Investigating the mediating and moderating effect of school-related self-efficacy on students' attitudes towards robotics and STEM

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Abstract

There is increased usage of technology and robotics in schools. One of these tools is *educational robotics* (ER), for which the positive learning outcomes are widely confirmed. The present study investigated whether a 6-week educational robotic course impacts secondary school students' (N= 67) school-related self-efficacy (SSE) and whether their SSE influences the relationship between the change in attitudes towards robotics and attitudes towards science technology, engineering, and math (STEM). Furthermore, it was tested whether changes in attitudes towards robotics and STEM are mediated or moderated by SSE. The data were analysed using SPSS, with 'PROCESS macro' as an extension for the mediation and moderation analysis. No significant increase in SSE was found. Nevertheless, SSE partially mediates the relationship between attitudes towards STEM (b = 12.74, p = .004), but does not moderate it. SSE does not mediate nor moderates the effect between attitudes toward robotics. Additionally, there was a significant effect in attitudes towards robotics before and after the intervention, with attitudes towards STEM before (b = .31, p = .047) and attitudes towards STEM after the intervention (b = .46, p = .002) acting as mediators. This implies that students' attitudes toward STEM partially explain the change in attitudes toward robotics. Furthermore, the study found a decrease in attitudes toward robotics, while at the same time, attitudes towards STEM increased. An explanation for the decrease could be the short duration of the robotic lessons (60 minutes). The attitudes towards STEM seemed not to be impacted by this limitation.

Keywords: educational robotics (ER), general self-efficacy, school-related self-efficacy, attitudes towards robotics, attitudes toward STEM

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The goal of schools is to teach students not only how to consume but how to learn, work or even produce technologies. All kinds of technology are more than ever-present in schools and curriculums (Kucuk & Sisman, 2018). Students are surrounded by technology in their school and home environment. That is why the education technology 'educational robotics' (ER) is becoming increasingly popular in schools.

ER provides hands-on learning activities. This active participation leads to a better learning process (Kucuk & Sisman, 2018; Tsai, Wang, Wu & Hsiao, 2021). ER is "a field of study that aims to improve learning experience of people through the creation, implementation, improvement and validation of pedagogical activities, tools [...] and technologies, where robots play an active role and pedagogical methods inform each decision" (Angel-Fernandez & Vincze, 2018, p. 42). ER kits are composed of small plastic pieces that can be used to build robots. Children can create robots using their imagination or following instructions from a guidebook. The robots can be programmed to perform the desired tasks. For that purpose, self-written codes or prepared codes can be utilised. The robots can interact with the environment through different sensors like infrared, touch, and sound (Kucuk & Sisman, 2018). By understanding the impact of the robotic sensors, students learn to manipulate and repair the robot's design to perform the desired actions.

Robotics courses initiate fascination that may also function as motivation for other subjects in school. One of those that have been researched in recent years is STEM. STEM is an acronym standing for Science, Technology, Engineering and Math. Students' STEM education achievement depends on multiple factors, including spatial thinking, personal interest in science, and aspiration for science-related careers. Xie, Fang, and Shauman's (2015) study has shown that beliefs about one's math and science ability predict participation in STEM subjects and careers. Related to beliefs about abilities is a person's self-efficacy, which stresses the importance of finding out about self-efficacy's impact on STEM.

The literature confirms the positive effects of ER on students' attitudes toward STEM (Kandlhofer & Steinbauer, 2016; Kucuk & Sisman, 2020; Yadav et al., 2011). This ranges from improving immediate science, engineering, technology, and mathematical skills to increasing teamwork and problem solving (Kandlhofer & Steinbauer, 2016). Additionally, conceptual understanding, cooperative learning, and critical thinking are enhanced (Atmatzidou & Demetriadis, 2016; Melchior et al., 2005). There is little known about the intervening role of self-efficacy, but it is known that the attitudes towards robotics can be crucial for the attitudes toward STEM (Kucuk & Sisman, 2018). Therefore, this study aims to examine the influence of self-efficacy on the interplay between students' attitudes towards robotics and STEM.

Advantages and Disadvantages of Educational Robotics

As Ioannou and Makridou (2018) summarised, all studies found increased skills in relevant 21st century problem-solving, collaboration, and communication. Furthermore, ER immensely increased computational thinking, an essential skill for the 21st century (Yadav et al., 2011). ER increases students' ability to think creatively and critically and solve real-world problems already in early childhood (Bers, Flannery, Kazakoff & Sullivan, 2014). Bargagna et al. (2019) showed that ER is a valuable tool to facilitate learning for special-need children. ER offers new stimuli and learning opportunities. In their study, ER improved the visuospatial memory and robotics programming skills of children with down-syndrome.

It is suggested that ER can impact students' social skills and school performance. In the study by Kandlhofer and Steinbauer (2016), the connection between social and soft skills and ER was tested and found a positive correlation between programming/robotics and teamwork and problem-solving. A correlation between general programming/robotics and self-efficacy in robotics was found in the same study. An additional finding in many studies was the positive correlation between self-efficacy and educational robotics (Beisser, 2005; Kandlhofer & Steinbauer, 2016; Nugent, Barker, Grandgenett & Adamchuk, 2010). It is known that students with higher self-efficacy, higher teamwork skills, goal orientation, effort regulation and high problem-solving skills have a higher school performance (Bandura, Freeman & Lightsey, 1999; Bouffard, Boisvert, Vezeau & Larouche, 1995; Goltz, Hietapelto, Reinsch & Tyrell, 2008; Ziegler & Opdenakker, 2018).

ER does not only have advantages. As the outcome of Castro et al. (2018) showed, it is essential to teach students and teachers how ER is working. It is not enough to only present the students with new technologies. An improved learning outcome is only viewable when the teachers are trained fittingly. The course must be integrated into a pedagogical framework, which the teachers need to develop and implement.

Another issue with ER is the need for time and time management. In a study by Cheng et al. (2010), students and teachers built robots. It was stated that they were faced with time management problems, as the robotics building process was time-consuming, resulting in frustration for teachers and students when ending the lesson without finishing the robot.

Theoretical Background of Educational Robotics

The theoretical background of ER builds upon Piaget's Constructivism. Knowledge is gained through hands-on experiences and project-based learning (Siegler & Ellis, 1996). Piaget's constructivism theory states that children construct more advanced understandings without being taught. Children can find solutions and new strategies for solving problems through a complex interplay between pre-existing knowledge and information from the external world (Siegler & Ellis, 1996). Piaget's Constructivism theory argues that students' knowledge does not build itself passively but needs active action by the student. For example, through interactions with the environment or physical artefacts (Ioannou & Makridou, 2018), as in the case of educational robotics.

The second theoretical background is Bandura's concept of self-efficacy. Self-efficacy is a person's own estimate of their abilities in conducting a task (Bandura & Wessels, 1994). Furthermore, self-efficacy is known to contribute to educational achievement (Bandura, 1993). Bandura, Freeman, and Lightsey (1999) described students' cognitive self-efficacy as a predictor of their effort and persistence related to a specific subject. High self-efficacy is coherent with high learning motivation and less frustration due to higher confidence in succeeding (Bandura & Wessels, 1994; Zimmerman, 2000). Schunk (1996) found that pupils who believe to be good at a task work harder and longer when faced with a problem. Whereas students with low self-efficacy beliefs are faster in giving up or avoiding the problem. Consequently, increasing students' belief in their ability can change their interest and attitude towards the subject, resulting in higher subject-related ability.

There are different forms of self-efficacy. General self-efficacy is known to be a stable measurement of a person's confidence in their general coping ability in situations over a life span (Dorfman & Fortus, 2019). While task-specific self-efficacies can change with the experience in a certain domain (Britner & Pajares, 2006). Regarding academic motivation and performance, school-related self-efficacy can predict a student's academic achievement (Jansen, Scherer & Schroeders, 2015).

Relevance of the Topic

Ioannou and Makridou (2018) suggested a need for more knowledge of robotics interventions. It is necessary to understand further the process and the conditions under which students profit from ER (Ioannou & Makridou, 2018). Another study describes a positive effect on pre-service teachers' self-efficacy when learning robotics (Liu, Lin & Chang, 2010). The study enhances the need for further research on this topic and evokes whether this positive effect can also be found in pupils. Screpanti, Cesaretti, Storti, and Scaradozzi (2021) found an inexplicable disparity in ER regarding students' learning outcomes. They argued that further research is required to determine why some students had more significant improvement in their skills while others had no improvement.

One possible mechanism is students' self-efficacy beliefs. Task or domain-specific self-efficacies change with the experience a person has undergone (Britner & Pajares, 2006). Therefore it is suggested that, for example, through participating in science-related courses, students' school-related self-efficacy can be increased. In comparison, general self-efficacy is understood as a stable factor of a person across multiple and different situations (Dorfman & Fortus, 2019). This stable measurement of general self-efficacy can be used as a control variable to endure that the possible effects are related to the task-specific, school-related self-efficacy and not due to general self-efficacy.

The current research contributes to closing the gap by determining which students benefit from the new technologies. As Screpanti, Miotti, and Monteriù (2021) described, it is still unknown what needs students and teachers have regarding the best implementation of educational robotics in schools. This is investigated by assessing the change in students' school-related self-efficacy beliefs, further by testing whether school-related self-efficacy mediates or moderates the increase of attitudes toward educational robotics and STEM before and after the intervention. To ensure that possible found effects are associated with school-related self-efficacy, general self-efficacy will be measured as a control variable. Thereby it can be distinguished if the change in attitudes is indeed mediated or moderated by school-related self-efficacy and not attributable to the participant's overall impression of being capable of performing and learning the task.

Consequently, the first hypothesis tests the possible increase in students' school-related self-efficacy pre-test and post-test.

H1: *There is a significant increase in students' school-related self-efficacy pre-and post- to the educational robotics course*.

It was found that self-efficacy beliefs mediate the effect of prior achievement, knowledge, and skills on later achievement (Schunk, 1985). Therefore it is reasonable to assess further if the effects of attitudes towards STEM and attitudes towards robotics pre-and post-test can be partly explained by school-related self-efficacy beliefs (see Figure 1 and Figure 2). The current study hypothesises that when school-related self-efficacy is stable, the effect between pre-/post-test attitudes towards robotics and STEM will be more negligible, as general self-efficacy accounts for parts of the effect.

H2a: *The direct effect of pre-test attitudes towards robotics on post-test attitudes decreases when school-related self-efficacy is used as a mediator.*

H2b: *The direct effect of pre-STEM on post-STEM decreases when school-related self-efficacy is used as a mediator.*

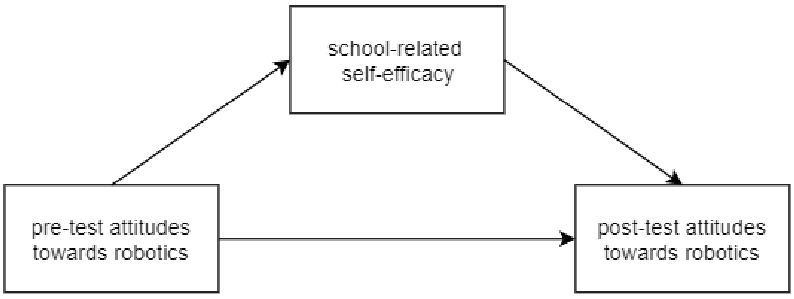

Fig. 1. Mediating effect model of pre-/post-test attitudes toward robotics and school-related self-efficacy

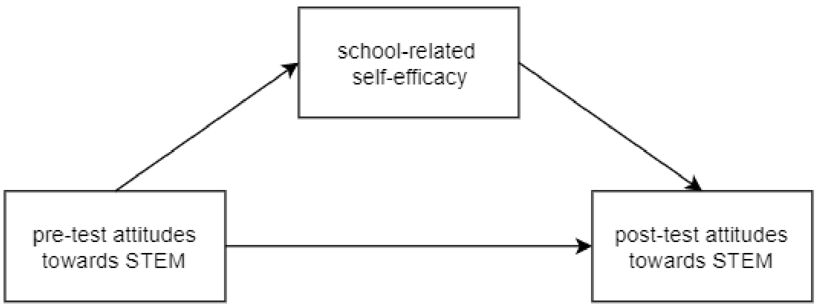

Fig. 2. Mediating effect model of pre-/post-test attitudes towards STEM and school-related self-efficacy

Additionally, when anticipating a mediation effect, it is plausible to rule out possible moderation effects (Baron & Kenny, 1986). Therefore, it is checked for the moderating role of school-related self-efficacy on pre-/post-test attitudes toward robotics and STEM (see Figure 3 and Figure 4).

H3a: *The moderating role of school-related self-efficacy affects the interplay of pre-test and post-test attitudes towards robotics by increasing the effect for students with low self-efficacy.*

H3b: *The moderating role of school-related self-efficacy affects the interplay of pre-STEM to post-STEM by increasing the effect for students with low self-efficacy.*

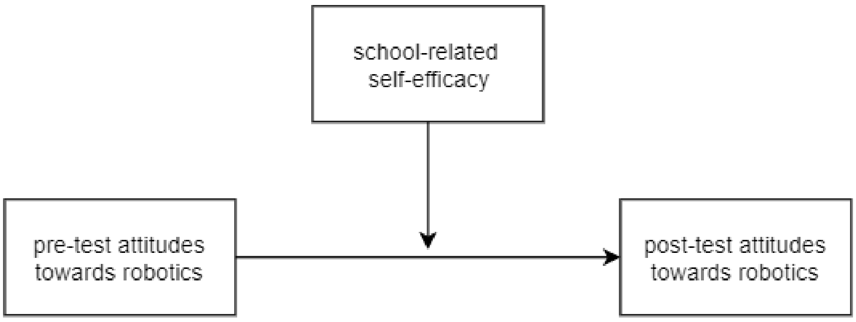

Fig. 3. Moderating effect model of pre/post-test attitudes toward robotics and school-related self-efficacy

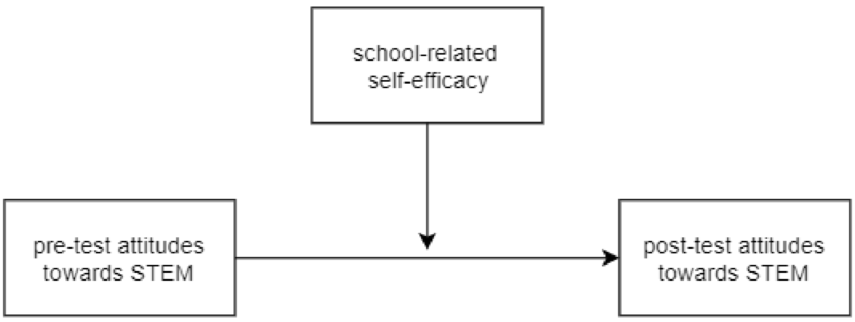

Fig. 4. Moderating effect model of pre/post-test attitudes toward STEM and school-related self-efficacy

Method

Research design

This study will measure the influence of ninth-grade students' self-efficacy beliefs on their attitudes towards STEM and robotics. The study's research design is pre-experimental.

Ethical consent

The students' consent was collected passively. The study was part of the student's regular school course. After the last session, students were debriefed and received a contact address for further or later questions about the research. The ethical approval was given by the ethical committee of the BMS faculty of the University of Twente with request number 220169.

Participants

The participants of this study consisted of 9th-grade school students from a high school in Ahaus, Germany (N= 67). The gender was nearly equally distributed between males (57%) and females (43%). The students' ages ranged from 14 to 16, with the majority of 58% being 14 years old, 37% being 15 years old, and 5% being 16 years old (see Table 1). The study was conducted in the academic year 2021/2022. The sample was selected based on convenience sampling. The students were not compensated for their participation.

Research process

The study was conducted over a six-week-long period. The first and last sessions included the pre-and post-test questionnaires. Weeks two, three, and four had the building of a robot as a focus. In week five, the emphasis was on programming robots. Robotis Dream ER kit was used. The researcher prepared the required pieces for building the robots to reduce the time pressure on the students.

Session 1

The students were informed that they are participating in a six-week-long study about ER. After a short introduction from the researcher, the students were asked to fill out the pre-test questionnaire. The questionnaire was offered to the students via iPad on Qualtrics.com in a German version. After filling out the questionnaire, the students received a short introduction to robotics and the Robotis Dream kits' usage.

Session 2

Session two started with a short recap of the first lesson, then the students were assigned to groups of 3 to 4 students and advised to build the 'Windmill-Robot' (see Figure 5). After finishing the robot, the students received a theoretical input about energy transformation.

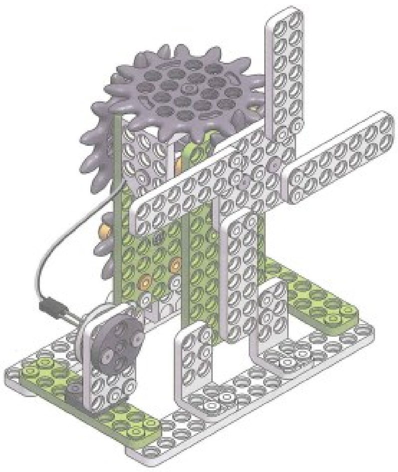

Fig. 5. Windmill robot

Session 3

The lesson started with a recap of the previous session. Then the students were advised to go into their groups and receive the Avoider robot's instructions (see Figure 6). Towards the end of the lesson, the students received theoretical input on infra-red sensors.

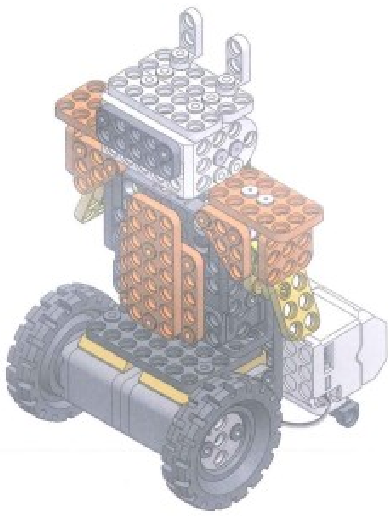

Fig. 6. Avoider Robot

Session 4

Session four started with an extended recap of the lasted sessions due to the two-week holiday break prior to the fourth lesson. Then the students found themselves again in groups of three to four and received instructions to build the 'Puppy Robot' (see Figure 7). At the end of the lessons, the student's attention was brought to the robot's algorithm to prepare for the following lesson.

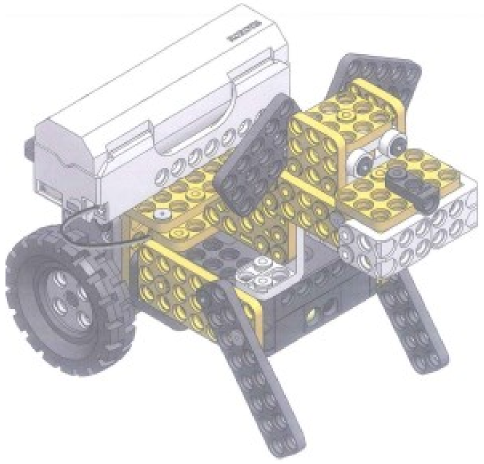

Fig. 7. Puppy Robot

Session 5

Lesson 5 started with the recap of the previous session. Then students were informed about algorithms and programming. They had to come up with their own flowchart for preparing tea. This was followed by a riddle for the students to figure out the flowchart of the puppy robot from session 4 (see Figure 7). In order to figure out the flowchart, the students received the finished puppy robot to try out the different conditions and processes of the robot.

Session 6

Students were presented with the post-test questionnaire in the last session and asked to fill it out. Afterwards, they receive the possibility to give written and anonym feedback about the intervention itself (see Appendix B).

Data Collection Tools

In order to create the questionnaire, Qualtrics.com was used, an online questionnaire tool for creating and managing questionnaires. The questionnaire was divided into five sections—section one starting with general questions about demographic variables, followed by a short questionnaire about general self-efficacy. In section three, a short questionnaire about school-related self-efficacy. Section four included the questionnaires about the attitudes towards STEM, and the last section contained the questionnaires about attitudes towards educational robotics. All questionnaire items were translated into German (see Appendix A).

Descriptive Statistics. The first section started with the gender question, with options for females, males, and others, following questions about age, their experience with robotics and the current math level. The current math level will be collected through self-reported questions regarding the current math course they are attending. In the case of this school, students can choose between an enhanced math class (E-Course) and a basic math class (B-Course).

General Self-Efficacy. Jerusalem and Schwarzer revised and shorted the questionnaire about general self-efficacy (1999). The internal consistency in the original study is high, with a Cronbach's alpha between .78 and .79. The current study found a similar Cronbach's alpha between .79 to .80. The 10 items are measured on a 4-point Likert Scale, with options ‘Not fitting/ Trifft nicht zu’, ‘Nearly fitting/ Trifft kaum zu’, ‘Kind of fitting/ Trifft ehr zu’, and ‘Fitting/ Trifft genau zu’. The scale is published in German with items like ‘For every Problem I can find a solution/ Für jedes Problem kann ich eine Lösung finden.’ Or ‘It does not cause me any difficulties to realize my intentions and goals/ Es bereitet mir keine Schwierigkeiten, meine Absichten und Ziele zu verwirklichen‘ (Schwarzer, & Jerusalem, 1999).

School-related Self-Efficacy. The second scale measures the school-related self-efficacy with seven items using a 4-point Likert scale. For the scale, Schwarzer and Jerusalem (1999) found a Cronbach's alpha between .70 and .73. The current study found a similar Cronbach's alpha between .72 and .73. The original scale is in German with items for example like ‘It is easy for me to understand new school material/ Es fällt mir leicht, neuen Unterrichtsstoff zu verstehen’ or ‘Even if the teacher doubts my abilities, I am sure that I can achieve good performance/ Auch wenn der Lehrer*in an meinen Fähigkeiten zweifelt, bin ich mir sicher, dass ich gute Leistungen erzielen kann’ (Schwarzer, & Jerusalem, 1999). For the final variable. First item 5 was recoded.

Attitudes toward STEM. The 'Middle/High School Student Attitudes towards STEM Survey (Middle/High S-STEM)' has four sub-factors: science, math, engineering and technology, and 21st-century skills (Faber et al., 2013). The survey has 37 items. All items are measured using a 5-point Likert scale with 'Strongly disagree', 'Disagree', 'Neither agree nor disagree', 'Agree', and 'Strongly agree' as options. The calculated reliability for the four constructs in the original study lies above .83 (Faber et al., 2018). For the current study, however, Cronbach's alpha lies between .56 and .90 for the subscales. The final attitudes towards STEM scales (STEM and pSTEM) include the sum of the sub-scales math, science, engineering and technology, and 21st-century skills. For the sub-scale math, items one, three and five were recoded, and for the sub-scale science, item eight was recoded.

The construct measuring the attitudes toward math has eight items, like 'Math has been my worst subject.'. Science-related attitudes are measured with nine items like 'I am sure of myself when I do science.'. Engineering and technology are also measured with nine items. Before answering the items, the students are given a short introduction to an engineer's job and how a technologist works. An example for an item is 'I am good at building and fixing things. Then the 21st Century Skills are assessed using 11 items like 'I am confident I can produce high-quality work'. Lastly, the student's interest in a future career is assessed using a 4-point Likert scale with the options 'Not at all Interested', 'Not so Interested', 'Interested', and 'Very Interested'. In this part, 12 different jobs are presented, and the student has to indicate an interest in a career in the subject area. For example' Environmental Work: involves learning about physical and biological processes that govern nature and working to improve the environment. This includes finding and designing solutions to problems like pollution, reusing waste and recycling. (pollution control analyst, environmental engineer or scientist, erosion control specialist, energy systems engineer and maintenance technician)'. The questionnaire ends with the segment 'About Yourself', where four questions are asked about how they expect to do in school and plan to attend college.

Educational Robotic Attitudes. The 'robotics activity attitudes scale (RAAS)' has five sub-scales: confidence, learning potential, personal robotics identity, technology identity, and curiosity. In the original study, the attitudes toward robotics (ERA) have an overall Cronbach's alpha of .97 (Cross et al., 2016). In the current study, Cronbach's alpha is between .86 and .91. All items were measured using a 5-point Likert scale with the statements "NO!", "no", "neither yes or no", "yes", and "YES!" (Cross et al., 2016).

Every sub-scale was computed by summing up the item values. The first sub-scale, 'confidence', is measured using ten items, for example, Item 1 'I am good at making robots'. 'Learning potential' is also measured using ten items, for example, item 6 'I like to learn new facts about robots'. The third sub-scale, 'personal robotics identity', is again measured with ten Items, for example, item 5, 'I am often trying to find out more about computers'. The fourth sub-scale, 'personal technology identity', is assessed through 6 Items, like Item 4, 'I look for as much information as I can about robots'. The final sub-scale, 'Curiosity', also has 6 Items, for example, Item 2 'I am curious about how robots work'.

Anonymous Feedback Sheets. The provided Feedback Sheets had to be filled in manually. Each student had to answer three questions about the lessons. The three questions included 'What did you like?', 'What did you dislike?' and 'What did you wish for differently?'.

Data Analysis

The complete data set included 88 participants, two of whom had to be removed because of an unfinished survey. Participants were also removed when they missed more than two out of four sessions, which was the case for four participants. Additionally, 15 pupils were not present in either the pre or post-data collection and were therefore missing in the data. After clearing the data, 67 participants were left.

In the first step of the data analysis, variables were checked for violations of independency, normality, linearity, and homoscedasticity assumptions. The data analysis was conducted using the statistical tool SPSS. In order to test how students' school-related self-efficacy beliefs change from pre-test to post-test, a dependent T-test was used to determine possible differences (H1). The mediation effects were measured using 'PROCESS macro' in SPSS (H2a, H2b), and the moderation effect was tested with an ANOVA test and the 'PROCESS macro' tool to test the interaction effect in the model (H3a, H3b).

The mediation analysis is a widely used technique in psychology to test theories regarding their process (Rucker et al., 2011). The mediation analysis tests whether the mediator's effect on the dependent variable fully or partially explains the relationship between the independent and dependent variables. The measuring tool 'PROCESS macro' in SPSS was developed by Andrew F. Hayes (Hayes, 2017). This tool can assess the significance level of the mediator. The significance level is determined in four steps. The first step is checking the initial relationship between the independent and dependent variables. Step two includes determining the relationship between the initial independent variables and the mediator. Step three analyses the mediator's effect on the dependent variable while the independent variable is present. The last step determines if a reduction of the initial independent variable's effect on the dependent is visible when the mediator is present. Mediation occurs when the effect without a mediator differs significantly from the effect with the mediator.

Likewise, moderation analysis is tested using the SPSS 'PROCESS macro' tool. Moderation analysis tests if a significant effect between a dependent variable and an independent variable and if a moderator variable changes the relationship between the initial variables. A moderation analysis would be conducted if a significant relationship between the dependent and independent variables was found. All values are automatically standardised through the SPSS extension 'PROCESS macro'. In a second step, a regression model is conducted to check the independent variable's significant effect and the moderator's effect on the dependent. In the third step, the interaction effect of the moderator with the independent variable is added. Moderation has occurred if the interaction effect is significant and can explain the model. Complete moderation only occurs when the individual effects of the independent variable and the moderator are insignificant when the interaction effect is included. Additionally, each student's hand-written anonymous feedback sheets were assessed and checked for any repeated answer schemes.

Results

The study's scope determined the students' self-efficacy and attitudes toward robotics and STEM.

Descriptive Statistics

The final sample consisted of 38 males (N = 67, 56.7%) and 29 females (N = 67, 43.3%). Most of the participants were 14-years old (N = 67, 58.2%), 25 participants were 15-years old (N = 67, 37.3%), and 3 participants were 16 years old (N = 67, 4.5%). Most of the students are enrolled in the enhanced math course (E-Course) (N = 67, 73.1%), and only 18 participants are following the basic math course (B-Course) (N = 67, 26.9%) (see Table 1).

Table 1
Demographic characteristics of the participants.

Item	Category	Frequency	Percentage
Gender	Male	38	56.7
	Female	29	43.3
Age	14	39	58.2
	15	25	37.3
	16	3	4.5
Math level	E-Course	49	73.1
	B-Course	18	26.9

The variables were checked for normality, linearity, homoscedasticity, and independency violations. Skewness and kurtosis statistics were controlled for each variable for normality distribution. It was observed that the data had normal distribution since these values were between −2 and +2. The descriptive statistics are given in Table 2.

Table 2
Descriptive statistics.

Variables	M	SD	Kurtosis	Skewness
Pre General Self-efficacy (GSE)	2.86	.43	.45	.12
Post General Self-efficacy (pGSE)	2.88	.44	.25	.71
Pre School-related self-efficacy (SSE)	2.90	.46	-.25	.25
Post School-related self-efficacy (pSSE)	2.91	.43	.16	-.10
Pre Attitudes towards STEM (STEM)	119.96	18.62	.24	.30
Post Attitudes towards STEM (pSTEM)	121.31	18.07	.31	.27
Pre Attitudes towards Robotics (ERA)	129.10	28.67	.10	.34
Post Attitudes towards Robotics (pERA)	125.21	26.72	.47	-.19

A correlation matrix was created, including all relevant variables, pre-test general self-efficacy (GSE), post-test general self-efficacy (pGSE), pre-test school-related self-efficacy

(SSE), post-test school-related self-efficacy (pSSE), pre-test educational robotics attitudes (ERA), post-test educational robotics attitudes (pERA), pre-test attitudes towards STEM (STEM), post-test attitudes towards STEM (pSTEM). Significant positive correlations were found between all variables (see Table 3).

Table 3
Correlation matrix.

Variables	GSE	pGSE	SSE	pSSE	ERA	pERA	STEM	pSTEM
GSE	1							
pGSE	.52**	1						
SSE	.58**	.61**	1					
pSSE	.46**	.71**	.53**	1				
ERA	.48**	.45**	.35**	.35**	1			
pERA	.41**	.44**	.36**	.26**	.69**	1		
STEM	.61**	.60**	.68**	.60**	.58**	.57**	1	
pSTEM	.44**	.57**	.67**	.59**	.56**	.64**	.78**	1

***. Correlation is significant at the 0.01 level (2-tailed).*

School-related self-efficacy

The first hypothesis that the mean of school-related self-efficacy post-condition will be higher than the mean of the pre-condition was tested using a dependent sample T-test. The results from the pre-condition (*M*= 2.90, *SD* = .46) and post-condition (*M* = 2.91, *SD* = .43), $t(66) = -.24$, $p = .810$, indicated that there was no significant increase in participants school-related self-efficacy pre and post to the robotics lessons.

Mediation role

Hypothesis 2a predicted that pre-test educational robotics attitudes (ERA) have an effect on post-test educational robotics attitudes (pERA), which is partially or fully mediated by school-related self-efficacy (SSE). This was tested using the four-step 'PROCESS macro' mediation analysis approach. Step one of the mediation model is the regression between post-test ERA and pre-test ERA, ignoring the mediator. This is found to be significant, $b = .64$, $t(65) = 7.55$, $p < .001$. In the second step the regression of ERA on the mediator SSE was found to be significant, $b = .04$, $t(65) = 2.79$, $p = .007$. Next, the mediator SSE was analysed while controlling the independent variable ERA. Here no significant effect was found, $b = .79$, $t(64) = 1.20$, $p = .234$. Simultaneously the effect of ERA on pERA was tested, while including the mediator SSE, showing a significant effect, $b = .60$, $t(64) = 6.77$, $p < .001$. Therefore, no mediation effect of SSE on ERA and pERA was found.

The second prediction (Hypothesis 2b) is that the effect of pre-test attitudes towards STEM (STEM) on post-test attitudes towards STEM (pSTEM) can be mediated by school-related self-efficacy. The regression analysis between post-test STEM and pre-test STEM showed a significant effect, $b = .70$, $t(65) = 8.45$, $p < .001$. The second step, including the regression analysis of STEM on the mediator SSE revealed to be significant, $b = .17$, $t(65) = 7.37$, $p < .001$. In the third step, the effect of the mediator SSE on the dependent variable pSTEM was tested while controlling for STEM, where a significant effect was found of SSE, $b = 12.74$, $t(64) = 2.97$, $p = .004$. At the same time there was a significant effect of STEM on pSTEM, when including SSE, $b = .49$, $t(64) = 4.60$, $p < .001$. Concludingly, SSE is partially mediating the relationship between STEM and pSTEM. Furthermore, general self-efficacy (GSE) was included as a control variable, which did not impact the partial mediation of SSE.

Moderation role

It was predicted that school-related self-efficacy would moderate the effect between pre-test educational robotics attitudes and post-test educational robotics attitudes (Hypothesis 3a). The moderation was calculated using 'PROCESS macro' in SPSS. In the first step, regression analysis for the model ERA and pERA was conducted and found significant, $F(1, 65) = 58.83$, $p < .001$. The moderator SSE and the interaction effect between ERA and SSE were added to test if it accounts for a proportion of the variance, the model summary was significant, R^2 = .50, F(3,63) = 20.83, p < .001, however no significant effect was found for the interaction effect between ERA and SSE, b =.12, t(63)= .85, p = .397. Concludingly, no moderation was found to be significant when including SSE as a moderator.

Hypothesis 3b is that pre-test attitudes towards STEM on post-test attitudes towards STEM are moderated by school-related self-efficacy. The regression analysis revealed a significant effect for STEM on pSTEM, F (1, 65) = 71.37, p < .001. After including SSE as a moderator and the interaction effect between SSE and ERA, the model summary stayed significant R^2 = .58, F(3,63) = 29.47, p < .001, however no significant results were found for the interaction effect of STEM and SSE , b = .09, t(63) = .66, p = .514. Leading to the conclusion that SSE is not moderating the effect between STEM and pSTEM.

Additional control analysis

Anonymous feedback sheets were analysed in addition. In the feedback sheets, students stated what they liked, disliked, and would want to change for the next time about the lessons. 43 of 67 pupils (64%) named the hands-on learning experience to answer the question 'what did you liked'. Five students (7.5%) named the teamwork, and three (4.5%) named the new learning experience. In answer to what they disliked, 27 out of 67 students (40%) included that they disliked the fact because they could not finish their robots within the given time.

Furthermore, a control analysis resulted in the finding that the effect between ERA and pERA is mediated by STEM, b = .31, t(64) = 2.02, p = .047. This change in attitudes towards robotics is even more explained by the post-test attitudes towards STEM, b = .46, t(63) = 3.18, p = .002. Interesting is also the finding regarding the variance of the pre to post-test results. There is a decrease in variance between ERA and STEM regarding the variance of results (see Table 2).

Discussion

This study aimed to explore the possible effects of self-efficacy on students' attitudes toward robotics and STEM. In the scope of the study, a short-term educational robotics course was implemented into the physics lessons of the students during their school time. The result showed a partial mediation of SSE for the relationship between attitudes towards STEM before and after the intervention. However, no mediation of SSE was found for the effect between attitudes towards robotics before and after the intervention. Furthermore, no moderating effect of school-related self-efficacy for neither attitudes towards robotics nor attitudes towards STEM was found.

A central finding is that school-related self-efficacy stayed stable before and after the intervention. A possible reason for the stable school-related self-efficacy could be that the intervention period was too short. Specific kinds of self-efficacy, like school-related self-efficacy, can change over time by learning a specific skill (Flammer, 2001). However, it is also suggested that specific self-efficacies are relatively stable (Bong, 2002), as is general self-efficacy. It is possible that the time frame of the intervention was too short to observe changes in school-related self-efficacy. Additionally, a two-week holiday break between the third and fourth weeks could have led to a decrease in possible effects of school-related self-efficacy. One implication of the observation that school-related self-efficacy did not change during the intervention points to a decoupling of attitudes and self-efficacy. This means that attitudes towards robotics and STEM may change while there is no change in students' school-related and school-related self-efficacy.

The study was conducted during the corona pandemic, for which studies have found that students' motivational levels decreased (Zaccoletti et al., 2020). General and school-related self-efficacy highly depend on motivational factors (Yusuf, 2011). Therefore it is possible that no increase in students' school-related self-efficacy was found due to a lack of motivation.

Furthermore, there was a significant finding of decreased students' attitudes towards robotics. The decrease in attitudes towards robotics could be due to the surrounding situation of the intervention. The intervention was implemented in the physic lessons of the school, with a maximum duration of 60 min per lesson. This time frame is comparably short to other robotic lessons (Alimisis, Karatrantou & Tachos, 2005; Bers et al., 2014; Nugent et al., 2010). In their anonymous feedback sheet, 40% of the students reported that they did not like the time shortage and the pressure to be finished. This is consistent with other studies showing that enough time is essential for conducting a robotics course (Cheng et al., 2018; Niemi, 2002).

Moreover, the short duration could have brought frustration and dissatisfaction, which could be an implementation of the decreasing attitudes toward robotics. The study by Bhattacherjee and Premkumar (2004) has shown the importance of satisfaction when determining attitudes towards a subject. The same study also showed that resource constraints, such as lack of time, can lead to decreased attitudes towards technologies. For example, students could not finish their building due to the missing time and felt discouraged and incapable of handling robotics. Therefore one implication for the decrease of attitudes toward robotics could be the lack of time while at the same time being unable to finish the task. Further research would be advised to assess the motivational and frustration level of the participants in order to come to a complete understanding of the situation.

However, there was a significant increase after the intervention compared to before in attitudes toward STEM. Even though the attitudes toward robotics decreased, the students' attitudes towards math, science, engineering and technology and 21st-century skills increased. This increase in attitudes towards STEM is consistent with the findings in the study of Nugent et al. (2010), who found that short-term robotics course, comparable to the one conducted in this study, primarily influences students' attitudes and motivations. In contrast, an intense robotics camp significantly affects students' learning. The short robotics course in their study did increase students' interest in STEM-related subjects; however, it has not significantly increased students' attitudes and knowledge toward STEM. This study's setup is comparable to the study's design by Nugent et al. (2010), as all lessons included a hands-on learning structure. After each robot was built, students received a theoretical input regarding the theoretical background of the action. Related studies have shown that hands-on learning activities increase students' attitudes towards a subject (Bandura & Wessels, 1994; Siegler & Ellis, 1996; Waliczek & Zajicek, 1999). The observation that attitudes towards STEM increased may be related to the hands-on activities that resulted during the intervention.

It was hypothesised that school-related self-efficacy would mediate the association between attitudes toward robotics and STEM because, as other research has indicated, self-efficacy may be considered an explanation for academic performance (Fosse, Buch, Säfvenbom & Martinussen, 2016). A significant mediation of SSE was confirmed for the effect between pre-test STEM and post-test STEM. At the same time, the effect between STEM and pSTEM stayed significant, which indicates that school-related self-efficacy is a partial mediator for the relationship. Furthermore, general self-efficacy was included as a control variable which had no impact on the partial mediation effect of school-related self-efficacy. There was no significant mediation effect of SSE on pre-test attitudes towards robotics on post-test attitudes towards robotics.

Furthermore, a moderation effect of self-efficacy was expected, as similar studies found self-efficacy to act as a moderator (Finn & Frone, 2004; Zainal et al., 2022). However, the current study revealed no significant effects when SSE was included as a moderator.

In addition, control analysis showed the mediating effect of STEM and pSTEM on the relation between ERA and pERA. It is suggested that the attitude towards STEM influences the relationship between ERA and pERA. This is in line with Kucuk and Sisman's (2020) findings, where a high relation between attitudes towards STEM and robotics was found. The partial relationship is even more substantial when the attitudes towards STEM after the intervention (pSTEM) are used. A possible implication could be that the variance decreases since the students are getting more similar in their attitudes towards robotics and STEM. For example, because the students have more understanding of the questions and the general topic, a more similar answer pattern is visible through the decrease in variance. The observed decrease in the variance could show that the group became more similar regarding their attitudes towards robotics and STEM. Therefore it is advisable to further research to test if those implications are possible explanations for the findings of this study.

Concludingly, it can be stated that school-related self-efficacy partially mediates the increase in students' attitudes towards STEM. However, SSE is not mediating the decrease in students' attitudes toward robotics. Furthermore, school-related self-efficacy is neither moderating the increase in students' attitudes towards STEM nor the decrease in students' attitudes toward robotics.

Strengths and Limitation

A strength of this study becomes visible when looking at the anonym feedback of the students. It was written in their feedback form that students enjoyed working with their hands, collaborating with other students, and learning new skills. Overall the learning atmosphere was positive during the intervention. As is visible in other studies, the hands-on learning experience can positively influence students' attitudes toward a subject and, in general, increase the learning outcome (Siegler & Ellis, 1996; Waliczek & Zajicek, 1999)

The study also had some limitations. The time frame of 60 minutes in which the robotics lessons were conducted was short. Due to the short time frame, more than half of the students could not finish their robots in the lessons. This could have left the students with the feeling of not being capable of working with robots. The impact of time pressure on the learning outcome has been affirmed in topic-related studies (Niemi, 2002).

The second limitation concerns the study design. The study was conducted without a control group. Therefore the measured effects were only viewable within the study. Hence, any side effects happening in the school at the time are not accounted for, and the measured effects cannot be generalised.

Future research

In the future, multiple factors could be improved. It would be interesting to gather more data regarding the motivation and frustration levels of the students. Additionally, it would be interesting to account for their achievement in each lesson, for example, by filling out short questions about each student's progress during the lesson. Next to increasing the number of participants, an increased time frame per lesson is advised to ensure that students can finish the robot projects. Besides, it is recommended to add a control group to get more information about the effect of the intervention overall.

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Appendix

Appendix A: Qualtrics Questionnaire

Final - Influence of student's self-efficacy on educational robotics and their attitudes towards STEM

Start of Block: Demographic Variables

Welches Geschlecht hast du?

- Weiblich (1)
- Männlich (2)
- Anderes (3)

Wie alt bist du?

- 13 (1)
- 14 (2)
- 15 (3)
- 16 (4)
- 17 (5)
- 18 (6)

Level Welchen Kurs besuchst du in Mathe?

- G-Kurs (1)
- E-Kurs (2)

Gib hier den ersten Buchstaben deines Vornamens, den ersten deines Nachnames und das Datum deines Geburstages und Monats (vier Zahlen).

Zum Beispiel: Max Musterman, 04.10.2003 --> MM0410
Yvonne Musterman, 15.03.2001 --> YM1503

____

Wie viel Erfahrung hast du mit Robotern?

- ○ sehr wenig (1)
- ○ wenig (2)
- ○ mittel (3)
- ○ viel (4)
- ○ sehr viel (5)

End of Block: Demographic Variables

Start of Block: Allgemeine Selbstwirksamkeitserwartung

Hier geht es um deine persönlichen Einschätzungen und Gefühle. Bitte kreuze das Kästchen an, das am ehesten zutrifft!

	Trifft nicht zu (1)	Trifft kaum zu (2)	Trifft eher zu (3)	Trifft genau zu (4)
Wenn sich Widerstände auftun, finde ich Mittel und Wege, mich durchzusetzen. (1)	○	○	○	○
Die Lösung schwieriger Probleme gelingt mir immer, wenn ich mich darum bemühe. (2)	○	○	○	○
Es bereitet mir keine Schwierigkeiten, meine Absichten und Ziele zu verwirklichen. (3)	○	○	○	○
In unerwarteten Situationen weiß ich immer, wie ich mich verhalten soll. (4)	○	○	○	○
Auch bei überraschenden Ereignissen glaube ich, dass ich gut mit ihnen zurechtkommen werde. (5)	○	○	○	○
Schwierigkeiten sehe ich gelassen entgegen, weil ich meinen Fähigkeiten immer vertrauen kann. (6)	○	○	○	○
Was auch immer passiert, ich werde schon klarkommen. (7)	○	○	○	○
Für jedes Problem kann ich eine Lösung finden. (8)	○	○	○	○
Wenn eine neue Sache auf mich zukommt, weiß ich, wie ich damit umgehen kann. (9)	○	○	○	○
Wenn ein Problem auf mich zukommt, habe ich meist mehrere Ideen, wie ich es lösen kann. (10)	○	○	○	○

End of Block: Allgemeine Selbstwirksamkeitserwartung

Start of Block: Schulbezogene Selbstwirksamkeitserwartung

Hier geht es um deine persönlichen Einschätzungen und Gefühle. Bitte kreuze das Kästchen an, das am ehesten zutrifft!

	Trifft nicht zu (1)	Trifft kaum zu (2)	Trifft eher zu (3)	Trifft genau zu (4)
Ich kann auch die schwierigen Aufgaben im Unterricht lösen, wenn ich mich anstrenge. (1)	○	○	○	○
Es fällt mir leicht, neuen Unterrichtsstoff zu verstehen. (2)	○	○	○	○
Wenn ich eine schwierige Aufgabe an der Tafel lösen soll, glaube ich, dass ich das schaffen werde. (3)	○	○	○	○
Selbst wenn ich mal längere Zeit krank sein sollte, kann ich immer noch gute Leistungen erzielen. (4)	○	○	○	○
Wenn der Lehrer / die Lehrerin das Tempo noch mehr anzieht, werde ich die geforderten Leistungen kaum noch schaffen können. (5)	○	○	○	○
Auch wenn der Lehrer / die Lehrerin an meinen Fähigkeiten zweifelt, bin ich mir sicher, dass ich gute Leistungen erzielen kann. (6)	○	○	○	○
Ich bin mir sicher, daß ich auch dann noch meine gewünschten Leistungen erreichen kann, wenn ich mal eine schlechte Note bekommen habe. (7)	○	○	○	○

End of Block: Schulbezogene Selbstwirksamkeitserwartung

Start of Block: Attitudes towards STEM

Anleitung Anleitung:

Auf den folgenden Seiten findest du Listen mit Aussagen. Bitte markiere deine Antwort durch das Markieren, je nachdem wie du dich bei der Aussage fühlst.

Zum Beispiel: Trifft nicht zu |Trifft ehr nicht zu |Teils-teils |Trifft ehr zu |Trifft zu
Ich mag Ingenieurwissenschaft. O O O O O

Wenn du den Satz liest, wirst du wissen, ob du zustimmst oder nicht. Klicke den Kreis an, der beschreibt, wie sehr du zustimmst oder nicht zustimmst.

Auch wenn einige Aussagen sehr ähnlich sind, beantworte bitte jede Aussage. Es gibt kein Zeitlimit; Arbeite schnell, aber sorgfältig.

Es gibt keine „richtigen" oder „falschen" Antworten! Die einzigen richtigen Antworten sind diejenigen, die wahr für dich sind. Immer wenn möglich, sollten die Dinge, die dir passiert sind, dir bei deiner Entscheidung helfen.
Bitte markiere pro Frage nur eine Antwort an.

Page Break

Mathematik

	Trifft nicht zu (1)	Trifft ehr nicht zu (2)	Teils - Teils (3)	Trifft ehr zu (4)	Trifft zu (5)
Mathe war mein schlechtestes Fach. (1)	○	○	○	○	○
Ich würde überlegen, einen Beruf zu wählen, der Mathematik beinhaltet. (2)	○	○	○	○	○
Mathe fällt mir schwer. (3)	○	○	○	○	○
Ich bin der Typ Schüler*in, der in Mathe gut abschneidet. (4)	○	○	○	○	○
Ich kann mit den meisten Fächern gut umgehen, aber mit Mathe kann ich nicht gut umgehen. (5)	○	○	○	○	○
Ich bin mir sicher, dass ich in Mathematik fortgeschrittene Arbeiten machen könnte. (6)	○	○	○	○	○
Ich kann gute Noten in Mathe bekommen. (7)	○	○	○	○	○
Ich bin gut in Mathe. (8)	○	○	○	○	○

Page Break

Wissenschaft

	Trifft nicht zu (1)	Trifft ehr nicht zu (2)	Teils - Teils (3)	Trifft ehr zu (4)	Trifft zu (5)
Ich bin überzeugt von mir, wenn ich wissenschaftlich arbeite. (1)	○	○	○	○	○
Ich würde eine wissenschaftliche Karriere in Erwägung ziehen. (2)	○	○	○	○	○
Ich erwarte, Wissenschaft zu nutzen, wenn ich mit der Schule fertig bin. (3)	○	○	○	○	○
Wissenschaftliche Kenntnisse werden mir helfen, meinen Lebensunterhalt zu verdienen. (4)	○	○	○	○	○
Ich werde Wissenschaft für meine zukünftige Arbeit brauchen. (5)	○	○	○	○	○
Ich weiß, dass ich in Naturwissenschaften gut abschneiden kann. (6)	○	○	○	○	○
Die Wissenschaft wird in meinem Alltag wichtig sein. (7)	○	○	○	○	○
Ich kann mit den meisten Fächern gut umgehen, aber mit Naturwissenschaften kann ich nicht gut umgehen. (8)	○	○	○	○	○
Ich bin mir sicher, dass ich fortgeschrittene wissenschaftliche Arbeiten machen könnte. (9)	○	○	○	○	○

Page Break

Ingenieurwesen und Technologie
Bitte lies diesen Absatz, bevor du die Fragen beantwortest.
„Ingenieure nutzen Mathematik, Naturwissenschaften und Kreativität, um Probleme zu erforschen und zu lösen, um das Leben aller zu verbessern, und um neue Produkte zu erfinden. Es gibt viele verschiedene Arten von Ingenieurwesen, wie z. B. Chemie, Elektrotechnik, Computertechnik, Mechanik, Bauwesen, Umwelttechnik und Biomedizin. Ingenieure entwerfen und verbessern Dinge wie Brücken, Autos, Stoffe, Lebensmittel und

Virtual-Reality-Vergnügungsparks. Technologen wenden Designs an, die Ingenieure entwickeln; Sie bauen, testen und prüfen Produkte und Prozesse.“

	Trifft nicht zu (1)	Trifft ehr nicht zu (2)	Teils - Teils (3)	Trifft ehr zu (4)	Trifft zu (5)
Ich stelle mir gerne vor, neue Produkte zu entwickeln. (1)	○	○	○	○	○
Wenn ich Ingenieurwesen lerne, kann ich Dinge verbessern, die Menschen jeden Tag benutzen. (2)	○	○	○	○	○
Ich bin gut darin, Dinge zu bauen und zu reparieren. (3)	○	○	○	○	○
Ich interessiere mich dafür, was Maschinen zum Funktionieren bringt. (4)	○	○	○	○	○
Das Entwerfen von Produkten oder Strukturen wird für meine zukünftige Arbeit wichtig sein. (5)	○	○	○	○	○
Ich bin neugierig, wie Elektronik funktioniert. (6)	○	○	○	○	○
Ich möchte Kreativität und Innovation in meiner zukünftigen Arbeit einsetzen. (7)	○	○	○	○	○
Wenn ich weiß, wie man Mathematik und Naturwissenschaften zusammen verwendet, kann ich nützliche Dinge erfinden. (8)	○	○	○	○	○
Ich glaube, dass ich in einer Ingenieurkarriere erfolgreich sein kann. (9)	○	○	○	○	○

Page Break

Fähigkeiten des 21. Jahrhunderts

	Trifft nicht zu (1)	Trifft zu (2)	Teils - Teils (3)	Trifft ehr zu (4)	Trifft zu (5)
Ich bin sicher, dass ich andere dazu bringen kann, ein Ziel zu erreichen. (1)	○	○	○	○	○
Ich bin sicher, dass ich andere ermutigen kann, ihr Bestes zu geben. (2)	○	○	○	○	○
Ich bin sicher, dass ich qualitativ hochwertige Arbeit leisten kann. (3)	○	○	○	○	○
Ich bin sicher, dass ich die Unterschiede meiner Altersgenossen respektieren kann. (4)	○	○	○	○	○
Ich bin sicher, dass ich meinen Altersgenossen helfen kann. (5)	○	○	○	○	○
Ich bin sicher, dass ich die Perspektiven anderer in meine Entscheidungen einbeziehen kann. (6)	○	○	○	○	○
Ich bin sicher, dass ich Änderungen vornehmen kann, wenn die Dinge nicht wie geplant verlaufen. (7)	○	○	○	○	○
Ich bin sicher, dass ich meine eigenen Lernziele setzen kann. (8)	○	○	○	○	○
Ich bin sicher, dass ich meine Zeit sinnvoll einteilen kann, wenn ich alleine arbeite. (9)	○	○	○	○	○
Wenn ich viele Aufgaben habe, kann ich auswählen, welche zuerst erledigt werden müssen. (10)	○	○	○	○	○
Ich bin sicher, dass ich gut mit Schülern mit unterschiedlichem Hintergrund zusammenarbeiten kann. (11)	○	○	○	○	○

Page Break

Deine Zukunft

Hier findest du Beschreibungen von Fachbereichen, die Mathematik, Naturwissenschaften, Ingenieurwesen und/oder Technologie umfassen, sowie Listen von Jobs, die mit jedem Fachbereich verbunden sind. Während du die folgende Liste liest, wirst du wissen, wie sehr du dich für das Thema und die Jobs interessierst.

Kreuze an, wie sehr der Job deinem Interesse entspricht. Es gibt keine „richtigen“ oder „falschen“ Antworten. Die einzigen richtigen Antworten sind die, die auf dich zutreffen.

	Überhaupt nicht interessant (1)	Nicht so interessant (2)	Interessant (3)	Sehr interessant (4)
Physik: ist das Studium der Grundgesetze, die die Bewegung, Energie, Struktur und Wechselwirkungen von Materie regeln. Dies kann das Studium der Natur des Universums beinhalten. (Luftfahrtingenieur*in, Alternativenergietechniker*in, Laborant*in, Physiker*in, Astronom*in) (1)				
Umweltarbeit: beinhaltet das Erlernen physikalischer und biologischer Prozesse, die die Natur regieren, und das Arbeiten zur Verbesserung der Umwelt. Dazu gehört das Finden und Gestalten von Lösungen für Probleme wie Umweltverschmutzung, Wiederverwendung von Abfällen und Recycling. (Schadstoffanalytiker*in, Umweltingenieur*in oder -wissenschaftler*in, Erosionsschutzspezialist*in, Energiesystemingenieur*in und Wartungstechniker*in) (2)				
Biologie und Zoologie: beinhalten das Studium lebender Organismen (wie Pflanzen und Tiere) und der Lebensprozesse. Dazu gehört die Arbeit mit Nutztieren und in Bereichen wie Ernährung und Zucht. (Biotechniker*in, Biowissenschaftler*in, Pflanzenzüchter*in, Tierwissenschaftler*in, Genetiker*in, Zoologe*in) (3)				
Veterinärwesen: Beinhaltet die Wissenschaft der Vorbeugung oder Behandlung von Krankheiten bei Tieren. (Tierärztliche Fachangestellter*in, Tierarzt*in, Tierhalter*in, Tierpfleger*in) (4)				
Mathematik: ist die Wissenschaft der Zahlen und ihrer Operationen. Es beinhaltet Berechnungen, Algorithmen und Theorien, die verwendet werden, um Probleme zu lösen und Daten zusammenzufassen. (Buchhalter*in, Angewandte Mathematiker*in, Wirtschaftswissenschaftler*in, Finanzanalyst*in, Mathematiker*in, Statistiker*in, Marktforscher*in, Börsenanalyst*in) (5)				
Medizin: umfasst die Erhaltung der Gesundheit sowie die Vorbeugung und Behandlung von Krankheiten. (Arztassistent*in, Krankenpfleger*in, Arzt/Ärztin, Ernährungsberater*in, Rettungssanitäter*in, Physiotherapeut*in, Zahnarzt*in) (6)				

Geowissenschaften: ist das Studium der Erde, einschließlich der Luft, des Landes und des Ozeans. (Geologe*in, Meteorologe*in, Archäologe*in, Geowissenschaftler*in) (7)	○	○	○	○
Informatik: umfasst das Entwickeln und Testen von Computersystemen, das Entwerfen neuer Programme und das Helfen anderer bei der Verwendung von Computern. (Fachkraft für Computerunterstützung, Computerprogrammierer*in, Computer- und Netzwerktechniker*in, Spieledesigner*in, Computersoftwareingenieur*in, Spezialist für Informationstechnologie) (8)	○	○	○	○
Medizinische Wissenschaft: umfasst die Erforschung menschlicher Krankheiten und die Suche nach neuen Lösungen für menschliche Gesundheitsprobleme. (Klinischer Labortechnologe*in, Mediziner*in, Biomedizintechniker*in, Epidemiologe*in, Pharmakologe*in) (9)	○	○	○	○
Chemie: verwendet Mathematik und Experimente, um nach neuen Chemikalien zu suchen und die Struktur der Materie und ihr Verhalten zu untersuchen. (Chemietechniker*in, Chemiker*in, Chemieingenieur*in) (10)	○	○	○	○
Energie: umfasst das Studium und die Erzeugung von Energie, wie Wärme oder Strom. (Elektriker*in, Elektroingenieur*in, Heizungs-, Lüftungs- und Klimatechniker*in, Nuklearingenieur*in, Systemingenieur*in, Installateur*in oder Techniker*in für alternative Energiesysteme) (11)	○	○	○	○
Ingenieurswissenschaften: umfasst das Entwerfen, Testen und Herstellen neuer Produkte (wie Maschinen, Brücken, Gebäude und Elektronik) durch den Einsatz von Mathematik, Naturwissenschaften und Computern. (Bau-, Industrie-, Agrar- oder Maschinenbauingenieure*in, Schweißer*in, Automechaniker*in, Maschinenbautechniker*in, Bauleiter*in) (12)	○	○	○	○

Page Break

About Yourself 1 Wie gut glaubst du bist du dieses Jahr in:

	Nicht sehr gut (1)	Ok/ Gut (2)	Sehr gut (3)
Deutsch-/Fremdsprachen Unterricht? (1)	○	○	○
Matheunterricht? (2)	○	○	○
Naturwissenschaftlicher Unterricht? (3)	○	○	○

About Yourself 2 Planst du in Zukunft fortgeschrittene Kurse zu belegen in:

	Ja (1)	Nein (2)	Nicht sicher (3)
Mathematik? (1)	○	○	○
Naturwissenschaftt? (2)	○	○	○

About Yourself 3 Planst du zu studieren?

	Ja (1)	Nein (2)	Nicht sicher (3)
Planst du zu studieren? (1)	○	○	○

About Yourself 4 Mehr über dich.

	Ja (1)	Nein (2)	Nicht sicher (3)
Kennst du einen Erwachsenen, der/die als Wissenschaftler*in arbeitet? (1)	○	○	○
Kennst du einen Erwachsenen, der/die als Ingenieure*in arbeitet? (2)	○	○	○
Kennst du einen Erwachsenen, der/die als Mathematiker*in arbeitet? (3)	○	○	○
Kennst du einen Erwachsenen, der/die als Technologe*in arbeitet? (4)	○	○	○

End of Block: Attitudes towards STEM

Start of Block: Attitudes towards ER

Bitte kreuze das Kästchen an, das am ehesten zutrifft!

	NEIN! (1)	nein (2)	Weder ja noch nein (3)	ja (4)	JA! (5)
Ich bin gut darin, Roboter zu bauen. (1)	○	○	○	○	○
Ich kann einen Roboter programmieren. (2)	○	○	○	○	○
Ich kann ein Computerprogramm schreiben. (3)	○	○	○	○	○
Ich kann einen Roboter bauen. (4)	○	○	○	○	○
Ich bin gut im logischen Denken. (5)	○	○	○	○	○
Ich habe Vertrauen in meine Fähigkeit, Roboter zu bauen. (6)	○	○	○	○	○
Ich löse gerne komplexe Probleme. (7)	○	○	○	○	○
Ich bin gut darin, Dinge zu entwerfen. (8)	○	○	○	○	○
Ich löse Probleme logisch. (9)	○	○	○	○	○
Ich könnte lernen, ein Computerprogramm zu schreiben. (10)	○	○	○	○	○

Page Break

Bitte kreuze das Kästchen an, das am ehesten zutrifft!

	NEIN! (1)	nein (2)	Weder ja noch nein (3)	ja (4)	JA! (5)
Wenn ich ein Robotikprojekt beginnen würde, würde ich es wirklich gut machen. (1)	○	○	○	○	○
Ich könnte lernen, einen Roboter zu bauen. (2)	○	○	○	○	○
Ich mag es, neue Dinge zu entwerfen. (3)	○	○	○	○	○
Ich würde gerne mehr über Robotik lernen. (4)	○	○	○	○	○
Ich fühle mich gut, wenn ich etwas über Technik lerne. (5)	○	○	○	○	○
Ich lerne gerne neue Fakten über Roboter. (6)	○	○	○	○	○
Ich finde es spannend, über Technik zu diskutieren. (7)	○	○	○	○	○
Ich mache gerne Robotik-Aktivitäten. (8)	○	○	○	○	○
Ich weiß, dass ich viel über Roboter lernen kann. (9)	○	○	○	○	○
Ich stelle viele Fragen zu Robotern, wenn ich sie nicht verstehe. (10)	○	○	○	○	○

Page Break

Bitte kreuze das Kästchen an, das am ehesten zutrifft!

	NEIN! (1)	nein (2)	Weder ja noch nein (3)	ja (4)	JA! (5)
Andere Leute halten mich für einen technischen Menschen (1)	○	○	○	○	○
Ich versuche, Aktivitäten zu machen, die mit Technik zu tun haben. (2)	○	○	○	○	○
Ich bin ein technischer Mensch. (3)	○	○	○	○	○
Wenn ich etwas über Computer nicht weiß, versuche ich, eine Antwort zu finden. (4)	○	○	○	○	○
Ich versuche oft, mehr über Computer herauszufinden. (5)	○	○	○	○	○
Ich bin ein Mensch, der gut mit Technik umgehen kann. (6)	○	○	○	○	○
Ich bin davon überzeugt, dass ich mehr über Technik weiß als meine Freunde. (7)	○	○	○	○	○
Technik ist für mich interessant. (8)	○	○	○	○	○
Ich habe ein gutes Gefühl bei Computern. (9)	○	○	○	○	○
Mir fallen Lösungen ein, auf die andere nicht kommen. (10)	○	○	○	○	○

Page Break

Bitte kreuze das Kästchen an, das am ehesten zutrifft!

	NEIN! (1)	nein (2)	Weder ja noch nein (3)	ja (4)	JA! (5)
Überall, wo ich hingehe, bin ich auf der Suche nach neuen Dingen über Roboter. (1)	○	○	○	○	○
Ich schaue gerne Fernsehsendungen und/oder lese über Roboter. (2)	○	○	○	○	○
Ich gehöre zu den Menschen, die Robotertechniker*in werden könnten. (3)	○	○	○	○	○
Ich suche so viele Informationen wie möglich über Roboter. (4)	○	○	○	○	○
Es ist wichtig für mich, etwas über Roboter zu lernen (5)	○	○	○	○	○
Es ist wichtig für mich, mehr über Technik zu wissen als die meisten Menschen (6)	○	○	○	○	○

Page Break

Bitte kreuze das Kästchen an, das am ehesten zutrifft!

	NEIN! (1)	nein (2)	Weder ja noch nein (3)	ja (4)	JA! (5)
Es ist cool, neue Dinge über Roboter zu lernen. (1)	○	○	○	○	○
Ich bin neugierig darauf, wie Roboter funktionieren. (2)	○	○	○	○	○
Es macht mir Spaß, neue Ideen über Robotik zu erforschen. (3)	○	○	○	○	○
Robotik ist für mich interessant. (4)	○	○	○	○	○
Ich bin daran interessiert, Dinge über Roboter zu entdecken. (5)	○	○	○	○	○
Ich möchte alles über Technik lernen, auch wenn es kompliziert ist. (6)	○	○	○	○	○

End of Block: Attitudes towards ER

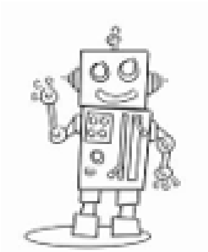
Appendix B: Feedback sheet

Roboter Unterricht mit Frau Lang

Was hat dir GUT gefallen?

Was hat dir NICHT GUT gefallen?

Was hättest du dir anders gewünscht?



Danke, dass du mitgemacht hast :)