PART 12: STRAND 12

Cultural, Social and Gender Issues in Science and Technology Education

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CONTENTS

SECONDARY STUDENTS' ATTITUDES TOWARDS SCIENCE BASED TECHNOLOGY – AN EXPLORATORY STUDY

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As part of a bi-national cooperation project between industry and Swiss- as well as Austrian secondary schools we explore the students' attitudes towards STEM with a special focus on science based technology. There is a shortage in STEM related professionals and interest of students for STEM careers is low. Our project aims at fostering students' interest in STEM professions by out-of-school visits in industries. We present first results from the ongoing research study based on a student questionnaire. Our data comprises students' attitudes towards science based technology related to value, cost, self-schemata, and socializer's beliefs. Results indicate that attitudes are rather low in general and as expected significantly lower for girls. Best motivational predictors for career interest in science related technology are enjoyment, personal value and a high self-concept in science based technology. In addition, interviews with their four science teachers show that technology is an integrated, but not very prominent part of science instruction.

Keywords: student attitudes, science based technology, secondary school.

INTRODUCTION

There have been many calls for more young people studying STEM related subjects internationally (Kudenko & Gras-Velázquez, 2016). Multiple research studies register a growing decline of pupil's interest in STEM subjects (Becker, 2010; Organisation for Economic Co-operation and Development (OECD), 2006b; Xie & Achen, 2009). All German speaking countries were below the OECD average in PISA 2006 with respect to the general value of science and technology. More than 50% of the students answered that science and technology is not relevant to them. This is problematic since in many European countries the shortage of engineers is growing as many active engineers will retire within the coming years. There is also the problem of a lack of STEM education teachers. Therefore, it is important to raise the interest of students for STEM professions. This is especially urgent for girls (Güdel, 2014; Riegle-Crumb, Moore, & Ramos-Wada, 2011; Robnett & Leaper, 2013). Our research is embedded within a Swiss-Austrian project that aims at developing positive students' attitudes towards science based technology by visiting STEM related industries. Targeted social psychological interventions that focus on certain elements of student motivation have been successfully used in different educational situations (Yeager & Walton, 2011). In a first step, we are interested in the students' attitudes towards science based technology in general. For this purpose, we developed a student questionnaire with items based on the expectancy-value model of Eccles and Wigfield (2002).

THEORY

Often technology is seen, also by teachers, as applied science (Jones, Buntting, & de Vries, 2013). However, this view is too limited (Jones, 2012). It is important that teachers and students develop an understanding of technology and science as two areas that can interact but are also distinct in nature. According to Jones (2012) technology allows people to expand their possibilities and to intervene in the world through the development of products, systems, and environments. This includes the discussion of social aspects, values and ethics in the science classroom. In Swiss secondary schools the subject of technology has not been a prominent feature of the curriculum in the past. The new Swiss curriculum 21 includes technology as part of science with respect to being able to talk about the relevance and the sustainability of technological inventions like, e.g., genetic engineering, electric engines, or communication technologies. Students should also possess the competence of using and understanding everyday tools (hair dryer, loud speaker, LED, etc.). The practical implementation of the new Swiss curriculum is still ongoing. Hence, it is reasonable to assume that Swiss science teachers do not put a lot of emphasis on teaching technology in the secondary classroom yet as this has not been an issue in the earlier curricula. Studies on science teachers' knowledge for teaching technology in German speaking countries do not exist. A current research project by Goreth, Geißel and Rehm (2015) aims at closing this gap. Research has shown that the early years of secondary education are crucial in terms of the impact a teacher can have on students' views of science and careers involving science (Regan & DeWitt, 2015). Therefore, it is important that Swiss secondary school teachers get professional training on how to conduct motivating technology lessons in the science classroom.

Student attitudes toward science are part of the PISA 2006 definition of scientific literacy (Bybee, McCrae, & Laurie, 2009). They underlie an individual's interest in, attention to, and response to science and technology. Career intentions for STEM correlate with general interest in STEM subjects (Kudenko & Gras-Velázquez, 2016). A STEM background like, e.g. the parents working in the STEM field, has a positive influence on the student's self-concept and career choice (Moakler & Kim, 2014; Regan & DeWitt, 2015; Wang & Degol, 2013). Students' attitudes towards science correlate with student outcomes in science and in consequence predict STEM study selection (Guo, Parker, Marsh, & Morin, 2015). These findings suggest that interventions targeting the promotion of academic performance and STEM pathways, should seek to enhance both self-concept and intrinsic value. To do this, utility value interventions, such as identifying personal utility value connections between students' lives and what they are learning in class, have been found to be effective to trigger students' interest and promote academic performance in STEM topics (Aeschlimann, Herzog, & Makarova, 2016; Hulleman & Harackiewicz, 2009). Also out-of-school experiences seem to enhance the students' interest for the STEM field (Henriksen, Jensen, & Sjaastad, 2015).

In investigating motivational attitudes of the students towards science based technology, the present study makes use of the expectancy-value model of Wigfield and Eccles (2002), which explains the achievement related choices by the value a student contributes to a subject and the student's competence beliefs related to that subject (Figure 1). The competence beliefs in turn determine the student's expectation for success.

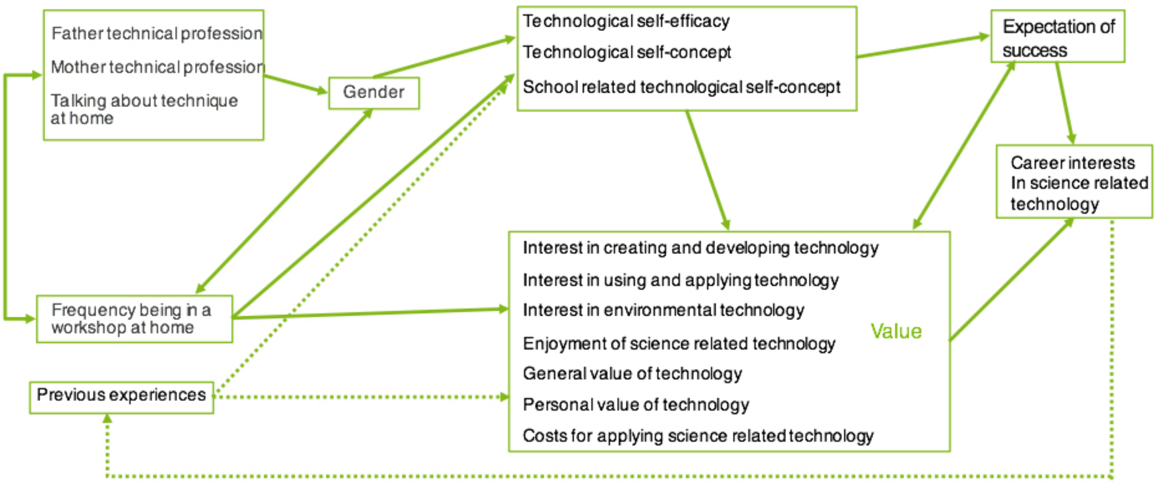

Figure 1. Research model based on Expectancy-Value Model of Eccles & Wigfield (2002). Dotted lines are not analyzed in this research.

Research question

What is the state of the secondary school students' attitudes related to science based technology?

Sub questions

- Do these attitudes correlate?
- Are there gender differences?
- What predicts students' career choice for technology related jobs?
- How do teachers teach science based technology?

METHOD

Design

Our longitudinal mixed-methods research design is embedded within a bi-national STEM implementation project. The Swiss-Austrian project started in 2016 and ends in 2018. Its main aim is to network industry and school and to motivate secondary school students for STEM related subjects. As part of the project, secondary school students in the region of St.Gallen (CH) and Vorarlberg (AT) visit a local company with a STEM background and work on STEM-tasks related to the company's products. The teacher prepares these exchanges and reflects with the students' afterwards. The exchanges will be repeated during the project time.

To evaluate the project, the students fill in questionnaires pre- and post of the implementation phase. In addition, we conduct teacher interviews. In the end, we intend to combine teachers' and students' project experiences in order to understand the effects of the project. However, since we don't have a control group, causal effects will not be identifiable.

Participants

In this paper, a preliminary first sample of Swiss student data is analysed. The sample consists of *N* = 116 students from four secondary school classes of two schools in the Eastern part of Switzerland. The mean age is 13 years (grade 7). All of the classes participated in the project 'STEM becomes a habit in schools'. More participants as well as additional data from Austrian schools are expected in the near future. We interviewed two teachers in each school who are responsible for the science lessons. In each school, we had one female and one male teacher participant.

Instruments

The student questionnaire consists of 85 items on students' attitudes towards mathematics, science based technology, and of some variables related to the students' background, e.g., gender, father/mother's job, importance of technology at home. Our items relate to the expectancy-value model of achievement by Eccles and Wigfield (2002), see Figure 1. Among the scales are three scales which cover the competence dimension of the model: Technology related self-concept and self-efficacy, as well as school related technological self-concept. Another seven scales form the value part of the model: Interest in creating or applying technology, environment-related technology, fun in technology, general and personal value of science based technology and technology related costs. Most of the items were adapted from literature: Items related to costs are adapted from Flake, Barron, Hulleman, McCoach and Welsh (2015) and Kosovich, Hulleman, Barron and Getty (2014), to interest and value from Güdel (2014) and PISA 2006 (Organisation for Economic Co-operation and Development (OECD), 2006a). Another four items asked for the students' future job wishes as in Riegle-Crumb et al. (2011). All items are summarized in scales and checked for reliability (Cronbach Alpha).

Teachers were interviewed with a structured guideline. The coding process followed the structure of the guideline. Accordingly, codes were partly developed deductively, but also as part of the coding process inductively.

Analyses

Statistical analyses (correlations, multiple regression, t-tests) of the student data were conducted with SPSS. For the interview data, we applied computer assisted content analysis (Mayring, 2000). For this paper, we included codes related to the topics relevance, instructional design, subject content and (experimental) material.

RESULTS

In general, the secondary school students' attitudes related to self-concept or value of technology are rather low (Table 1). In addition, it shows that female students have significantly lower values for all scales.

Related to the students' background, it appears that around 50% of the fathers have a technology related occupation while only 9% of the mothers do. Rather unexpectedly, t-tests reveal no significant difference for students' career choice between groups with father or mother having a technological profession or not (mother: t(113) = -1.46, $p = 0.15$; father: t(112) = -1.34, $p = 0.18$). Moreover, there are no such differences for any variable in the research model except for technical self-efficacy, which is higher in the group with father having a technology related occupation (t(112) = 2.11, $p < 0.05$).

Students never or seldom talk about technology or are in workshops at home. Boys are more often in a workshop at home than girls, but both frequent them only rarely (t(110) = 2.95, $p < 0.01$). Students where technology is more often a topic at home and students who are more often in a workshop at home show a higher technological self-concept and a technological career choice is more probable.

All scales from the expectancy-value model related to the students' competence beliefs correlate (Table 1). The same is true for the scales related to value of technology. The competence scales and the value scales also correlate with each other except for general value of technology. Students value technology on a general level but don't feel competent in science related technology at the same time. On a personal level, it is different: the more they feel competent the more they value technology for themselves. The cost scale has a negative relationship to all other scales, meaning the more competent a student feels and the higher the student values technology the less costs the student needs to invest to achieve success in a technology related task.

Table 1. Descriptive statistics and correlations of students' attitudes towards science based technology

	M	SD	1	2	3	4	5	6	7	8	9
1. Technological self-efficacy	3.97	1.05	-								
2. Technological self-concept	3.81	1.01	.51*	-							
3. School related technical self-concept	3.69	.86	.47*	.75*	-						
4. Interest in creating and developing technology	3.56	1.23	.38*	.44*	.47*	-					
5. Interest in using and applying technology	3.35	1.26	.66*	.55*	.51*	.67*	-				
6. Interest in environmental technology	3.59	1.11	.42*	.33*	.39*	.68*	.55*	-			
7. Enjoyment of science related technology	3.43	1.17	.69*	.58*	.52*	.58*	.88*	.51*	-		
8. General value of technology	3.74	.84	.20	.18	.36*	.38*	.37*	.34*	.38*	-	
9. Personal value of technology	3.72	.95	.32*	.50*	.58*	.51*	.56*	.39*	.53*	.44*	-
10. Costs for applying science related technology	3.06	.92	-.46*	-.72*	-.55*	-.44*	-.64*	-.27*	-.63*	-.14	-.45*

Note: $N = 116$; ** $p < .001$. All scales 1-6, α >.80.

Both, competence and value scales also correlate with career choices. Interest of the students for a future job in a technology related branch is however rather low ($M = 3.13$, $SD = 1.14$). As an exploratory research question, we investigated which of variables in our research model (Figure 1) explains the secondary students' career interests for science based technology best.

Based on a multiple regression analysis three predictors which explain 57% of the variance in the students' career interest were identified. These variables are technology related enjoyment, personal value and self-concept (see Table 2). The more a student enjoys technology, e.g., applying technical tools, taking apparatus apart, the higher technology is personally valued and the higher the student's technological self-concept is, the more a student might opt for a technological job.

Table 2. Standardized coefficients for regression model of secondary students' career interests for science based technology

Career interests in science based technology			
	M	*SD*	*β*
Enjoyment of science related technology	3.43	1.17	.34
Personal value of technology	3.72	.95	.37
Technological self-concept	3.81	1.01	.18
N			112
R^2			.57

Note: $N = 116$; all predictors $p < .05$.

Based on the first four teacher interviews it shows that only the two teachers of one school find it important that students discuss the relevance of technical innovations in school, like, e.g. nuclear power or energy saving. Three of the four teachers mention that they think technology lessons should enable the students to gain self-confidence when a device gets broken and they need to fix it. With respect to the content of the technology lessons three teachers indicated separation processes in chemistry lessons. Two teachers of one school refer also to physics (working with electric circuits, functioning of an engine). One teacher says she has no specific lesson goals for science based technology. It was also indicated by one person that lessons with a technology content need a lot of preparation time and require a lot of experimental material. This limits the number of lessons that are spent on science based technology. One teacher also remarks that the new technology related competences in the curriculum 21 have already been part of her lessons so far.

DISCUSSION AND CONCLUSIONS

We expected and obtained low attitudes towards science based technology with a gender effect (Kudenko & Gras-Velázquez, 2016). As in other studies girls tend to have less favourable attitudes than boys towards STEM subjects and they show lower job aspirations in the STEM field (Wang & Degol, 2013). We also detected that science based technology is not yet a prominent topic in science lessons at secondary school in Switzerland. This is however not untypical for other regions as well (Jones, Buntting & de Vries, 2013). Hence, up to now, students who have had no contact with technology at home did not have the chance to develop positive attitudes during adolescence. Therefore, the visits in the industry as part of our project 'STEM becomes a habit in schools' represent a unique opportunity for students to discover undiscovered talent or interest for STEM professions. It is important to pay more attention to educating students about the career opportunities offered by science (Tytler & Osborne, 2012).

After all, students cannot aspire to that which they have never seen. The second wave of our measurements will show whether students have positively changed their attitudes. This might depend on the individual project each local school-industry cooperation has designed.

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