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The effect of stem and stem-based robotic activities on the development of students' perceptions of mental risk-taking and its predictors and their inquiry skills in science learning

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ABSTRACT

The research explores the effect of STEM and STEM-based robotic activities on the development of students' perceptions of mental risk-taking and its predictors and their perceptions of inquiry learning skills related to science. A mixed method was applied in the research. Its sample consisted of 35 students in a high school of the Ministry of National Education in a medium-scale province of the Eastern Anatolia Region between the 2017-2018 educational year. The Scale for Perceptions of Mental Risk-taking in Science Learning and Its Predictors (SPMRSLIP) and the Scale for Perception of Inquiry Learning Skills for Science (SPILSS) were applied to obtain the quantitative data in the research. In addition, the focus group interview was held. The STEM and STEM-based robotic activities have been performed with the students for 14 weeks. In the findings obtained at the end of the research, no significant difference was determined between the perception pre-test and post-test scores related to mental risk-taking and its predictors in science learning. However, difference was found in the dimension of interest. It was found that there was a significant difference between the pre-test and post-test scores in the inquiry learning skills perception scale for science and the qualitative findings also supported this result. According to the results, it can be recommended that STEM and Robotic educations should be given in other grades.

Contribution/ Originality: In this study, different from other STEM studies in the literature, mental risk-taking and inquiry learning skills perceptions, which have not been studied before, are being researched. In the literature, mental risk taking and inquiry learning skills are important in terms of raising students as qualified individuals in the future.

1. INTRODUCTION

Science is a process of describing the universe by using and arranging real scientific methods (Çepni, 2015). Since science is a quite significant branch of science that investigates the events in nature with the same purpose and contributes to the development of countries economically and scientifically, it plays an important role in the education system to be able to live in parallel with the developing structures and educate qualified individuals who can ensure this parallelism (Ayas, 1995). The science course, which has a wide scope in this aspect, offers an interactive environment that necessitates mental risk-taking such as making statements, asking questions, investigating and approving as required by its content. It is suggested in the literature that there is a positive relationship between academic achievement in science and mental risk-taking and inquiry skills (Trimpop, 1994).

Risk-taking is defined as behaviours in which there is no definite perception about the outcomes, that is, performed consciously or unconsciously, and are affected by logical reasoning, psycho-social and affective factors (Bozkurt, 2014). It is stated that activities such as planning a task, working with a group and achieving a task are effective in increasing risk-taking skills; thus, individuals would demonstrate positive tendencies related to their skills (Denrell, 2007). When it is considered that the risk-taking behaviours of, specifically, teenagers are fairly high compared with the other groups, it is realised that there are efforts towards teaching and developing this skill which is one of the important factors in giving decisions. Mental risk-taking is defined as a behaviour that indicates the students' willingness and unwillingness to cope with learning difficulties (Denrell, 2007; Peled, 1997). Its purpose is to provide the students to think deeply, analyse a problem situation, share his/her thoughts with others, consider their thoughts and use their experiences for the solution (Dweck, 2000). It is stated that the behaviours such as asking questions to teachers and peers, taking responsibility for situations whose outcomes are not specified, the tendency to answer the questions even though they do not know the answer, and making explanations about the subjects which have been studied are some of the mental risks that students may encounter in schools (Miller & Byrnes, 1997). It is claimed that taking mental risks is effective in increasing students' motivation and consequently contributes to the increase in academic achievement (Feldman, 2003). In this respect, risk-taking behaviour has a very important place in science learning, which is an important field in the age of science-technology. Another significant skill that is parallel with the mental risk in science learning is the skill of inquiry. Inquiry, that is, one of the high levels of inquiry thinking is the evaluation of the claims with the most common expression. It is a valid and reliable way of information search in directing individuals' decisions, beliefs and behaviours (Galinsky, 2010). The skill of inquiry is among the common skills that constitute the vision of curricula and aim to be acquired by individuals. Today, it is of great importance that students have the inquiry learning skills in learning not only in the school environment but also throughout their lives, to adapt to the changing and developing technological age. Students with inquiry learning skills gain meaningful and permanent learning by questioning (Balım & Taşkoyan, 2007). In addition, rather than memorising the scientific subjects in science learning, the students are given the skills to research, understand and apply these concepts. In other words, it provides students to discover information and increase their interest related to science. Thanks to the increasing interest, developments are observed in the researching, inquiring and problem-solving skills of the individuals (Akbaba, 2017).

The purpose of our education system is to educate individuals who can use their inquiry skills against the increasing competition between countries in the rapidly developing technological age, have a clear perception of mental risk-taking, have gained problem-solving skills, and are willing to research and investigate. Achieving these purposes necessitates providing learning environments in which the students participate actively (Ozturk, 2019). Accordingly, to ensure effective science teaching, STEM education, which is the most effective in creating environments and supports the skills of the student such as questioning, risk-taking, problem-solving, and creativity, directs individuals to produce, and whose positive results have been determined in the literature, comes forth (Çakır & Altun, 2022). STEM education is stated as an educational process which provides meaningful learning among students by bringing various sciences, associating learning information with daily life, increasing the skills necessary for life, taking risks mentally, and inquiring with a high-level point of view (Bybee, 2010). STEM, which is created with the first letters of the English words of the disciplines of science, technology, engineering and mathematics, is an up-to-date understanding of education in which these disciplines are integrated (Altun, 2019). With STEM education, the student is asked to realise the inquiry skills stages by giving problem situations from daily life and solving them. In addition, the development of their risk-taking skills is encouraged by putting into practice the solutions they produce for the solution of the problem situation. STEM provides the students use the knowledge and experiences that they learned to meet the needs of society and have the knowledge and skills to make the necessary directions. In addition, providing the permanence of the information learned primarily in science education and in other branches, to encourage inquiry, concrete applications are largely included (Batı, Çalışkan, & Yetişir, 2017). Some of these applications consist of robotic coding technologies. It is not only sufficient to know how to use technology but also the students must know how technology was created and develop knowledge-operation understanding skills (Göncü, Cetin, & Ercan, 2018). Robotic coding education also supports the individuals' mental development since it develops the learners' creativity, logical reasoning and high-level skills. Therefore, the countries argue that interdisciplinary education is significant to give STEM education and robotic coding education within the scope of STEM (Çepni, 2015). It is stated that robotic coding education which takes place within the scope of STEM education facilitates the studies in terms of education and training and helps to present the achievements in the field of science effectively (Eraslan, 2012). It creates a learning environment where the students can have fun while coding, playing, exploring, building and applying what they have learned to program for those who get robotic coding education (Ayşe & Boyuk, 2013). However, robotics training cannot be given at the desired level in the teaching process in our country due to both the costs and the lack of teacher competence (Kuş, 2016). In the literature review, it has been observed that there was not any study exploring STEM and STEM-based robotic activities in terms of mental risk-taking and prediction perceptions in science learning and inquiry learning skills towards science. The research aims to explore the effect of STEM and STEM-based robotic activities on the development of the PMRSLIP and PILSS.

2. METHOD

2.1. Research Model

A sequential explanatory mixed method pattern was used in the study. The sequential explanatory mixed method pattern aims to start the research problem with a quantitative stage and carry out qualitative data to explain the obtained quantitative results in the second stage. This study stands for two stages built upon one another, easily understood and differentiated (Sözbilir, 2017). The study was created as a single-group pre and post-test model. This group design is to find out the effect of the application on a group by comparing the pre-and post-test scores (Cohen, Manion, & Morrison, 2007; Creswell & Tashakkori, 2007). The focus group interview was conducted to collect qualitative data. The focus group interview is a special group method which is held within the scope of a definite topic to determine the detailed information and ideas of a selected participant group (Çokluk, Yılmaz, & Oğuz, 2011).

2.2. Research Group

The research sample consisted of 35 students at the 9th-grade level in a medium-level province in the Eastern Anatolia Region. The participants were included in the study voluntarily and by taking the necessary consent forms. The students stated that they had not taken any education related to STEM and Robotic activities before. The purposeful sampling method was applied to make deeper research in determining the participant group (Büyüköztürk, 2006).

2.3. Data Collection Tools

The scale for "Perceptions of Mental Risk-taking in Science Learning and Its Predictors (PMRSLIP)", which was developed by Beghetto (2009) and overlaps with the study purpose was used to measure the students' mental risk-taking and predictive perceptions towards science learning. The 5-point Likert-type scale consists of 18 items and its Cronbach alpha reliability coefficient is 0.86.

The scale for "Perception of Inquiry Learning Skills for Science (PILSS)", which was developed by Balım and Taşkoyan (2007) was applied to determine the inquiry learning skills of the students related to science. The 5-point Likert-type scale consists of 22 items and its Cronbach alpha reliability coefficient was 0.84.

A focus group interview was held to collect the qualitative data. In the focus group interview, in which 9 questions were asked, the questions were arranged in parallel with the open-ended and quantitative scale items and examined by two experts in the field of science in terms of the purpose.

2.4. Data Analysis Techniques

The quantitative data were subjected to statistical analysis in the study. At first, for the normality test, the Kolmogorov–Smirnov test was applied since the number of participants was above 30. It was found in the study that the PMRSLIP and the PILSS scales demonstrated normal distribution ($p=0.2>0.05$). Since the data demonstrated normal distribution, a correlated samples t-test was applied. It was observed that a homogeneous distribution was provided for this test ($p=0.96>0.05$; $p=0.108>0.05$) (Can, 2016).

A content analysis was used for the data. For this, firstly the audio records of the focus group discussions were transcribed, and the codes and categories were created. The steps in the content analysis are orderly as coding data, determining categories, and defining and interpreting themes (Yıldırım & Şimşek, 2008). In the validity and reliability part of the data analysis, the codes and categories which were created have been presented to two different experts for a month and the results from each coder have been combined and calculated as percentages. Accordingly, the reliability value was found as 85%. That the reliability value between the coders is above 70% indicates that it is reliable (Arastaman, Öztürk, & Fidan, 2018).

2.5. Implementation Process

The activities which would be applied before the applications were analysed by the two experts in the STEM field by examining the relevant research and applying the knowledge of various academicians. Some significant criteria and limitations were taken into account in this determining stage. It was taken care that activities would encourage mental risk-taking, predictive and inquiry skills for science in line with the purpose of the study, and be able to gain these skills, contain the characteristics of STEM education in each stage, the exciting features that the students could create designs by using the information they learned in the past and structuring them with the information they just learned. Especially, it was regarded that the STEM education and teaching steps were appropriate and students could create designs that would attract their attention during the activity. The activities consisted of the features that would enable students to use materials in daily life, to learn that they would use each material for a different purpose, and thus to approach the materials around them from different perspectives. The activities contained the production of machinery and robots, the production and development of algorithms, the understanding and production of coding logic with specially designed legos for waste materials (cardboard, plastic bottles, garbage skewers, etc.) and robotic coding. They need to obtain new information and integrate it with their existing knowledge to solve these problems since they might encounter problems continuously. Students learn to create solutions in a group to solve the problem and reach success by trial and error method. It was provided to remove the prejudices about the problem encountered in daily life with the experiences and learnings gained by the individual and to activate the ability to question and take risks by enabling them the opportunity to evaluate the process.

The activities were planned for 14 weeks in total and 2 hours per week. The activities were continued by creating groups with 4-5 members accompanied by a guide trainer in each group. In the first 8 weeks of the process, various activities that can be created with simple materials (pet bottles, tongue bars, paper, tin cola boxes etc.) that can be found in each side of daily life were applied. Then, robotic coding applications (designing robots with specially designed robotic coding Legos for engineering design and coding on the computer) were performed for the sixth week. During the application process, the necessary materials determined for each week and for a problem situation that is important to be related to real life are distributed to the groups. Student opinions related to the materials are taken (such as what can you do with these, what can you design). Then, a problem situation is presented and a discussion environment is formed. And theoretical information related to the design that will be created (for instance setting up a circuit, giving theoretical information about it) and the information about the design that will be created is given by the instructors. Then, the students are asked to make their designs as a group within 45+45 minutes using their imaginations and design ideas. The instructors have been in the position of guiding the process, not managing it. The students have been provided to reach them by giving directions and asking questions instead of telling the solutions directly. Besides, uniqueness was taken as the basis in the activities; that is, each group was left free to use their uniqueness in design, in a way that will serve the same purpose in the given problem situation, rather than being put into a certain mould and creating the same product for each group. In addition, each activity has certain traces of the previous activity. Thus, the individuals make progress by developing new experiences and perspectives by using the experience they have gained in the previous activity. According to this information, in a traffic lamp activity, among the activities, the participants were asked to come up with a traffic light design that works by using their theoretical knowledge such as science, mathematics and technology, by giving necessary materials such as conductive cable, cola cans, led lights, abeslang, which we call as simple material. Finally, the research scales were applied to the students and the research was concluded by making focus group interviews with the volunteer participants pre and post-activity.

3. FINDINGS

The quantitative and qualitative findings related to the PMRSLIP and PILSS scales in the study are presented together below.

Table 1. Correlated samples t-test results regarding to PMRSLIP scale.

Measurements	N	$\bar{X}$	Ss	T	Sd	P
Pre-test	27	63.333	14.994	1.502	26	0.145
Post-test	27	68.851	11.474			

Note: p>0,05.

The correlated samples' t-test results applied to determine the effect of the activities on PMRSLIP are presented in Table 1. No significant difference was found between the pre-activity score average (pre-test = 63.33) and post-activity score average (post-test =68.85) (t49: -1.502; p>0.05). However, it was observed that the average increased in the post-test.

Table 2. Correlated samples t-test results regarding to the sub-dimensions of PMRSLIP scale.

Sub-dimensions	Measurements	N	$\bar{X}$	Ss	T	Sd	P
Creative self-efficacy	Pre-test	27	16.407	5.256	0.372	26	0.713
	Post-test	27	15.888	4.651			
Mental risk-taking	Pre-test	27	23.703	4.102	1.026	26	0.314
	Post-test	27	22.518	5.228			
Interest in science	Pre-test	27	17.407	2.912	2.680	26	0.013
	Post-test	27	15.185	4.261			
Perception of teacher support	Pre-test	27	11.333	3.025	1.764	26	0.900
	Post-test	27	9.740	2.781			

The sub-dimension results related to the PMRSLIP of the students are presented in Table 2. In the test results, no significant difference was found between the pre-activity score average (pre-test = 16.40) and post-activity score average (post-test=15.88) in the creative self-efficacy dimension (t49: -0.372; p>0.05). In the dimension of mental risk-taking, no significant difference was encountered between the pre-activity score average (pre-test =23.70) and post-activity score average (post-test =22.51) (t49: 1.026; p> 0.05). In the dimension of interest in science, a significant difference was observed between the pre-activity score average (pre-test=17.40) and post-activity score average (post-test =15.18) (t49: 2.680; p<0.05). In the dimension of the perception of teacher support, no significant difference was encountered between the pre-activity score average (pre-test=11.33) and post-activity score average (post-test=9.74) (t49: 1.764; p>0.05).

Table 3. Correlated samples t-test results for the PILLS scale.

Measurements	N	$\bar{X}$	Ss	T	Sd	P
Pre-test	27	80.703	16.212	-3.219	26	0.003
Post-test	27	91.888	12.671			

Note: p>0,05.

The correlated samples' t-test results applied to determine the significant difference between the students' PILSS pre-and post-test scores are presented in Table 3. A significant difference was found between the pre-activity score average (pre-test = 80.70) and post-activity score average (post-test = 91.88) (t49: -3.219, p<0.05).

Table 4. Correlated samples t-test results for the sub-dimensions of the PILLS scale.

Sub-dimensions	Measurements	N	$\bar{X}$	Ss	T	Sd	P
Positive perceptions	Pre-test	27	34.111	8.741	2.382	26	0.025
	Post-test	27	37.963	5.431			
Negative perceptions	Pre-test	27	20.037	6.223	3.539	26	0.002
	Post-test	27	25.444	3.734			
Perception for inquiry accuracy	Pre-test	27	26.555	6.326	1.953	26	0.062
	Post-test	27	29.259	4.528			

The results related to the sub-dimensions of PILSS of the students are presented in Table 4. As the results of the test are examined, it was observed that there was a significant difference between the pre-activity score average (pre-test=34.11) and post-activity score average (post-test=37.96) in the dimension of positive perceptions dimension (t49:2.382; p>0.05). In the dimension of negative perceptions, a significant difference was observed between the pre-activity score average (pre-test=20.03) and the post-activity score average (pre-test=25.44) (t49:3.539; p<0.05). No significant difference was encountered between the pre-activity score average (pre-test = 26.55) and post-activity score average (post-test =29.25) in the dimension of perception for inquiry accuracy (t49: 1.953, p>0.05).

A focus group interview was held with the voluntary students selected among the participant groups in which STEM and STEM-based robotic activities were performed and the results are presented in the tables.

The answers related to the question are placed in Table 5 and 5 categories have been created. When the codes were examined, the students stated in general that they preferred to use their methods primarily in solving the problems in activities; they would apply their peers' ideas if they were not able to reach a result. However, some students found their peers' content knowledge insufficient and claimed that they could apply only the opinions of professionals.

While some students paid attention to the fact that the people they would take their opinions from were the people they liked, some stated that they could try all the logical ways, regardless of the method and personal quality, as long as they brought results.

Besides, the students stated that they could take the methods of other groups as an example during the activity, they tried to identify the mistakes by looking at the methods of the groups that successfully completed the activity before them, and they tried to complete the activity successfully. They also claimed that they were careful not to make the same mistakes by observing why the unsuccessful groups were unsuccessful, tried to solve the problems in cooperation, developed various ways, completed each other's deficiencies and supported each other.

Table 5. Student opinions related to the questions "Do you try to apply to your friends' ways of solutions in solving a problem in the activities? Have you tried to find a better way of solution by following your friends' ways of solution? How? Are your friends' opinions important for you?".

Category	Code name
Decision-making skills	Adopting own opinion Based on a different thought Inspiring a different opinion
Evaluation	Being result-oriented Empathy Content knowledge Qualification of idea owner Familiarity with the design process
Value	Reasonableness Empathy Achievement
Way of solution	Taking as example Trying new ways Working in group Group support Simulate
Thought	Individuality Achievement-oriented

Table 6. The student's opinions for the question " How did you feel in the activities? How should be the activities for you? How did you feel when you did not reach the result in the activities and what was your thoughts about why you could no reach the result? Have you tried to create solution ways? How?".

Category	Code name
Solution way	Trying to solve the problem Trial and error
Problem	Experiencing a setback Wrong method Being aware of mistakes
Thought	Reaching the result Resuming the activity
Feeling	Having fun Being happy Enjoying Being upset
Benefit	Getting the reward of your work Self-confidence The feeling of being clever Discovering skills Getting positive result
Activity process-environment	Extracurricular activity Wide area A small number of groups Supervisor qualification A supervisor, a student Group work

Student answers were included related to the question in Table 6 and 6 categories were created. When the codes were examined, the students stated that they tried to reach the result by trying various possibilities and thoughts during the activities, that they produced different solutions by considering their experiences in the previous activities, despite the setbacks, and that they completed the process. They claimed that they did not quit the activity when they realised that the wrong method was used in the activities, continued the activity, tried again according to the quality of the result, tried to fix the problem, and regretted the setbacks experienced during the activity, but the state of sadness did not affect the maintenance of the activity much, instead, they tried to reach the result by trying various possibilities. They also expressed that the activities made them feel smart, they feel good when they were successful at something, they had fun and they discovered their talents in the process. Most students claimed that doing the activities outside of school hours, giving a supervisor teacher to each student and having a wider-silent environment will further increase the efficiency of problem-solving activities.

Table 7. Student opinions related to the question "Have you ever thought what would you do with the material given to you?".

Category	Code name
Pre-education process	Not using simple material Inability to make a prediction Extraordinary Estimating
Post-education process	Skill of fiction Simple material Design Going from the part to the whole

Student answers related to the question are presented in Table 7 and 2 categories were created. When the codes were analysed, the students had never thought about designing something with simple materials at first; however, as they did the activities their skills in this field were developed and in the upcoming activities everyone had an idea of design.

They stated that the predictions made about what to design with the materials given during the activity were sometimes correct, and sometimes they made extraordinary estimations. In addition, they claimed that they experienced designing things with simple materials by going from the part to the whole.

Table 8. Student opinions related to the question "How do you behave when you encounter a problem in daily life? How do you behave when you encounter the problems during the activities?".

Category	Code name
Problem situation in the activity	Concrete Integration with daily life
Solution way in activity	Group support Trial and error Dexterity Reasoning
Thought	Abstract Personal problem Making life easier
Solution way in daily life	Reasoning

In Table 8, students' answers related to the question are presented and 4 categories have been created. When the codes were examined, the students claimed that they tried to find solutions by reasoning since the problems they encounter in daily life are abstract and personal situations.

They claimed that while they did not think that they could design something with the simple materials they saw around them until today, they can now design something with these materials, and this situation will facilitate the difficulties in case of problems and needs in life. During the activities, they stated that they encountered concrete situations contrary to the abstract situations encountered in daily life, and therefore they tried to reach the result by reasoning with the trial and error method.

In Table 9, the students' answers related to the question are presented and 3 categories have been created. When the codes were examined, the students stated that the activities were very fun, they liked to produce something using simple materials, they learned to make various trials to produce, it included subjects close to daily life, they were psychologically influenced positively as they succeeded, that it could be beneficial for the future humanity, and that it might create the opportunity to make production.

Table 9. Some high school students' opinions related to the questions "Have you enjoyed producing new things? Do you make an effort to produce them? Have the activities changed your feelings about producing?".

Category	Code name
Method	Producing with simple material Trying to produce
Feeling-thought	Having fun Production possibility Loving to produce
Benefit	Meeting the needs Not needing Contribution to psychology Benefit for humanity Closeness to life Being free-rider

Table 10. Some high school students' opinions related to the question "Do you try new ways even if you know you will not reach the result regarding to a problem you encountered in your daily life? Why? What are the effects of the activities to this?".

Category	Code name
Method	Trial and error Creating solution
Information	Prior information Given information New information
Feeling-thought	Giving up Hoping Having no time

The answers of the students to the question are presented in Table 10 and 3 categories have been created. When the codes were examined, most of the students claimed that they did not give up trying even if they could not reach the result, they tried various ways and they achieved. They stated that they tried to produce ways of the solution by syncretising the new knowledge they learned in the activities with their existing knowledge. On the other hand, some students claimed that if the method they applied failed, they were not willing to try another way.

Table 11. Students' opinions related to the question "Did these activities cause a change in your wish to learn about science, the desire to succeed, and the attitude towards the science-physics lesson?".

Category	Code name
Feeling	Achievement Pleasure Feeling good Caring for science
Learning	Comprehension of subject Concretising Learning by doing Science learning Ability to design Being in sync with the curriculum Setting up a machinery
Thought	Group work Suitability for the curriculum Viewpoint Giving up Learning from mistakes Paying attention to

The students' answers related to the question are presented in Table 11 with three categories. When the codes were examined, the students stated that the fact that the activities embody the abstract science subjects was more effective in comprehending the subjects and that it would be more effective if the current course subject was concurrent with the curriculum. They expressed that the situation such as their mistakes can be detected and corrected in the activity, the opportunity of learning by doing, the persistence without giving up have positive effects, that some science subjects that could not be learned in the past years can be easily understood as a result of these activities, and this creates a sense of achievement, makes them feel good and they like science. Most students claimed that teaching science with these activities was effective in their learning and created a willingness to succeed, while some students stated that they did not like science subjects and that a change in the way it was taught would not change their viewpoint on science.

Table 12. Student opinions related to the question "How did your activities contribute to your willingness to cope with the issues you could not achieve?.

Category	Kod Adık code
Feeling	Caring for learning Caring for science Caring for robotics
Thought	Standing firm Being result focused Contribution to coping with the problem Contribution to the future
Learning	Being in sync with the curriculum Wish to learn Problem-solving Different field

The students' answers related to the question are presented in Table 12 and 3 categories were created. When the codes were examined, most of the students claimed that they had already cared for science, and cared more thanks to these activities, the activities did not contribute to the lessons in the period they were studying and it would be more effective if they were in accordance with the curriculum of that year's course, but the knowledge and skills they learned in these activities may have an effect on the curriculum subjects to be achieved in the future. They also stated that it increased their desire to achieve, that they cared for robotics, that it contributed to their skills to cope with a problem situation, and that they learned not to give up on the route to achieve.

4. RESULT AND DISCUSSION

In the study, the effect of STEM and STEM-based robotic activities which were applied in 11th grade on the PMRSLIP was examined and a significant difference was not encountered in the end. No significant difference was found even in the sub-dimensions of the scale as mental risk, creative self-efficacy, and perception related to teacher support. However, a significant difference was detected in the interest in the science sub-dimension. Besides it was observed that there was an improvement in their skills related to the sub-dimensions of creativity, interest in science, self-efficacy, mental risk-taking and perception as a result of the focus group interview conducted related to measuring the mental risk and predicting perceptions. The findings were obtained from the qualitative data rather than the quantitative data provided to realise the development more in detail. The basic reason for this may be originated from using qualitative data to explain the quantitative data (Fırat, Yurdakul, & Ersoy, 2014). Accordingly, when the students' opinions related to science, taking a mental risk and supporting qualitatively were analysed, they expressed that there was a change in their point of view towards science, they began to care for it, mechanical subjects started to attract their attention, and the sense of achievement positively affected their interest in a science lesson. The qualitative results of the interest in science sub-dimension are "I like science", and "Science as a subject is important for me". The students claimed in the results of the perception related to teacher support sub-dimension that their instructors guided them was useful for the activity. Gazibeyoglu (2018) suggested that STEM education increases students' attitudes, perceptions and motivations towards science courses and the students claimed that the courses became more fun. Butuner (2019) expressed in a study that the students, who got robotic coding education, had more interest towards school and course, developed their problem-solving skills, increased their course motivations, considered the topics from different dimensions than usual, the desire and success of the students were also effective in other courses and they became willing to produce. In the present study, the students claimed that they became more motivated for success at the end of the activity, the achievement encouraged them to more desire and effort, increased their interests, tried various methods and were able to make evaluations according to the results. In addition, Doppelt, Mehalik, Schunn, Silk, and Krysinski (2008) claimed in their study that STEm education had a significant place in the student's interest in science, desired to learn and increased their achievements. Miller and Byrnes (1997) suggested that the classroom environment that the teachers created and the opportunities they offered to the students were significant in terms of both revealing individual skills and abilities and in focusing on success by taking risks. Henriksen and Mishra (2013) claimed that students' mental risk-taking levels can not be as high as expected in today's education environment, the student's performance could be increased by improving this environment with various arrangements and the supportive guidance of teachers. Besides, mental risk-taking behaviours also include the behaviours such as problem-solving in the learning environment, making decisions, asking questions, discussing and criticising. It was realised even in the results of the present study that the STEM and robotic activities increased the students' decision-making learning desire for science; and had a positive effect on the mental risk-taking skills such as critical thinking, researching-inquiring and problems solving. The mentioned mental risk-taking behaviours are the behaviours suitable for the nature of teaching science (Beghetto, 2009). Therefore, it is thought that individuals' mental risk-taking behaviours should be increased in increasing achievement in science (Dasci & Yaman, 2014). Tay, Özkan, and Akyürek-Tay (2009) refer that STEM education raises these behaviours; as the interest in the science of students with high risk-taking levels increases, their willingness to take mental risks also increases. In the qualitative results of the study, it was determined that the activities made the students experience the feeling of achievement, and provided developments in the creative and self-efficacy competencies which have the sub-dimension of cognitive risk-taking such as producing, designing motivation increase, and high-level thinking. In addition, it was paid attention to cooperation in groups and the students claimed that they were satisfied with this cooperation and learned various points of views-way of solutions, they did not know the exact result by taking encouragement from each other while creating the product, but they made different experiments in line with the possibilities and they felt a sense of achievement when it gave positive results, and when it did not, it was an experience for other activities. Çömek and Avcı (2016) stated that teachers, who apply robotic coding education in science education, increase the students' active participation and positive attitudes towards the course and this also has a positive effect on academic achievement, collaborative learning, motivation, and in cognitive and affective fields.

Developing the students' interests and attitudes towards Science course which has a significant place in the field of education in today's information and technology age is fairly significant for them to be qualified individual who researches, thinks critically, has questioning skills, is productive, compatible with the competition of the age (Cepni & Cil, 2012). According to this purpose, the effect of STEM and STEM-based activities on the students' PILSS was investigated in the second problem situation of the study. Consequently, it was found that there was a significant difference between the pre-and post-test scores of the positive and negative perceptions among the sub-dimensions of the PILSS scale. On the other hand, no difference was found in the dimension of perceptions of inquiring about accuracy. However, it was observed that it provided positive effects on the qualitative data. Accordingly, the students claimed that they had carried out the experiment process with their peers and tried to reach a positive result in cooperation by searching for the reasons for the setbacks they encountered and examining the mistakes by evaluating the process, result and product. Besides, the students claimed that their desires for concretising the contents of courses enrichening with an experimental setup indicated that the activities developed their perceptions of inquiring about the accuracy. Çakır and Altun (2020) suggest that the Montessori approach-based STEM activities develop the student's skills such as learning with cooperation, problem-solving, critical thinking and creativity. Ministry of National Education (2013) refers that the efforts of raising individuals who can research, question and work in cooperation with students for educational purposes can be achieved through the course content carried out with STEM activities. Individuals are expected to present ways of solutions by using various disciplines in their routes to solve the problems they encounter in daily life, thinking creatively and analytically and working in cooperation. The educational objectives are in parallel with the results gained by the students in the study. In the results, the students found solutions to the problem given by using the STEM disciplines and applying them. They used their creativity by questioning the source of the problem in creating their products. They claimed that they were pleased with producing and they wanted to learn the subjects in the school curriculum by doing instead of learning passively in the course. In this process, it was determined that they wanted to design the items they need in daily life and develop their design skills. It was observed that each individual in the group exchanged ideas with her groupmates and respected different opinions and engaged in a level discussion. Jacobs (1989) referred that the students solved the problems they encountered in daily life by considering various disciplines with a critical point of view during the activities in the STEM field. Sanders (2009) emphasised that the social interaction between students in STEM learning environments makes them more enthusiastic to learn and increases academic achievement. Çömek and Avcı (2016) claimed that the robotic applications attracted the students' attention in the lessons, and they enjoyed doing the activities and developed their creativity. Besides, they added that these applications improved their hand skills, produced new things, increased their self-confidence and gained a different perspective. Thomasian (2011) stated that STEM education increased the students' basic knowledge levels in the science, technology, engineering and mathematics disciplines and provided creative solutions to solve relevant problems in their daily life. Bakırcı and Kutlu (2018) claimed that STEM developed the students' research-inquiry skills, provided them to design the products appropriate to the problem situation, and permanent learning by concretising the science topics. Adıgüzel, Ayar, Corlu, and Özel (2012); Kaya (2010); Kökdemir (2003) and Uğraş (2017) reached the thoughts and results including that STEM education would offer the students an inter-disciplinary point of view, develop their perceptions for inquiry, the skills of analysing, problem-solving, engineering designs, analytical thinking and creativity.

No research on STEM and STEM-based Robotics activity related to the development of mental risk-taking and predictive and inquiry learning skills, which are stated to play an important role in science learning have been encountered in the literature. The students should have the robotic coding skills that can question, produce, take mental risks to produce, have predictive skills, can solve problems, think critically, and be intertwined with technology for students to grow up as qualified individuals of the future (Altun, 2019). It is possible with STEM education to train the students in this field and support their development (Topsakal, Yalçın, & Çakır, 2022). In line with the results of the study conducted with this purpose, these recommendations can be given: It is thought that giving STEM and Robotics education from the preschool period will increase effectiveness and permanence, and supporting teachers with in-service training in these areas will ensure the spread of education, and application of the course topics included in the activities by integrating them with the curriculum of that year will give more effective results. As the limitations of the study, the effect of STEM education on mental risk and questioning perceptions in science learning was limited in terms of gender, and only female students were investigated. Only the experimental group was included in the sample group due to time and cost problems.

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