HOW STUDENTS SEE THE ROLE OF SCIENCE AND TECHNOLOGY IN SOLVING HUMANITARIAN AND ENVIRONMENTAL PROBLEMS?

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Abstract: One aspect of scientific and technological literacy is to understanding the impact scientific research as well as existing and emerging technologies will have upon cultural development, as well as the potential and actual consequences these technologies will have upon the environment. Although such goals have been a part of science curricula all around the world, there is a lack of research in how students perceive the relationships between science, technology, society and environment. In this qualitative case study, we investigated how a group of 35 international gifted students–possible future scientists–aged 15 to 19 perceive the role of science in solving the humanitarian and environmental problems humanity is currently facing. Interviewed students recognized both environmental and humanitarian issues. And although many students saw that science and technology plays a big role especially in solving the environmental problems, most of them also discussed the structural causes for problems, as well as the interplay of social, economic, and political forces. Science and technology were discussed mainly from two perspectives. The first was focused on research and science as production of new technologies. The other perspective focused on science as a producer of knowledge. Results show that the interviewed future scientists are able and willing to explore the societal values, beliefs and values that both constrain and promote science and technological developments. If our intent is to produce students with not just adequate skills for coping in a society, but critical citizens and scientists taking part in saving the world, there is a need for science education, which critically considers also the premises of scientific practice.

Keywords: science-technology-society, science education, technology education, education for sustainability

INTRODUCTION

The term scientific and technological literacy has developed into an umbrella term covering most aims of science education, and has become a central educational objective of science and technology education (e.g. Laugksch, 2000). One aspect of scientific and technological literacy is to understanding the impact scientific research as well as existing and emerging technologies will have upon cultural development, as well as the potential and actual consequences these technologies will have upon the environment (e.g. Vesterinen, Manassero-Mas & Vázquez-Alonso, 2014). Although such goals have been a part of science curricula all around the world, there is a lack of research in how students perceive the relationships between science, technology, society and environment. In this qualitative case study, we investigated how a group of 35 international gifted students–possible future scientists–aged 15 to 19 perceive the role of science in solving the humanitarian and environmental problems humanity is currently facing.

BACKGROUND AND DATA COLLECTION

The data for this study was collected from 35 participants of the Millennium Youth Camp held in summer 2013. The participants of the camp were selected through a rigorous, two stage application process (for more details, see Tolppanen & Aksela, 2013), insuring that the students were interested in and talented in science. The interviewed participants came from 21 countries and included 20 boys and 15 girls. As the study sought to describe the variation in students' perceptions on science, an international group of highly motivated, interested and active students was seen as a way to provide rich data to chart the variation, as they were expected to have opinions on the issues in question and be adequately articulate to be interviewed.

The interviews focused on two interconnected main themes of discussion, as well as on several tangential themes. The two main themes were: (i) the biggest problems facing humanity, and (ii) what students had done and do to make the world a better place. Tangential themes included discussion on questions such as:

- Can humanity solve the problems humanity is currently facing?
- Who is responsible for solving the problems?
- How do students contribute to solving these problems?

During the interviews, the interviewers asked clarifying or additional questions until they felt that the main themes were discussed in adequate detail.

The set of questions and themes of discussion went through two rounds of piloting, during which the interview protocol was refined to better support discussion on the main themes. First round with four teacher students and second one with ten gifted upper secondary school students chosen amongst international students in a prestigious upper secondary schools in Finland.

The first analysis of the interviews (see Vesterinen, Tolppanen & Aksela, in press) focused on students' actions towards a more just and sustainable world, as well as their rationalizations for such actions. The analysis showed that students took a wide range of actions, including personally responsible actions, participating in school or community efforts, as well as doing things to prepare for future actions (see Table 1).

The rationalizations included both moral conceptions as well as identity-based conceptions (see Kiwan 2007, 2008). Often mentioned rationalizations included: being responsible or virtuous student, consumer, community member, or citizen; engaging others and inspiring change; as well as self-expression and self-actualization.

Table 1. Description and sample actions for each category of analysis (Vesterinen et al., in press)

	Personally responsible actions	Participatory actions	Preparing for future
Description	Acting responsibly towards the environment or personally helping other people	Organizing or taking part in school and community efforts	Doing things to prepare for future actions towards a better world
Sample actions	Buys ecologically produced food to minimize impact on environment Recycles actively to act as an example for others Lends money for a friend who needs it to study abroad	Organizes an event collecting money for charity organization Mentors fellow students to help them in reaching their potential Volunteers in a community group which cleans nearby beaches	Aspires to do well in school to become a medical doctor who can help the people in her/his community Works to learn the knowledge and skills needed to design more sustainable technology Seeks to acquire new experiences, to be able to write a book persuading others to act more responsibly

ANALYSIS

Transcribed interviews were analyzed in two phases. During the first phase, categories were created from the transcribed interviews using inductive content analysis (see Mayring, 2000; Elo & Kyngäs, 2007). In the second phase, the categories created were organized and assembled to describe the various ideas-about-science and ideas-about-technology students' described while discussing the humanitarian and environmental problems humanity is currently facing. The phase combined both inductive and deductive analysis, as the descriptions were constantly compared to the views presented in the research (see Miles & Huberman, 1994).

RESULTS

Students recognized both environmental issues (e.g. climate change, scarcity of clean water, and mass extinction of species) and humanitarian issues (e.g. poverty, terrorism, corruption and discrimination). Most students saw that people have different roles and responsibilities in solving the problems humanity is facing. Although many students saw that science and technology plays a big role especially in solving the environmental problems, most of them also discussed the structural causes for problems, and the interplay of social, economic, and political forces.

Science and technology were discussed mainly from two perspectives. The first was focused on research and science as production of new technologies. Several students hoped that technological development could alleviate or solve some of the major environmental problems humanity is currently facing (e.g. alleviate climate change by coming up with new renewable ways to produce energy). Technology was not seen as solely beneficial. Few students perceived that many of the problems we face are caused by the technological development, and most new technologies imply risks that need to be considered before they are taken into use (see Excerpt 1).

Excerpt 1 (Interview 11): Girl, 18 years

> Well, as I'm going to be genetic engineer, of course I've got a lot of chances to change something. And working as a genetic engineer means creating some genetically modified organisms and creating new organism, means that you can give them features you want. And this is a tool, which can be used in different ways. And maybe everything powerful in our world may be used in different ways. We have got an example of nuclear power, which can be used in nuclear stations to produce energy, and it can be used to create a nuclear bomb.

Some of the students also acknowledged, that technological progress is influenced by the social, economical and political factors. Gaining benefits from technological solutions require also political changes.

Excerpt 2 (Interview 23): Boy, 17 years

> Most of the developing nations now, their main point is, like boosting economy. So they don't care about the manufacturing process does anything to the environment. They just want to produce, produce and produce. So, yeah, for other problems like hunger problems and food and water scarcity, they can be solved if the first world nations are willing to donate some amount of some to the third world countries. But environmental problems–I think besides money–it's the mentality of people that's supposed to change. Because if you just invest more and more in greener technology, yes it sure does help but then that will be only done by the first world countries who can afford it. The developing nations are struggling to just, are struggling the have the manufacturing processes going.

The other perspective focused on science as a producer of knowledge. Students described how research supports more sustainable future by providing us information about the problems and the feasibility of possible solutions (e.g. understanding about the mass extinction of species and ways to alleviate it). Such knowledge was seen especially important in raising awareness and communicating the imperative for action. As was pointed out in our previous study (see Vesterinen et al., in press), even this role of research was not seen as unproblematic. Few students saw a need for a scientific practice, that would be more vocal in voicing the urgency of the change and use interdisciplinary approaches in solving social and political dimensions of sustainability issues (see Excerpt 3). Studies in sustainability science have also highlighted the need for such approaches for solving the "wicked" nature of sustainability problems (e.g. Jerneck et al., 2011; Thompson & Whyte 2012).

Excerpt 3 (Interview 1): Boy, 17 years

> I think one of the other issues is how we use the renewable resources in a sustainable way. (…) For example science is going, I think, in a negative way in some parts, because they are researching about different topics. They are not considering that the use that we can make of science is not good. So I think that we should work together as teams. (…) Not only team of the same area. We should work together with physics, chemistry, biology, but also philosophy and other social science. I think, it is very important. (…) We should start solving or analyzing the social and political problems.

DISCUSSION AND CONCLUSIONS

The results show that future scientists are interested in moral issues related to science as well as able and willing to explore the societal beliefs and values that both constrain and promote science and technological developments (cf. Jones 2007; Tirri et al. 2012).

In science education, research and development is often presented as a way to produce knowledge and technologies, benefitting both the environment and the society (Vesterinen et al., 2009, 2013). The results of this study suggest that students understand the potential of technology in solving the world's problems. However, as risk is an inherent characteristic of the technological society, presenting technology as exclusively beneficial for human beings is not only naïve, but also manipulative and misleading (Santos, 2008). Furthermore, Hynes (1993) and many others have argued that in order to overcome the environmental challenges that the world is facing, a combination of scientific and technological solutions needs to be combined with societal solutions (e.g. political decisions) and individuals' behavior (e.g. reducing affluence). Therefore, though science education should address the potential of technological innovations, it also needs to present its' limitations, including societal and economic constraints. On a more concrete level, education should bring understanding on how (i) some of the benefits of technological development are lost, as technological development tends to increase affluence (York, Rosa & Dietz, 2002); (ii) the price of a new technologies needs to be competitive in order for it to be adopted; and (iii) political will is needed to subsidies certain new technologies to make make them more competitive. Therefore, as has been highlighted by Stevenson (2007), understanding how governments operate is important in understanding how big of a role new technologies can play in solving environmental problems.

In this study, some of the students seemed to understand the role of such external factors. However, such societal aspects are often lacking in science curricula and textbooks (Vesterinen et al., 2009, 2013). Therefore, to help all students understand the link between technology and society, there is a need to tackle the myth that the development and implementation of technology and science is neutral, value-free, and objective. Based on the results of this study, we argue that discussing the societal and ethical factors affecting research and development could expand students' view of scientific and technological practice, and it's significance. By leaving out the societal and ethical dimensions of research and the impact that existing and emerging technologies will have upon the environment, we dehumanize research. Furthermore, such an approach does not take into consideration the urgency of many of the current environmental problems humanity is facing. If our intent is to produce students with not just adequate skills for coping in a society, but critical citizens and scientists taking part in saving the world, there is a need for science education, which critically considers also the premises of scientific practice.

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