to provide suitable science learning to DHH students so they can gain more knowledge according to with their interests and limitations. Researchers, such as Atwater (1996); Aikenhead and Jegede (1998); Lemke, (2000) have emphasized the importance of recognizing how the life world of the learner influences their involvement and understanding of science. Deaf learners need to be guided to see the links between the science that is taught in class and their daily lives (McIntosh et al., 1995). In this way, they will be encouraged to be critical and innovative thinkers and contribute to the world of science. As Lang and Propp (1982) state in Naidoo (2008), *"Overall, the future of science education for deaf learners should look very similar to the future of every other student"*.

Implementation of education for all as a universal human right should get attention to break down barriers for people with special needs (UNESCO, 2015). Students with special needs who have different characteristics have faced many challenges with their ability (Patalano, 2015) specifically to achieve the learning contents in the school. The challenge that emerges now is to carry out appropriate learning based on the needs of the students. It means adapting teaching practices are needed to cater for all (UNESCO, 2015). Educators also need to be aware of cultural characteristics, so that they can plan and implement appropriate instructional strategies and ensure that deaf learners are educated (Naidoo, 2008). With proper treatment, it is possible for deaf students to achieve STS domains such as hearing students. Based on the STS character that can increase the achievements in hearing students, STS can also be applied to improve DHH students' achievements with visual learning characteristics. STS approach characterizes student-centered instruction. STS approach through experimental activities could provide hands-on/ mind-on in science learning, which leads to a more meaningful learning. STS approach related to real-life problems also could make students noticed to be more willing to participate in social responsibility studies. Science learning using STS approach makes science more meaningful, exciting, and appropriate with the real life, so that DHH students can learn the abstract concept of science more easily. With the right approach in science learning, it will reduce the gap in the implementation of science learning both for hearing and DHH students to implement science for all.

Based on the literature review, STS approach can be used as an alternative method in science learning for hearing students, but there is no information related to the use of STS approach for DHH students. Nevertheless, the results of the literature review indicate that the characteristics of the STS approach which connect the concepts of science with technology and society are predicted can improve the DHH students' achievements, it is because STS approach provides five domains that make the science concepts are more real in a life context. Finally, the review remains important to explore in order to provide a framework for further research.

CONCLUSION

The literature review indicates that when students are in more control of the science classrooms and when science concepts and processes are unified and approaches are presented in real-world contexts, students learn more. Using STS approach in science learning, hearing students could gain five domains of STS. They are more creative; they have more positive attitudes about science classes/teacher; they see the usefulness of science in their daily lives, and they are more interested in scientific careers in science and technology.

The findings in this literature review have indicated that STS approach can be used in science learning. This study strongly shows that research on implementation of STS approach in DHH students is highly recommended to be conducted to identify its impacts to students' achievements through science learning.

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