Croatian Journal of Education
Vol.28; No.1/2026, pages: 47-81
Original scientific paper;
Paper submitted: 19th January 2026
Paper accepted: 29th March 2026
https://doi.org/10.15516/cje.v28i1.41863

# Nurturing the Gifted Scientific Mind: The Role of Enriched Science and Engineering Modules in Developing Science Process Skills

**Nurettin Can Bodur, Cengiz Tuysuz and Ilker Ugulu**
*Usak University, Faculty of Education*

## *Abstract*

*The aim of this study was to examine the effects of an enriched module series prepared for gifted students on their scientific process skills (SPS). In the study, the modules were implemented to the students at science lesson and the effect of the implementation on students' SPS was analysed. Embedded quasi-experimental mixed design, one of the mixed methods designs, was used. According to quantitative results, it was identified that the enriched module series had positive effect on students' SPS. The collected qualitative data show that the implementation especially contributed to identifying the problem, forming a hypothesis, collecting information, creating a list of materials, determining control variables, making a plan for observation, drawing conclusions about the data and repeating the test. The quantitative and qualitative results of the study show that the application has a significant positive effect on the development of gifted students' SPS.*

**Keywords**: *differentiation; enrichment; gifted education; science education*

## Introduction

The necessities of society have changed throughout this era, known as the information age, when scientific and technical advancements are happening at an incredible pace (Verdugo-Perona et al., 2016). Technological revolutions have made educational reforms necessary (Tuysuz et al., 2024). This situation has further increased the importance of the education of the gifted (Ying, 2025). It is necessary to update the education programs for the gifted in line with the needs of the 21st century (Callahan et al. 2017;

Simut & Godor, 2023). Systematic and multi-faceted support of gifted students in the field of science education is an important part of the education strategies of developed countries (Ugulu, 2020).

### *Mainstream gifted education in Turkey*

Gifted education practices vary by country (Vekić-Kljaić & Mlinarević, 2024). When the literature is examined, interventions for the education of gifted students can be expressed in four groups: acceleration, grouping, differentiation and enrichment (Smith, 2006; Reis et al., 2021). In Turkey, gifted education, which is basically based on differentiation and enrichment, is provided by science and art centres (SACs) operating under the Ministry of National Education (Genç, 2016). Students identified as gifted continue their formal education at schools. In addition to their schools, students receive education at SACs in line with the programs designed for them. Individual education programs prepared according to the students' interests are implemented at SACs. The main purpose of SACs is to develop students' high-level skills with their individual talents and to maximize their potential (Bodur et al., 2026).

The SAC Science Course Program in Turkey aims to help gifted students realize their individual talents and gain the field-specific attitudes and skills necessary to maximize their creativity and potential. It also aims to direct students to the science fields in which they are most interested, for which they possess talent and can work on in depth in the future (MEB, 2024). For this reason, it is important to ensure that students think like scientists, work systematically and discover knowledge by structuring it. In this respect, the inquiry-based learning approach is an appropriate model for enriching the programs for gifted students (Ozgur & Yilmaz, 2017). Studies in the literature show that inquiry-based learning is effective in terms of in-depth understanding of the scientific process, discovering the laws of nature, placing knowledge in a meaningful context, developing critical thinking and developing positive attitudes towards science (Trna, 2014; Banchi & Bell, 2008). Sampson et al. (2013) stated that the science curriculum should include scientific writing for middle and high school students in order to provide scientific practices and better understanding of the basic ideas of science. In this respect, it is important include scientific writing in the science education of the gifted. SACs are institutions that aim to provide active learning and provide activity and project-based education. In this respect, it is very important to plan and implement interdisciplinary activities that provide the skills needed in the future and develop scientific thinking and writing skills (Tuysuz et al., 2023; Ugulu et al., 2024 a,b).

### *Scientific process skills and conceptual framework*

Various researchers have defined scientific process skills (SPS) differently. Gagne (1977) defined SPS as the basis for students' participation in scientific research. He stated that SPS enable students to understand and apply the scientific method effectively.

He stated that these skills include observation, classification, measurement, prediction, data interpretation and drawing conclusions. According to Padilla (1990), SPS are the basic competencies that students need to master in the context of scientific inquiry. These skills enable students to approach scientific questions with a structured and systematic method, allowing them to observe phenomena, create hypotheses, collect and analyse data, and draw evidence-based conclusions (Padilla, 1990). Çepni et al. (1996) defined scientific process skills as basic skills that activate the learner in science and facilitate learning, encourage them to take responsibility for their own learning processes, increase the chance of permanent learning and provide research methods. Lind (1998) defined SPS as thinking skills used to obtain information, think about solving problems and explain the obtained data. According to him, these skills are the essence of the skills that scientists use during their scientific studies and the basis of scientific thought and research. The American Association for the Advancement of Science (AAAS) defined SPS as a set of skills that are accepted as a reflection of the correct behaviours that scientists demonstrate during scientific studies. It has been stated that these skills have been adopted for many of the current science disciplines and are widely transferable (AAAS, 1994).

Although there are differences between the definitions and classifications of SPS made by different researchers, it can be said that all of them are similar in terms of basic principles and subskills. Regarding the application of SPS, Ferreira (2004) emphasized the necessity of taking into account the individual differences and cognitive development levels of students in the process of imparting SPS. Padilla (1990) classified SPS as basic and integrated skills. According to Padilla (1990), basic skills include observation, classification and measurement, while integrated skills include more advanced activities such as formulating hypotheses, conducting experiments and interpreting data. Integrated skills are necessary for higher-level scientific studies, and developing these skills at an early age prepares students for more complex scientific studies in the future. In addition, SPS are valuable not only in science-related fields but also in everyday life, where analytical thinking and evidence-based reasoning are useful (Tobin & Capie, 1982).

Teaching SPS from an early age contributes to long-term academic success as students become more proficient in applying these skills in a variety of contexts and subjects (Tuysuz et al., 2024). Research shows that students who regularly practice science skills develop stronger analytical thinking skills, better understand scientific content and improve their problem-solving abilities (Bybee, 1994). Effective methods for teaching SPS include hands-on experiments, cooperative learning and real-life problem-based scenarios in the learning process. These approaches strengthen students' understanding of the scientific method and increase their engagement with the material by allowing them to observe, experiment and hypothesize in a safe learning environment (Gormally et al., 2012). In this context, it is very important to develop SPS in the education of gifted individuals who are trained to be leaders in the development and progress of societies.

In this context, one of the main purposes of gifted education and science courses should be teaching students SPS (Padilla, 1990). In this study, the classification made by Çepni et al. (1996) was taken as a basis. According to Çepni et al. (1996), SPS are skills that activate the learner and facilitate learning, encourage them to take responsibility in their own learning processes, increase the chance of permanent learning and provide research methods. SPS entail basic process skills, causal process skills and experimental process skills (Figure 1).

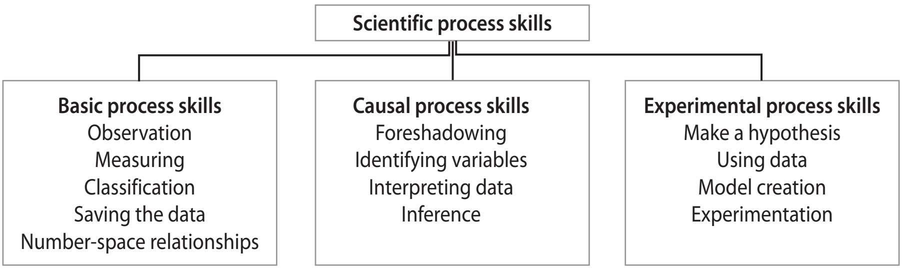


*Figure 1.* Classification of Scientific Process Skills (Çepni et al., 1996)

## Purpose and rationale of the research

Research, observation, experimentation, measurement and rationality used in the formation of scientific knowledge are the focus of the SAC science framework curriculum, instead of solely providing students with information, and the use of the scientific method is adopted as the main purpose (Ugulu, 2019; 2021). It is important to enrich the science curriculum appropriately in order to support gifted students in realizing their individual talents and maximizing their potential. The educational process in SACs is planned in line with the needs and talents of the individual (Hakkari et al., 2017; Bodur et al., 2022). This situation increases the importance of the variety of enriched in-class activities. In addition, when preparing the curriculum for gifted students, students' individual interests and talents should be taken into account (Gubbins et al., 2013). It is thought that providing students with the opportunity to choose the in-class activities is an effective way to recognize their individual interests and talents. In the study conducted by Tuysuz et al. (2024), the problem of the number and/or variety of in-class activities aimed at the realization of students' talents was revealed. In this context, the aim of this study was to examine the effects of an enriched module series prepared for gifted middle school students on their SPS. Based on the purpose of the study, the following research questions were formulated:

RQ1. Does the implementation of the enriched science and engineering module series have a significant effect on the scientific process skills (SPS) of gifted students compared to the standard SAC curriculum?

RQ2. How do gifted students perceive the effects of the enriched module series on the development of their scientific process skills?

RQ3. What are teachers' views regarding the effectiveness of the enriched module series in supporting students' scientific process skills?

# Methodology

## Research design

The research was conducted using the embedded quasi-experimental design, which is one of the mixed research designs (Cresswell, 2021). The mixed method is a research method in which quantitative and qualitative data are used together to seek a solution to the problem. In this study, quantitative data were collected before and after the intervention. Some of the qualitative data were collected during the intervention to verify the quantitative results. Some of the qualitative data were collected after the quantitative data collection process to explain the quantitative results. The data were integrated according to certain rules. Thus, the quantitative results were explained and verified with the qualitative data. The research process is represented in Figure 2.

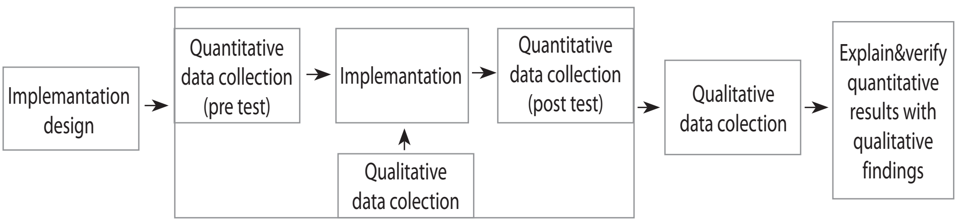


*Figure 2.* Research Process Chart (Cresswell, 2021)

## Research group

The research group consisted of 69 gifted middle school students who were educated in SACs located in 5 different provinces of Turkey (Table 1). The experimental group included 37 of these students, and 32 students were in the control group. The names of the students were kept confidential. Girls were coded as "G1, G2…" and boys as "B1, B2…". Given the quasi-experimental nature of the study, particular attention was paid to establishing the baseline comparability of the experimental and control groups. Pretest results indicated no statistically significant differences between the groups in terms of SPS scores ($p > 0.05$), which suggests that the groups were equivalent prior to the intervention. The selection of students for the experimental group was done via typical case sampling because the students educated in SACs were identified as gifted and met the necessary conditions to take the science course in the individual abilities recognition program (BYFP). Although the sample size ($N = 69$) was consistent with similar quasi-experimental studies conducted in the contexts of gifted education, no a priori power analysis was conducted. Therefore, the sample size and its representativeness should be considered as a limitation when considering the generalizability of the findings.

Table 1
*Information about the Students*

| Group | Province/ District | Grade Level | | | Gender | | Total |
|---|---|---|---|---|---|---|---|
| | | Grade 5 | Grade 6 | Grade 7 | Girls | Boys | |
| Experimental | Uşak/Center | - | 7 | 2 | 1 | 8 | 9 |
| | Uşak/Eşme | - | 5 | 4 | 5 | 3 | 8 |
| | Rize/Center | 8 | - | - | 6 | 2 | 8 |
| | Konya/Center | - | 6 | - | - | 6 | 6 |
| | Kütahya/Gediz | 2 | 4 | - | 4 | 2 | 6 |
| Control | Uşak/Center | - | 4 | 4 | 3 | 5 | 8 |
| | Uşak/Eşme | - | 2 | 5 | 4 | 3 | 7 |
| | Rize/Center | 5 | - | - | 1 | 4 | 5 |
| | Konya/Center | - | 5 | 2 | 2 | 5 | 7 |
| | Kütahya/Gediz | 2 | 3 | - | 4 | 1 | 5 |

## *Enhanced module series development process*

Within the scope of the enriched module series development, 20 activity modules were prepared. Activities were planned in the form of modules because each activity was structured through interdisciplinary integration within a theme framework (Barakos et al., 2012). Activities had certain limits and durations, with science discipline at the centre. An activity plan, activity notebook and activity poster were prepared for each module activity. Activity plans were for teachers, while activity notebooks were intended for students. Each activity notebook contained an introduction, problem status, discovery and research process guide, evaluation sections and a research report related the activity.

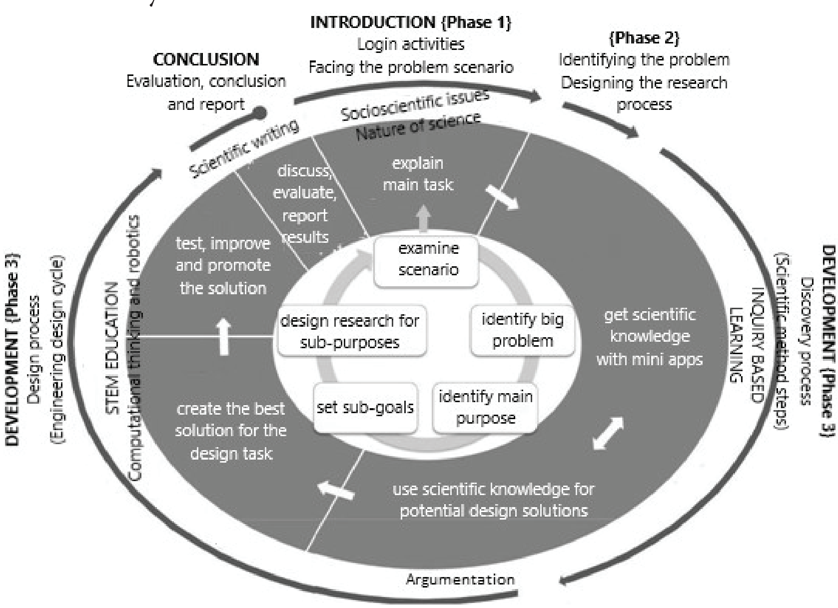


*Figure 3.* Enriched Activity Modules Design Framework (Moon et al., 2009)

For the development of the enriched module series, the design-based science education framework was used as the basis in the design process (Wendell et al., 2010). Inquiry-based learning, STEM education and scientific writing approaches were combined while creating the main structure of the modules. Some models were not used in all activities, and they were described as supportive: science, technology, society, environment, socio-scientific issues and nature of science, computational thinking, and robotic coding and argumentation. Enrichment was done using the Purdue Three-Stage Enrichment Model (Moon et al., 2009) (Figure 3).

### *The training process of teachers*

The participant teachers underwent an 18-hour course before the modules were implemented in classes with the students. A WhatsApp group was established after the course. Communication continued through the group. In addition, an online evaluation meeting was held at the end of each month during the application. The planning of the course was based on the professional development program design suggested by Loucks-Horsley et al. (2010).

### *Enriched module series implementation process*

The activities were implemented in five SACs located in the provinces of Uşak, Rize, Konya and Kütahya in Turkey in the first term of the 2023-2024 academic year (Table 1). The application lasted 18 weeks; two lessons per week. Activities were

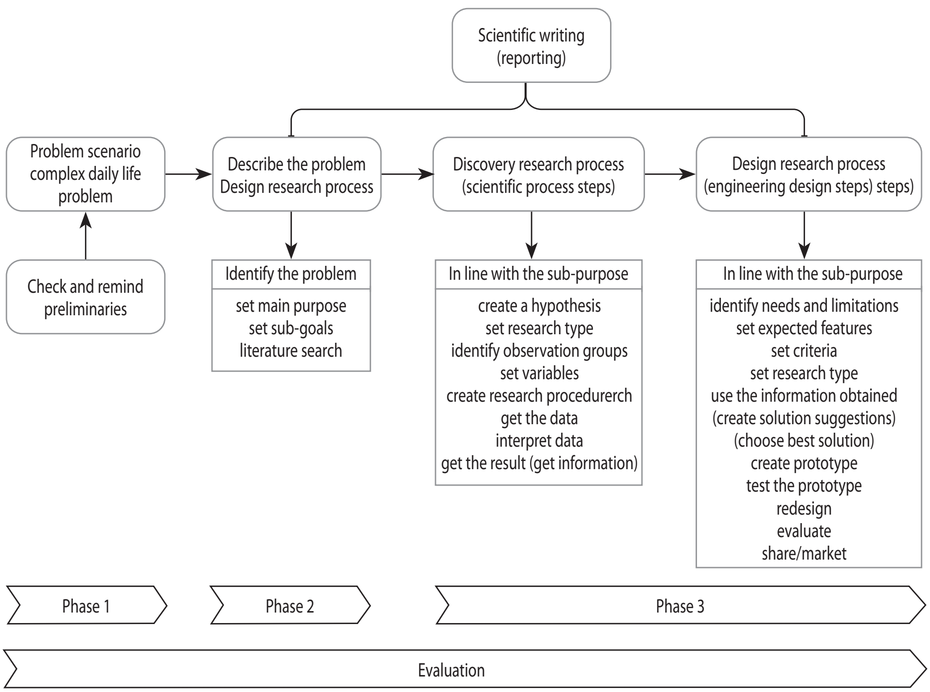


*Figure 4.* Scheme of the Activity Implementation Process

carried out in small groups (four to eight students). At the end of the application, the groups completed four activities. During the intervention period, the experimental group participated in the enriched science and engineering module series, whereas the control group continued to receive the standard SAC science curriculum without additional enrichment components. This distinction was critical for isolating the effect of the intervention. The stages of the implementation process are presented in Figure 4.

## *Data collection tools*

### Scientific process skills scale (SPS scale)

The SPS test was used in this study to determine the SPS of the students. This tool was created by Fowler (1990) and adapted by Ülger (2019). The instrument consists of open-ended assessment tasks designed separately for the pretest and post-test formats. Each task was evaluated using an analytical scoring rubric, with total scores ranging from 0 to 30. The KR-21 reliability coefficient of the instrument was reported as 0.828, which indicated acceptable internal consistency. In addition, content validity was ensured through expert review during the adaptation process (Ülger, 2019). However, the use of different open-ended questions in the pretest and post-test may raise concerns regarding test equivalence (Ugulu et al., 2008). Although both forms were designed to assess the same SPS constructs, this issue should be considered when interpreting the results.

### Student interview form

The form, prepared in a semi-structured format, consisted of five open-ended questions and probes related to these questions. The form was reviewed by three experts in their fields and updated in line with their opinions. Interviews were conducted online. The sub-dimensions in the SPS scale were taken as basis for the questions.

### Teacher interview form

The form, prepared in a semi-structured format, included one open-ended question and probes related to the question. The form was examined by three experts in the field and updated in line with expert opinions. This form was applied to five Science teachers who were responsible for the implementation. The interviews were conducted online.

## *Data Analysis*

Qualitative and quantitative analysis methods were used to process the obtained qualitative and quantitative data. Observer diversification was performed to ensure the validity and reliability of qualitative data. Kurtosis and skewness values were calculated to determine which tests would be used in the analysis of quantitative data (Table 2). Since the kurtosis and skewness values related to the distribution of the SPS post-test data were between the values of -1 and +1, the analysis was performed using parametric tests. To determine whether there was a difference between the post-tests, ANCOVA assumptions were tested. In addition, pretest scores were included as covariates in the ANCOVA model to control for initial group differences and to strengthen causal inferences within the quasi-experimental design. The results indicated that the assumption of homogeneity of regression slopes and equality of covariates was met (p > 0.05) (Table 3).

Table 2
*Skewness and Kurtosis Values of Quantitative Data*

| | | |
|---|---|---|
| SPS Pretest | Skewness | 1,126 |
| | Kurtosis | 0,756 |
| SPS Post-Test | Skewness | 0,01 |
| | Kurtosis | -1,00 |

Table 3
*Value of Equality of Covariates between Groups*

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | ,383[a] | 1 | ,383 | ,021 | ,886 |
| Intercept | 5353,427 | 1 | 5353,427 | 290,304 | ,000 |
| Group | ,383 | 1 | ,383 | ,021 | ,886 |
| Error | 1235,530 | 67 | 18,441 | | |
| Total | 6611,000 | 69 | | | |
| Corrected Total | 1235,913 | 68 | | | |

a. R Squared = ,000 (Adjusted R Squared = -,015)

Qualitative data sources were examined separately by two different observers using the disagreement and consensus principle (Yorek et al., 2010). Miles and Huberman (1994) recommended a standard of 80 % agreement on 95 % of the codes. In this context, the agreement percentage for the student interview form was calculated as 89 %, for the teacher interview form as 90 % and for the student reports as 84 %.

# Results

## *Results on scientific process skills*

The descriptive statistics values for the pretest and post-test are shown in Table 4. The pretest scores indicate that the control group (M = 8.90, SD = 4.23) and the experimental group (M = 8.76, SD = 4.35) had comparable baseline levels of SPS. The post-test results show an increase in both groups; however, the improvement was more pronounced in the experimental group (control group: M = 11.94, SD = 5.09; experimental group: M = 18.43, SD = 4.43). To test whether there was a statistically significant difference between the groups prior to the intervention, the Kruskal Wallis test was performed (Table 5). The results indicated that there was no significant difference between the SPS pretest scores of the groups ($\chi^2$ = 0.029, df = 1, p = .865). This result confirms the baseline equivalence of the groups.

Table 4
*Descriptive Statistics of Pretest and Post-tests*

| | Group | N | Mean | Std. Deviation | Std. Error |
|---|---|---|---|---|---|
| SPS_Pretest | Control_Group | 32 | 8,90 | 4,23 | ,75 |
| | Experiment_Group | 37 | 8,76 | 4,35 | ,71 |
| SPS_Post_Test | Control_Group | 32 | 11,94 | 5,09 | ,90 |
| | Experiment_Group | 37 | 18,43 | 4,43 | ,73 |

Table 5
*Kruskal Wallis Test Results*

| Test Statistics[a,b] | |
|---|---|
| | SPS_Pre_Test |
| Chi-Square | ,029 |
| df | 1 |
| Asymp. Sig. | ,865 |

*Note:* a. Kruskal Wallis Test, b. Grouping Variable: Group

According to ANCOVA analysis, a significant difference was found between the groups in terms of post-test scores (Table 6). After controlling for pretest scores as a covariate, the difference between the experimental and control group was statistically significant ($F(1,65) = 21.78$, $p < .001$). The effect size associated with this difference was moderate to large ($\eta^2 = .52$), indicating a substantial impact of the intervention on students' SPS. When the adjusted means are considered, it is seen that this difference is in favour of the experimental group. These results indicate that the enriched module series is an effective tool for improving the scientific process skills of gifted students.

Table 6
*ANCOVA Results for the Scientific Process Skills Post-Tests Scores*

| Source | Sum of Squares | df | Mean Squares | F | p | Effect Size |
|---|---|---|---|---|---|---|
| Pretest | 402,06 | 1 | 402,06 | 24,40 | 0,00 | 0,52 |
| Group | 358,99 | 1 | 358,99 | 21,78 | 0,00 | |
| Error | 1071,23 | 65 | 16,48 | | | |
| Total | 18640,00 | 69 | | | | |

### Students' opinions on enriched science and engineering modules

Interviews were conducted with the students after the implementation to verify and explain the quantitative results and provide data diversity. The theme, code, frequency and examples of students' ideas are presented in Table 7. Students found the enriched science and engineering modules useful primarily in terms of defining the problem (n = 14), formulating hypotheses (n = 13) and determining goals (n = 11) (Table 7).

The views of gifted students regarding the skills of planning show that they found the implemented modules useful primarily in terms of their ability to define the type of research (n = 14) and research steps (n = 12), and to plan security measures (n = 11) (Table 7). Students' views reveal that enriched modules can be an efficient tool in terms of planning a scientific study. A student's opinion is presented below:

Table 7
*SPS Student Interview Form*

| Theme | Code | Frequency (f) |
|---|---|---|
| Identifying the problem | Identifying the problem | 14 |
| | Hypothesis formulation | 13 |
| | Identifying the purpose | 11 |
| | Learning the meaning of a hypothesis | 6 |
| | Defining the problem | 3 |
| | Finding the problem in a long text | 2 |
| | Understanding the causes of problems | 2 |
| Planning research | Identifying the type of research | 14 |
| | Identifying research steps | 12 |
| | Planning security measures | 7 |
| | Making a plan before the research | 4 |
| | Implementing the research plan | 4 |
| | Security measures | 2 |
| | Learning the research process | 1 |
| Collecting information | Reviewing literature | 11 |
| | Determination of keywords | 6 |
| | Identification of keywords | 5 |
| | Checking the source of information | 4 |
| | Characteristics of secure sites | 2 |
| | Writing a references | 2 |
| | Learning to use technology | 1 |
| | Confirmation via different sources | 1 |
| | Presenting information in own words | 1 |
| Planning the data collection process | Learning the data collection process | 11 |
| | Identifying experimental variables | 10 |
| | Making a list of materials | 6 |
| | Designing experiments for a purpose | 6 |
| | Planning the measurement process | 5 |
| | Identifying the measurement tools | 5 |
| | Gaining material knowledge | 4 |
| | Presenting data (tables, graphs etc.) | 3 |
| | Testing the hypothesis | 1 |
| | Using technology when collecting data | 1 |
| Evaluation and conclusion | Writing reports | 13 |
| | Evaluation and making conclusions | 11 |
| | Test repetition | 10 |
| | Interpreting the data | 10 |
| | Presenting (sharing) data | 7 |
| | Learning the role of test repetition | 6 |
| | Reading and comprehension | 2 |
| | Consistent conclusion making | 2 |
| | Interpreting tables, graphs, etc. | 1 |

> *"It had an impact. It affected me in terms of determining the type of research... Now I can better select the type of research I need to do and the research steps I need to choose."* (B12, January 2024)

Regarding the theme of collecting information, which is another stage of the scientific research process, gifted students stated that they found the implementation of the enriched modules useful, especially in terms of providing literature review skills (Table 7). In terms of planning the data collection process, the expressions "learning the data collection process" (n = 11) and "identifying experimental variables" (n = 10) stand out (Table 7). The answers given to the relevant question of th semi-structured interview form showed that the students were able to learn the data collection stage through the experiment and observation process with the help of the developed module series. A student's view is presented below.

> *"We have determined which tool will be used in the experiment. Is it a microscope or a protractor? For example, are you measuring the angle? Like that… I now know how to plan for measurement and experimental variables. Independent, dependent and controlled variables…"* (G13, January 2024)

Regarding the evaluation and conclusion stage of the scientific process, the students stated that they found the enriched module useful for writing reports, evaluation and making conclusions, test repetition and interpreting data (Table 7). The frequency and variety seen in the students' answers regarding evaluation and conclusion can be taken as an indicator of the enriched modules' efficiency in skills development.

### *Teachers' opinions on enriched science and engineering modules*

The purpose of the interview with teachers was to verify and explain the quantitative results and provide data diversity. The information on themes, codes, frequencies and examples of students' ideas from the SPS interview with teachers is presented in Table 8. When the teachers' opinions on the effect of the implementation on students' SPS are examined, it can be seen that they considered the modules useful primarily for developing the skills of solving (n = 3), identifying (n = 2) and defining the problem (n = 2) (Table 8).

Regarding the gifted students' planning skills, the interviewed teachers found the modules useful primarily in terms of students' ability to define the research steps (n = 5) (Table 8). Teachers also stated that the enriched module's implementation was useful in terms of providing gifted students with the skill of literature review, especially in the stage of collecting data, which is another phase of the scientific process (Table 8). A teacher's statement reflecting this view is presented below.

*"I can say that children are now almost at a level where they can objectively solve all the problems they will encounter in life by including scientific process skills. Because we have included them in everything... There is a problem, there is a purpose, there is a hypothesis, there is literature review, there is a bibliography, there are variables in the experimental process. Enough questions were asked, it is very good."* (T2, January 2024)

Table 8
*SPS Teacher Interview Form*

| Theme | Code | Frequency (f) |
|---|---|---|
| Identifying the problem | Problem solving | 3 |
| | Identifying the problem | 2 |
| | Defining the problem | 2 |
| | Hypothesis formulation | 1 |
| | Working with purpose | 1 |
| | Gaining a scientific perspective | 1 |
| Planning research | Scientific research steps | 5 |
| | Planning the research process | 3 |
| | Selecting the type of research | 2 |
| | Learning basic scientific methods | 2 |
| | Forming observation groups | 1 |
| Collecting information | Literature review | 2 |
| | Using digital technologies | 1 |
| | Conducting interviews | 1 |
| | References | 1 |
| Planning the data collection process | Conducting the experimental process | 3 |
| | Testing the hypothesis | 2 |
| | Experimentation | 2 |
| | Data collection | 1 |
| | Using digital technologies | 1 |
| | Designing an experiment | 1 |
| | Designing a controlled experiment | 1 |
| Evaluation and conclusion | Writing a report | 4 |
| | Transferring collected data | 3 |
| | Presenting the research | 2 |
| | Conclusion | 1 |
| Others | Activity design suitable for SPS | 5 |
| | Learning by doing and writing | 4 |
| | Suitable materials for SPS | 3 |
| | Suitable scenarios for SPS | 3 |
| | Consciously developing SPS | 3 |
| | Real problems linked to SPS | 2 |
| | Report format suitable for SPS | 2 |
| | Working like a scientist | 1 |
| | Effective feedback cycle | 1 |

According to teachers' opinions regarding the effect of the module's implementation, gifted students' skills of planning the data collection process, conducting the experiment (n = 3), testing the hypothesis (n = 2) and experimentation (n = 2) come to the fore (Table 8). The teachers' responses to the relevant question showed that students were able to learn the experimental data collection stage with the help of the developed module series. The teachers also found the implementation useful with regard to the evaluation and conclusion stage of the scientific research process, especially in terms of providing gifted students with the skill of writing a report (n = 4) (Table 8). A teacher's opinion is presented below.

> *"The discovery process in the activity notebook and activity report was good for developing scientific process skills. In addition, the fact that the notebook and the report were structured contributed to the students' learning by doing them consciously."* (T3, January 2024)

The last question of the teacher SPS interview form regarded other themes the teachers would like to add to the implementation of the enriched science and engineering modules. All teachers who participated in the study (n = 5) stated that the modules were suitable for developing students' SPS (Table 8). The expressions indicate that the enriched science and engineering modules are useful and student-centred teaching materials and have features that support the development of students' SPS.

## Discussion

The results of this study show that the developed enriched science and engineering modules had a positive effect on the SPS of gifted students. These results show that the implemented series of science and engineering modules is an efficient tool that can be used in gifted education and included in the Gifted Education Curriculum in Turkey. Similarly, Özdeniz (2021) examined the effects of the enriched science module, which was designed according to the problem-based learning method founded on the integrated curriculum model and implemented in a blended learning environment. In line with the results obtained from the research, the science teaching design used in the study contributed to the development of students' inquiry-related competencies. In the present study, these outcomes are interpreted specifically within the framework of scientific process skills (SPS). However, VanTassel-Baska et al. (1998), Renzulli (2012), Ülger (2019) and Sanad et al. (2021) observed that the enriched curriculum tools on various contents improved the SPS of gifted students.

The results obtained from the semi-structured interviews conducted with gifted students support the quantitative results. In addition, the students' views explain the dimensions of the development in SPS. In the interviews, students referred to the SPS concepts, explained them in detail and reflected on the experienced processes via related examples. Furthermore, they gave detailed explanations regarding the processes of defining the problem, planning research, collecting information, planning data collection, evaluating and drawing conclusions. Moreover, they used the concepts that constitute the content and concepts related to the scientific process in their explanations. Similarly, Robinson et al. (2014) stated that the design of the enriched problem-based inquiry curriculum for gifted students was effective in terms of the development of students' SPS, basic scientific concepts and science content knowledge. Shin (2013) stated that higher-level SPS such as problem perception, problem result and planning the research should be more present. He drew attention to the fact that the activities should be designed in this way. It is important for students to express detailed opinions about these processes, which form the basis of SPS. Yıldız (2022) stated that STEM activities contribute to the development of sub-dimensions of scientific process skills of gifted students, such as determining variables, establishing hypotheses, conducting experiments, and making observations and predictions. The present study and the stated studies overlap in these respects.

The results of the semi-structured interviews with teachers also support the quantitative results and are in line with the students' opinions. In addition, the teachers' opinions helped examine the dimensions of the gifted students' SPS development. In the interviews, teachers stated that the application was useful in terms of developing problem-solving skills. Students also expressed similar opinions and stated that the application contributed especially in terms of determining the problem. Similarly, in the studies conducted by Renzulli (1977), Chávez et al. (2009) and Tüysüz et al. (2024), it was found that the enriched science curriculum contributed to students' problem-solving skills. Elmas (2020) stated that the enriched curriculum tool developed for gifted students was useful in terms of including different teaching methods (modelling, experiment, simulation) and ensuring active participation. Similarly, in the interviews conducted within the scope of this study, teachers frequently mentioned the data collection processes of their students.

Qualitative data obtained from the participant students' reports confirm and explain the quantitative results. These data show the longitudinal development of students' SPS throughout the process. Data obtained through student and teacher interviews also quantitative data. Reis et al. (2021) stated that gifted students generally develop their skills by including applied experiments, interdisciplinary studies and going beyond the standard curriculum through enriched curriculum. The qualitative data obtained in this study show that the modules' implementation contributed to determining the problem, creating hypotheses, collecting information, creating a list of materials, determining control variables, making plans for observation, drawing conclusions about the data and repeating the test, which are the sub-dimensions of SPS.

## Conclusion

This study demonstrates that an enrichment approach integrating inquiry-based learning, STEM practices and scientific writing can effectively support the development of scientific process skills in gifted students. The results highlight the potential of structured and interdisciplinary module designs to foster not only skills acquisition but also a deeper engagement with scientific thinking processes. By situating enrichment within a design-based and student-centered framework, the study provides a concrete example of how contemporary pedagogical approaches can be operationalized in gifted education contexts. In this respect, the study contributes to the literature by bridging theoretical perspectives on inquiry and enrichment with practical classroom implementation. Finally, the results underscore the importance of systematically designed enrichment experiences in supporting the development of higher-order scientific competencies and offer a foundation for further research and practice in this field.

### *Implications*

This study provides practical implications for curriculum designers, educators and policymakers. For curriculum designers, the results suggest integrating structured, interdisciplinary enrichment modules into science curricula, explicitly embedding stages of the scientific process within inquiry-based and STEM-oriented frameworks. For educators, the results highlight the importance of student-centered practices, including hands-on, problem-based activities and structured scientific writing tasks that engage students in designing experiments, identifying variables and interpreting data. For policymakers, the results support the development of enrichment-oriented frameworks in gifted education and emphasize the need for sustained teacher training in inquiry-based learning and STEM integration. Beyond Turkey, these results indicate that module-based enrichment approaches can be adapted to different educational contexts to support the development of scientific thinking and inquiry skills.

### *Limitations*

This study has several limitations that should be considered when interpreting the findings. First, the relatively small sample size (N = 69) and the absence of an a priori power analysis may limit the statistical power and generalizability of the results. Second, the quasi-experimental design, despite evidence of baseline equivalence between groups, restricts the ability to draw strong causal inferences due to the lack of random assignment and potential selection bias. Third, although the control group continued with the standard SAC curriculum, uncontrolled contextual differences between groups cannot be entirely ruled out. Fourth, potential researcher bias should be acknowledged, as the development, implementation and evaluation processes were conducted within the same research framework, despite efforts to enhance validity through triangulation and observer agreement. Fifth, the measurement approach had limitations; although the SPS instrument demonstrated acceptable reliability (KR-21 = 0.828) and content validity, the use of different open-ended questions in pre and post-tests raises concerns regarding measurement equivalence. Finally, the results are context-bound, as the study was conducted with gifted students in SACs in Turkey, which limits broader generalizability; additionally, the relatively short intervention period (18 weeks), the limited number of implemented modules, and potential variations in implementation's validity and teacher-related effects across centers may have influenced the results and limited conclusions regarding long-term sustainability.

## Acknowledgement

This study was prepared and implemented as a part of the doctoral dissertation by Nurettin Can Bodur under the supervision of Assoc. Prof. Dr. Cengiz Tuysuz and Assoc. Prof. Dr. Ilker Ugulu.

This study was conducted in accordance with ethical guidelines for research involving human subjects, including the principles outlined by the American Psychological Association (APA) and the Declaration of Helsinki. Participation was entirely voluntary, and informed consent was obtained from all students and their guardians prior to data collection. Confidentiality and anonymity were ensured throughout the research process, and participants had the right to withdraw at any time without any consequences. The study was designed to minimize potential risks and adhered to the ethical standards set forth by institutional and international research ethics committes.

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**Nurettin Can Bodur**
Usak University, Faculty of Education
Ankara-Izmir Street, 1 Eylul Campus
64100, Usak, Turkey
nurettincanbodur@gmail.com

**Cengiz Tuysuz**
Usak University, Faculty of Education
Ankara-Izmir Street, 1 Eylul Campus
64100, Usak, Turkey
cengiz.tuysuz@usak.edu.tr

**Ilker Ugulu**
Usak University, Faculty of Education
Ankara-Izmir Street, 1 Eylul Campus
64100, Usak, Turkey
ilkerugulu@gmail.com

# Razvijanje znanstvenoga uma nadarenih učenika: uloga obogaćenoga modula znanosti i inženjerstva u razvoju vještina znanstvenoga procesa


## *Sažetak*

*Cilj ovoga istraživanja bio je ispitati učinke obogaćenoga niza modula za nadarene učenike na njihove vještine znanstvenoga procesa (SPS). Pripremljeni moduli primijenjeni su na satima znanstvenih predmeta, pri čemu je analiziran njihov učinak na vještine znanstvenoga procesa učenika. Korišten je kvazieksperimentalni miješani dizajn, jedan od dizajna miješanih metoda. Sakupljeni kvantitativni podatci pokazali su da je niz obogaćenih modula imao pozitivan učinak na SPS učenika. Dobiveni kvalitativni podatci pokazali su da je primjena posebno doprinijela identificiranju problema, formiranju hipoteza, sakupljanju informacija, sastavljanju popisa materijala, određivanju kontrolnih varijabli, planiranju promatranja, donošenju zaključaka o podatcima i ponavljanju testa. Kvantitativni i kvalitativni rezultati istraživanja pokazali su da je primjena modela imala značajan pozitivan učinak na razvoj vještina znanstvenoga procesa učenika.*


**Ključne riječi**: *diferencijacija; obogaćivanje; obrazovanje nadarenih učenika; znanstveno obrazovanje*

## Uvod

Potrebe društva promijenile su se tijekom ovoga, informacijskoga doba, kada se znanstveni i tehnički napredak odvija nevjerojatnom brzinom (Verdugo-Perona i sur., 2016). Tehnološke revolucije učinile su obrazovne reforme nužnima (Tuysuz i dr., 2024). Ova je situacija dodatno povećala važnost obrazovanja darovitih (Ying, 2025). Važno je ažurirati obrazovne programe za darovite u skladu s potrebama 21. stoljeća (Callahan i sur., 2017; Simut i Godor, 2023). Sustavna i višestruka podrška darovitim učenicima u području znanstvenoga obrazovanja važan je dio obrazovnih strategija razvijenih zemalja (Ugulu, 2020).

## *Redovno obrazovanje nadarenih učenika u Turskoj*

Prakse obrazovanja darovitih učenika razlikuju se od zemlje do zemlje (Vekić-Kljaić i Mlinarević, 2024). U relevantnoj literaturi navode se intervencije u obrazovanju darovitih učenika koje se mogu svrstati u četiri skupine: ubrzanje, grupiranje, diferencijacija i obogaćivanje (Smith, 2006; Reis i sur., 2021). U Turskoj obrazovanje darovitih, koje se u osnovi temelji na diferencijaciji i obogaćivanju, provode centri za znanost i umjetnost (SAC) pod nadležnošću Ministarstva obrazovanja (Genç, 2016). Učenici prepoznati kao daroviti nastavljaju svoje formalno obrazovanje u školama. Osim u školama, učenici se obrazuju i u SAC-ovima u skladu s programima osmišljenima za njih. U SAC-ovima se provode individualni obrazovni programi pripremljeni prema interesima učenika. Glavna svrha SAC-ova jest razvijanje vještina visoke razine učenika u skladu s njihovim individualnim talentima i maksimiziranje njihova potencijala (Bodur i sur., 2026).

Program znanstvenoga obrazovanja u SAC-ovima u Turskoj ima za cilj pomoći darovitim učenicima pri ostvarivanju njihovih individualnih talenata i stjecanju specifičnih stavova i vještina potrebnih za maksimiziranje kreativnosti i potencijala. Također ima za cilj usmjeriti učenike na znanstvena područja koja ih najviše zanimaju, za koja imaju talenta i u kojima mogu predano raditi u budućnosti (MEB, 2024). Zbog toga je važno osigurati da učenici razmišljaju poput znanstvenika, rade sustavno i stječu znanje strukturiranjem. U tom pogledu, pristup učenju temeljenom na istraživanju prikladan je model za obogaćivanje programa za darovite učenike (Ozgur i Yilmaz, 2017). Istraživanja u literaturi pokazuju da je učenje temeljeno na istraživanju učinkovito u smislu dubokoga razumijevanja znanstvenoga procesa, otkrivanja zakona prirode, stavljanja znanja u smislen kontekst, razvijanja kritičkoga mišljenja i razvijanja pozitivnih stavova prema znanosti (Trna, 2014; Banchi i Bell, 2008). Sampson i suradnici (2013) navode da bi kurikul prirodnih znanosti trebao uključivati znanstveno pisanje za učenike viših razreda osnovne i srednje škole kako bi se osigurale znanstvene prakse i bolje razumijevanje temeljnih ideja znanosti. U tom pogledu važno je da znanstveno pisanje bude uključeno u znanstveno obrazovanje darovitih. SAC-ovi su institucije koje imaju za cilj omogućiti aktivno učenje i obrazovanje temeljeno na aktivnostima i projektima. U tome smislu vrlo je važno planirati i provoditi interdisciplinarne aktivnosti koje pružaju vještine potrebne u budućnosti i razvijaju znanstveno razmišljanje i vještine pisanja znanstvenih radova (Tuysuz i sur., 2023; Ugulu i sur., 2024 a,b).

## *Vještine znanstvenoga procesa i konceptualni okvir*

Različiti su istraživači različito definirali vještine znanstvenoga procesa (SPS). Gagne (1977) je definirao SPS kao temelj za sudjelovanje učenika u znanstvenome istraživanju. Navodio je da SPS omogućuju učenicima učinkovito razumijevanje i primjenu znanstvene metode. Smatrao je da te vještine uključuju promatranje, klasificiranje, mjerenje, predviđanje, tumačenje podataka i donošenje zaključaka. Prema Padilli (1990), SPS su osnovne kompetencije koje učenici trebaju usvojiti u kontekstu znanstvenoga istraživanja. Te vještine omogućuju učenicima da znanstvenim pitanjima pristupe na strukturiran i sustavan način, što im omogućuje promatranje pojava, definiranje hipoteza, prikupljanje i analizu podataka te donošenje zaključaka utemeljenih na dokazima (Padilla, 1990.). Çepni i suradnici (1996) definirali su vještine znanstvenoga procesa kao osnovne vještine koje aktiviraju učenika u znanosti i olakšavaju učenje, potiču ga da preuzme odgovornost za vlastite procese učenja, povećavaju mogućnost trajnoga učenja i omogućuju primjenu istraživačkih metoda. Lind (1998) je definirao SPS kao vještine razmišljanja koje se koriste za dobivanje informacija, promišljanje o rješavanju problema i objašnjavanje dobivenih podataka. Prema njemu, te su vještine suština vještina koje znanstvenici koriste tijekom svojih znanstvenih istraživanja i temelj znanstvenoga razmišljanja i istraživanja. Američko udruženje za unaprjeđenje znanosti (AAAS) definiralo je SPS kao skup vještina koje predstavljaju odraz ispravnoga ponašanja znanstvenika tijekom znanstvenih istraživanja. Navodi se da su te vještine usvojene u mnogim suvremenim znanstvenim disciplinama i da su uvelike prenosive (AAAS, 1994).

Iako postoje razlike između definicija i klasifikacija SPS-a koje su dali različiti istraživači, može se reći da su sve slične u pogledu osnovnih načela i podvještina. Što se tiče primjene SPS-a, Ferreira (2004) je naglasio nužnost uvažavanja individualnih razlika i razina kognitivnoga razvoja učenika u procesu poučavanja SPS-a. Padilla (1990) je klasificirao SPS kao osnovne i integrirane vještine. Prema Padilli (1990) osnovne vještine uključuju opažanje, klasifikaciju i mjerenje, dok integrirane vještine uključuju naprednije aktivnosti kao što su formuliranje hipoteza, provođenje eksperimenata i tumačenje podataka. Integrirane vještine nužne su za znanstvene studije višega nivoa, a razvijanje tih vještina u ranoj dobi priprema učenike za složenije znanstvene studije u budućnosti. Osim toga, SPS su vrijedne ne samo u znanstvenim područjima, već i u svakodnevnom životu, u kojemu su analitičko razmišljanje i rasuđivanje utemeljeno na dokazima vrlo korisni (Tobin i Capie, 1982).

Poučavanje SPS-a od rane dobi doprinosi dugoročnom akademskom uspjehu jer učenici postaju vještiji u primjeni tih vještina u različitim kontekstima i predmetima (Tuysuz i sur., 2024). Istraživanja pokazuju da učenici koji redovito vježbaju znanstvene vještine razvijaju analitičke sposobnosti više razine, bolje razumiju znanstveni sadržaj i poboljšavaju svoje sposobnosti rješavanja problema (Bybee, 1994). Učinkovite metode poučavanja SPS-a uključuju praktične eksperimente, suradničko učenje i scenarije učenja temeljene na problemima iz stvarnoga života. Ovi pristupi produbljavaju razumijevanje znanstvene metode učenika i povećavaju njihovu angažiranost u usvajanju nastavnoga sadržaja tako što im omogućuju promatranje, eksperimentiranje i postavljanje hipoteza u sigurnome okružju za učenje (Gormally i sur., 2012). U tome kontekstu vrlo je važno razvijati SPS u obrazovnim i odgojno-obrazovnim procesima darovitih pojedinaca koji se obučavaju da budu vođe u razvoju i napretku društava.

U ovome kontekstu jedna od glavnih svrha obrazovanja darovitih iz znanstvenih predmeta trebala bi biti pružanje mogućnosti učenicima za razvoj SPS-a (Padilla, 1990). Ova studija zasnovana je na klasifikaciji SPS-a Çepnija i suradnika (1996), koji SPS definiraju kao vještine koje aktiviraju učenika i olakšavaju učenje, potiču ga da preuzme odgovornost za vlastite procese učenja, povećavaju mogućnost trajnoga učenja i pružaju mogućnost primjene istraživačkih metoda. SPS obuhvaćaju osnovne procesne vještine, kauzalne procesne vještine i eksperimentalne procesne vještine (Slika 1).

*Slika 1.*

## Svrha i razlog istraživanja

Istraživanje, opažanje, eksperimentiranje, mjerenje i racionalnost koji se koriste u stvaranju znanstvenoga znanja u središtu su kurikula znanosti SAC-a, umjesto isključivo pružanja informacija učenicima, a primjena znanstvene metode usvojena je kao glavni cilj (Ugulu, 2019; 2021). Važno je primjereno obogatiti kurikul znanosti kako bi se nadarenim učenicima pomoglo u ostvarivanju njihovih individualnih talenata i maksimiziranju njihovih potencijala. Odgojno-obrazovni proces u SAC-ovima planira se u skladu s potrebama i talentima pojedinca (Hakkari i sur., 2017; Bodur i sur., 2022). Ta situacija povećava važnost osiguravanja raznolike ponude obogaćenih aktivnosti u učionici. Osim toga, prilikom pripremanja nastavnoga plana i programa za darovite učenike treba uzeti u obzir individualne interese i talente učenika (Gubbins i sur., 2013). Smatra se da je osiguravanje mogućnosti odabira učioničkih aktivnosti za učenike učinkovit način prepoznavanja njihovih individualnih interesa i talenata. U studiji koju su proveli Tuysuz i suradnici (2024) otkriven je problem broja i/ili raznolikosti učioničkih aktivnosti usmjerenih na ostvarenje talenata učenika. U tom je kontekstu cilj ove studije bio ispitati učinke obogaćene serije modula za darovite učenike osnovne škole na njihove vještine znanstvenoga procesa. Na temelju ovako postavljenoga cilja formulirana su sljedeća istraživačka pitanja:

IP1. Ima li niz obogaćenih modula znanosti i inženjerstva značajan učinak na vještine znanstvenoga procesa (SPS) darovitih učenika u usporedbi sa standardnim SAC kurikulom?

IP2. Kako daroviti učenici percipiraju učinke serije obogaćenih modula na razvoj svojih vještina znanstvenoga procesa?

IP3. Koja su stajališta nastavnika o učinkovitosti niza obogaćenih modula u razvoju vještina znanstvenoga procesa učenika?

## Metodologija

### *Dizajn istraživanja*

Istraživanje je provedeno primjenom kvazieksperimentalnoga dizajna, koji je jedan od mješovitih istraživačkih dizajna (Cresswell, 2021). Mješovita metoda je istraživačka metoda u kojoj se kvantitativni i kvalitativni podatci koriste zajedno kako bi se pronašlo rješenje za problem. U ovoj studiji kvantitativni su podatci prikupljeni prije i nakon intervencije. Neki su kvalitativni podatci prikupljeni tijekom intervencije, a neki nakon procesa prikupljanja kvantitativnih podataka radi njihova objašnjenja. Podatci su integrirani prema određenim pravilima. Na taj su način kvantitativni rezultati objašnjeni i provjereni pomoću kvalitativnih podataka. Proces istraživanja prikazan je na Slici 2.

*Slika 2.*

## *Uzorak ispitanika*

Istraživačka skupina obuhvatila je 69 darovitih učenika viših razreda osnovne škole koji su pohađali SAC-ove smještene u 5 različitih provincija u Turskoj (Tablica 1). Eksperimentalna skupina uključivala je 37 učenika, a kontrolna skupina 32 učenika. Sudjelovanje je bilo anonimno: djevojčice su kodirane kao „G1, G2…“, a dječaci kao „B1, B2…“. S obzirom na kvazieksperimentalnu prirodu istraživanja, posebna je pozornost posvećena uspostavljanju početne usporedivosti eksperimentalne i kontrolne skupine. Rezultati preliminarnoga testiranja nisu pokazali statistički značajne razlike između skupina u pogledu SPS bodova ($p > 0,05$), što upućuje na to da su skupine prije intervencije bile podjednake. Odabir učenika za eksperimentalnu skupinu proveden je metodom tipičnoga uzorkovanja slučajeva jer su učenici obrazovani u SAC-ovima identificirani kao daroviti i ispunili su potrebne uvjete za pohađanje nastave iz prirodnih znanosti u programu prepoznavanja individualnih sposobnosti (BYFP). Iako je veličina uzorka ($N = 69$) bila u skladu sa sličnim kvazieksperimentalnim studijama provedenima u kontekstu obrazovanja darovitih učenika, nije provedena a priori analiza statističke snage. Stoga se veličinu uzorka i njegovu reprezentativnost treba smatrati ograničenjem pri uopćavanju rezultata istraživanja.

Tablica 1

## *Proces razvoja pojačanoga modula*

U sklopu razvoja obogaćene serije modula pripremljeno je 20 modula aktivnosti. Aktivnosti su planirane u obliku modula jer je svaka strukturirana putem interdisciplinarne integracije unutar tematskoga okvira (Barakos i dr., 2012). Aktivnosti su imale određene granice i trajanja; znanstvena disciplina bila je u središtu. Za svaku aktivnost modula pripremljeni su plan aktivnosti, bilježnica aktivnosti i poster aktivnosti. Planovi aktivnosti bili su namijenjeni nastavnicima, dok su bilježnice aktivnosti bile namijenjene učenicima. Svaka bilježnica aktivnosti sadržavala je uvod, status problema, vodič za proces otkrivanja i istraživanja, odjeljke za evaluaciju i istraživačko izvješće povezano s aktivnošću.

*Slika 3.*

Za razvoj niza obogaćenih modula kao osnova korišten je okvir znanstvenoga obrazovanja (Wendell i sur., 2010). Pristupi učenju temeljenom na istraživanju, STEM obrazovanju i znanstvenom pisanju kombinirani su pri izradi glavne strukture modula. Neki moduli nisu korišteni u svim aktivnostima te su opisani kao potporni: znanost, tehnologija, društvo, okoliš, društveno-znanstvena pitanja, priroda znanosti, računalno razmišljanje te robotsko kodiranje i argumentacija. Obogaćivanje je provedeno prema Purdueovu modelu obogaćivanja u tri faze (Moon i dr., 2009) (Slika 3).

### *Proces obrazovanja učitelja*

Tečaj u trajanju od 18 sati održan je za nastavnike koji su provodili program. Nakon tečaja osnovana je WhatsApp grupa, a komunikacija je nastavljena putem grupe. Osim toga, na kraju svakoga mjeseca tijekom provedbe održan je *online* sastanak za evaluaciju. Planiranje tečaja temeljilo se na okviru dizajna programa stručnoga usavršavanja koji su predložili Loucks-Horsley i suradnici (2010).

### *Proces provedbe obogaćenoga modula*

Aktivnosti su provedene u pet SAC-ova smještenih u provincijama Uşak, Rize, Konya i Kütahya u Turskoj u prvom obrazovnom razdoblju školske godine 2023./2024. (Tablica 1). Primjena je trajala 18 tjedana, dva sata tjedno. Aktivnosti su se provodile u malim grupama (četiri do osam učenika). Na kraju provedbe grupe su dovršile četiri aktivnosti. Tijekom razdoblja intervencije eksperimentalna je skupina sudjelovala u seriji obogaćenih modula iz znanosti i inženjerstva, dok je kontrolna skupina nastavila obrazovanje prema standardnome SAC kurikulu iz znanosti bez dodatnih obogaćujućih komponenti. Ta je razlika bila ključna za izoliranje učinka intervencije. Faze procesa provedbe prikazane su na Slici 4.

*Slika 4.*

### *Proces prikupljanja podataka*

#### Skala vještina znanstvenoga procesa (SPS skala)

U ovoj je studiji SPS test korišten za utvrđivanje vještina znanstvenoga procesa učenika. Ovaj je alat kreirao Fowler (1990), a prilagodio Ülger (2019). Instrument se sastoji od zadataka otvorenoga tipa za procjenu, koji su osmišljeni odvojeno za format preliminarnoga testa i posttesta. Svaki je zadatak ocijenjen pomoću analitičke tablice za bodovanje, pri čemu se ukupni broj bodova kretao od 0 do 30. Izviješten je koeficijent pouzdanosti KR-21 instrumenta od 0,828, što je ukazivalo na prihvatljivu unutrašnju dosljednost. Osim toga, sadržajna valjanost osigurana je stručnom recenzijom tijekom procesa prilagodbe (Ülger, 2019). Međutim, upotreba različitih otvorenih pitanja u pretestu i posttestu može izazvati zabrinutost u pogledu ekvivalentnosti testa (Ugulu i sur., 2008). Iako su oba obrasca osmišljena za procjenu istih konstrukata SPS-a, ovo pitanje treba uzeti u obzir pri tumačenju rezultata.

#### Obrazac intervjua s učenicima

Pripremljen u polustrukturiranom formatu, obrazac intervjua s učenicima sastojao se od pet otvorenih pitanja i dodatnih provjera povezanih s tim pitanjima. Obrazac su pregledala tri stručnjaka u svojim područjima i ažuriran je u skladu s njihovim mišljenjima. Intervjui su provedeni *online*. Poddimenzije SPS ljestvice uzete su kao osnova u pripremi pitanja.

### Obrazac intervjua s učiteljima

Obrazac je pripremljen u polustrukturiranom formatu i uključivao je jedno otvoreno pitanje i dodatna pitanja vezana uz to pitanje. Obrazac su pregledala tri stručnjaka iz toga područja i ažuriran je u skladu s njihovim mišljenjima. Ovaj je obrazac primijenjen na pet nastavnika prirodnih znanosti koji su bili odgovorni za provedbu. Intervjui su provedeni *online*.

### *Analiza podataka*

Korištene su kvalitativne i kvantitativne metode analize za obradu dobivenih podataka. Provedena je diversifikacija promatrača kako bi se osigurala valjanost i pouzdanost kvalitativnih podataka. Izračunate su vrijednosti zaobljenosti i asimetrije kako bi se odredilo koje će se testove koristiti u analizi kvantitativnih podataka (Tablica 2). Budući da su vrijednosti zaobljenosti i asimetrije vezane uz distribuciju podataka SPS posttesta bile između -1 i +1, analiza je provedena parametrijskim testovima. Kako bi se utvrdilo postoje li razlike između posttestova, testirane su pretpostavke analizom kovarijance. Osim toga, rezultati pretesta uključeni su kao kovarijance u ANCOVA model kako bi se kontrolirale početne razlike među skupinama i ojačale kauzalne inferencije unutar kvazieksperimentalnoga dizajna. Rezultati su pokazali da su pretpostavke o homogenosti regresijskih nagiba i jednakosti kovarijanci ispunjene ($p > 0{,}05$) (Tablica 3).

Tablica 2

Tablica 3

Dva različita promatrača odvojeno su ispitivala kvantitativne izvore podataka primjenom načela neslaganja i konsenzusa (Yorek i sur., 2010). Miles i Huberman (1994) preporučuju standard od 80 % slaganja na 95 % kodova. U ovome je kontekstu postotak slaganja za obrazac intervjua s učenicima iznosio 89 %, za obrazac intervjua s nastavnicima 90 %, a za izvještaje učenika 84 %.

## Rezultati

### *Rezultati istraživanja vještina znanstvenoga procesa*

Vrijednosti deskriptivne statistike za pretest i posttest prikazane su u Tablici 4. Rezultati pretesta pokazuju da su kontrolna grupa ($M = 8{,}90$, $SD = 4{,}23$) i eksperimentalna grupa ($M = 8{,}76$, $SD = 4{,}35$) imale usporedive početne razine SPS-a. Rezultati posttesta pokazuju porast u objema skupinama, međutim, poboljšanje je bilo izraženije u eksperimentalnoj skupini (kontrolna skupina: $M = 11{,}94$, $SD = 5{,}09$; eksperimentalna skupina: $M = 18{,}43$, $SD = 4{,}43$). Kako bi se testirala statistički značajna razlika između skupina prije intervencije, proveden je Kruskal-Wallisov test (Tablica 5). Rezultati su pokazali da nije bilo značajne razlike između rezultata preliminarnoga testiranja SPS-a grupa ($\chi^2 = 0{,}029$, $df = 1$, $p = {,}865$). Ovaj nalaz potvrđuje početnu ekvivalentnost grupa.

Tablica 4

Tablica 5

Provedbom analize kovarijance utvrđena je značajna razlika između skupina s obzirom na rezultate posttesta (Tablica 6). Nakon kontrole rezultata predtesta kao kovarijance, razlika između eksperimentalne i kontrolne skupine bila je statistički značajna ($F(1,65) = 21,78$, $p < 0,001$). Veličina učinka povezana s ovom razlikom bila je umjerena do velika ($\eta^2 = 0,52$), što ukazuje na značajan utjecaj intervencije na SPS učenika. Kada se uzmu u obzir prilagođene srednje vrijednosti, vidi se da je dobivena razlika u korist eksperimentalne skupine. Ovi rezultati ukazuju na to da je serija obogaćenih modula učinkovit alat za poboljšanje vještina znanstvenoga procesa darovitih učenika.

Tablica 6

### *Mišljenja učenika o obogaćenim modulima znanosti i inženjerstva*

Učenici su intervjuirani nakon provedbe kako bi se potvrdili i objasnili rezultati dobiveni iz kvantitativnih podataka te osigurala raznolikost podataka. U Tablici 7 prikazani su tema, kod, frekvencija i primjeri mišljenja učenika. Učenici su obogaćene znanstvene i inženjerske module smatrali korisnima prvenstveno za definiranje problema (n = 14), formuliranje hipoteza (n = 13) i određivanje ciljeva (n = 11) (Tablica 7).

Stavovi nadarenih učenika o vještinama planiranja pokazuju da implementirane module smatraju korisnima osobito u kontekstu sposobnosti definiranja vrste istraživanja (n = 14) i koraka istraživanja (n = 12) te planiranja sigurnosnih mjera (n = 11) (Tablica 7). Stavovi učenika otkrivaju da obogaćeni moduli mogu biti učinkovit alat za planiranje znanstvene studije. U nastavku je navedeno mišljenje jednoga učenika:

Tablica 7
*SPS obrazac intervjua s učenicima*

| Teme | Kod | Frekvencija (f) |
|---|---|---|
| Određivanje problema | Određivanje problema | 14 |
| | Formulacija hipoteza | 13 |
| | Određivanje svrhe istraživanja | 11 |
| | Učenje značenja hipoteze | 6 |
| | Definiranje problema | 3 |
| | Pronalaženje problema u dugačkome tekstu | 2 |
| | Razumijevanje uzroka problema | 2 |
| Planiranje istraživanja | Određivanje vrste istraživanja | 14 |
| | Određivanja koraka u istraživanju | 12 |
| | Planiranje mjera sigurnosti | 7 |
| | Planiranje prije provedbe istraživanja | 4 |
| | Provedba istraživačkoga plana | 4 |
| | Mjere sigurnosti | 2 |
| | Učenje istraživačkoga procesa | 1 |

| Teme | Kod | Frekvencija (f) |
|---|---|---|
| Prikupljanje informacija | Pregled literature | 11 |
| | Određivanje ključnih riječi | 6 |
| | Formulacija ključnih riječi | 5 |
| | Provjeravanje izvora informacija | 4 |
| | Osobine sigurnih mrežnih stranica | 2 |
| | Pisanje referenci | 2 |
| | Učenje upotrebe tehnologije | 1 |
| | Potvrda informacija u različitim izvorima | 1 |
| | Predstavljanje informacija vlastitim riječima | 1 |
| Planiranje procesa prikupljanja podataka | Učenje procesa prikupljanja podataka | 11 |
| | Određivanje eksperimentalnih varijabli | 10 |
| | Izrada popisa materijala | 6 |
| | Dizajniranje eksperimenta s nekom svrhom | 6 |
| | Planiranje procesa mjerenja | 5 |
| | Određivanje mjernih alata | 5 |
| | Stjecanje materijalnoga znanja | 4 |
| | Predstavljanje podataka (tablice, grafovi itd.) | 3 |
| | Testiranje hipoteza | 1 |
| | Korištenje tehnologije pri prikupljanju podataka | 1 |
| Evaluacija i zaključak | Pisanje izvještaja | 13 |
| | Evaluacija i donošenje zaključaka | 11 |
| | Ponavljanje testa | 10 |
| | Tumačenje podataka | 10 |
| | Predstavljanje (dijeljenje) podataka | 7 |
| | Učenje uloge ponavljanja testa | 6 |
| | Čitanje i razumijevanje | 2 |
| | Dosljedno donošenje zaključaka | 2 |
| | Tumačenje tablica, grafova itd. | 1 |

> *„Imalo je utjecaj. Utjecalo je na mene u smislu određivanja vrste istraživanja... Sada mogu bolje odabrati vrstu istraživanja koje trebam provesti i korake istraživanja koje trebam odabrati.“ (B12, siječanj 2024)*

Što se tiče teme prikupljanja informacija, koja je još jedna faza znanstvenoga istraživačkog procesa, daroviti učenici naveli su da su primjenu obogaćenih modula smatrali korisnom, osobito u stjecanju vještina pregleda literature (Tablica 7). Što se tiče planiranja procesa prikupljanja podataka, ističu se izrazi „učenje procesa prikupljanja podataka“ (n = 11) i „identificiranje eksperimentalnih varijabli“ (n = 10) (Tablica 7). Odgovori na relevantno pitanje polustrukturiranoga intervjua pokazali su da su učenici mogli naučiti fazu prikupljanja podataka tijekom procesa eksperimentiranja i promatranja uz pomoć razvijenoga niza modula. U nastavku je prikazan stav jednoga učenika.

*„Odredili smo koji će se alat koristiti u eksperimentu. Je li to mikroskop ili kutomjer? Na primjer, mjeriš li kut? Tako… Sada znam kako planirati mjerenje i eksperimentalne varijable. Neovisne, ovisne i kontrolirane varijable…“ (G13, siječanj 2024)*

Što se tiče faze evaluacije i donošenja zaključaka u znanstvenome procesu, učenici su naveli korisnost obogaćenoga modela za pisanje izvještaja, evaluaciju i donošenje zaključaka, ponavljanje gradiva i tumačenje podataka (Tablica 7). Učestalost i raznolikost u odgovorima učenika o temi evaluacije i donošenju zaključaka mogu se smatrati pokazateljem učinkovitosti implementacije obogaćenih modula u razvoju vještina znanstvenoga procesa.

### *Mišljenja učitelja o obogaćenim modulima znanosti i inženjerstva*

Svrha intervjua s učiteljima bila je potvrditi i objasniti kvantitativne rezultate te osigurati raznolikost podataka. Informacije o temama, kodovima, učestalosti i primjerima stajališta učenika iz SPS obrasca za intervju s učiteljima prikazane su u Tablici 8. Kada se ispituju mišljenja nastavnika koji su implementirali osmišljene module o njihovom utjecaju na vještine definiranja problema darovitih učenika, vidljivo je kako učitelji module smatraju korisnima prvenstveno za razvijanje učeničkih vještina rješavanja (n = 3), prepoznavanja (n = 2) i definiranja problema (n = 2) (Tablica 8).

Što se tiče vještina planiranja darovitih učenika, ispitani nastavnici su izrazili mišljenje o korisnosti dizajniranih modula ponajprije s obzirom na razvoj sposobnosti učenika da definiraju korake istraživanja (n = 5) (Tablica 8). Nastavnici su također korist obogaćenoga modula u smislu osposobljavanja darovitih učenika za izradu pregleda literature, osobito u fazi prikupljanja podataka, što je još jedna faza znanstvenoga procesa (Tablica 8). U nastavku je navedena izjava nastavnika koja odražava ovo stajalište.

*„Mogu reći da su djeca sada gotovo na razini na kojoj mogu objektivno riješiti sve probleme na koje će naići u životu uključivanjem vještina znanstvenoga procesa. Jer smo ih uključili u sve... Postoji problem, postoji svrha, postoji hipoteza, postoji pregled literature, postoji bibliografija, postoje varijable u eksperimentalnom procesu. Postavljeno je dovoljno pitanja, što je vrlo dobro.“ (T2, siječanj 2024*)

Prema mišljenjima nastavnika o učinku provedbe modula, do izražaja dolaze vještine darovitih učenika u planiranju procesa prikupljanja podataka, provođenju eksperimenta (n = 3), testiranju hipoteze (n = 2) i eksperimentiranju (n = 2) (Tablica 8). Odgovori nastavnika na relevantno pitanje pokazali su da su učenici uspjeli svladati fazu prikupljanja eksperimentalnih podataka pomoću razvijene serije modula. Također, nastavnici su smatrali provedbu obogaćenoga modula korisnom za fazu evaluacije i zaključivanja u znanstveno-istraživačkom procesu, osobito u pogledu razvijanja vještine pisanja izvještaja darovitih učenika (n = 4) (Tablica 8). U nastavku je prikazano mišljenje jednoga nastavnika.

Tablica 8
*SPS obrazac intervjua s učiteljima*

| Tema | Kod | Frekvencija (f) |
|---|---|---|
| Određivanje problema | Rješavanje problema | 3 |
| | Identifikacija problema | 2 |
| | Definiranje problema | 2 |
| | Formuliranje hipoteza | 1 |
| | Rad sa svrhom | 1 |
| | Stjecanje znanstvene perspektive | 1 |
| Planiranje istraživanja | Koraci znanstvenoga istraživanja | 5 |
| | Planiranje procesa istraživanja | 3 |
| | Odabiranje vrste istraživanja | 2 |
| | Usvajanje osnovnih znanstvenih metoda | 2 |
| | Formiranje opservacijskih skupina | 1 |
| Prikupljanje podataka | Pregled literature | 2 |
| | Korištenje digitalnih tehnologija | 1 |
| | Provedba intervjua | 1 |
| | Reference | 1 |
| Planiranje procesa prikupljanja podataka | Provedba eksperimenata | 3 |
| | Testiranje hipoteza | 2 |
| | Eksperimentiranje | 2 |
| | Prikupljanje podataka | 1 |
| | Korištenje digitalnih tehnologija | 1 |
| | Osmišljavanje eksperimenta | 1 |
| | Osmišljavanje kontroliranoga eksperimenta | 1 |
| Evaluacija i zaključak | Pisanje izvješća | 4 |
| | Prijenos dobivenih podataka | 3 |
| | Predstavljanje istraživanja | 2 |
| | Zaključak | 1 |
| Ostalo | Dizajn aktivnosti primjeren za SPS | 5 |
| | Učenje putem aktivnosti i pisanja | 4 |
| | Primjereni materijali za SPS | 3 |
| | Odgovarajući scenariji za SPS | 3 |
| | Svjestan razvoj SPS-a | 3 |
| | Stvarni problemi vezani za SPS | 2 |
| | Primjeren oblik izvještaja za SPS | 2 |
| | Znanstveni rad | 1 |
| | Učinkovit ciklus povratnih informacija | 1 |

*„Proces otkrivanja u bilježnici aktivnosti i izvješću o aktivnosti bio je dobar za razvijanje vještina znanstvenoga procesa. Osim toga, činjenica da su bilježnica i izvješće bili strukturirani doprinijela je učenju učenika time što su ih svjesno izrađivali.“ (T3, siječanj 2024)*

Posljednje pitanje obrasca za intervju s nastavnicima o SPS-u učenika odnosilo se na druge teme koje bi nastavnici željeli dodati u provedbu obogaćenih modula iz znanosti i inženjerstva. Svi su nastavnici koji su sudjelovali u istraživanju (n = 5) izjavili da su moduli prikladni za razvoj SPS-a učenika (Tablica 8). Učitelji smatraju da su obogaćeni moduli iz znanosti i inženjerstva korisni nastavni materijali usmjereni na učenike te da imaju značajke koje podržavaju razvoj SPS-a učenika.

## Diskusija

Rezultati istraživanja pokazali su da je primjena osmišljene serije obogaćenih modula znanosti i inženjerstva imala pozitivan učinak na sposobnosti znanstvenoga procesa darovitih učenika. Ovi rezultati pokazuju da je serija obogaćenih modula učinkovit alat koji se može koristiti u obrazovanju darovitih učenika i uključiti u kurikul za obrazovanje darovitih u Turskoj. Slično tome, Özdeniz (2021) je istraživao učinke obogaćenoga znanstvenog modula, koji je osmišljen prema metodi problemskoga učenja na temelju modela integriranoga kurikula i proveden u okružju hibridnoga učenja. Dizajn nastave prirodnih znanosti korišten u ovoj studiji pridonio je razvoju istraživanih učeničkih kompetencija. U ovoj studiji ti se ishodi tumače specifično u okviru vještina znanstvenoga procesa (SPS). Međutim, VanTassel-Baska i drugi (1998), Renzulli (2012), Ülger (2019) i Sanad i suradnici (2021) primijetili su da su obogaćeni nastavni materijali o različitim sadržajima poboljšali SPS darovitih učenika.

Podatci dobiveni u polustrukturiranim intervjuima s darovitim učenicima podupiru kvantitativne rezultate. Osim toga, stavovi učenika objašnjavaju dimenzije razvoja u SPS-u. U intervjuima učenici su se osvrnuli na koncepte povezane sa SPS-om, detaljno ih objasnili i razmislili o procesima koje su iskusili, navodeći i primjere vezane uz te koncepte. Također su pružili i detaljna objašnjenja o definiranju problema, planiranju istraživanja, prikupljanju podataka, planiranju procesa prikupljanja podataka, evaluaciji i donošenju zaključaka. Osim toga, u svojim su objašnjenjima koristili koncepte povezane kako za sadržaj tako i za znanstvene procese. Slično tome, Robinson i suradnici (2014) navode da je dizajn obogaćenoga kurikula istraživanja temeljenoga na problemu za darovite učenike bio učinkovit u pogledu razvoja SPS-a učenika, osnovnih znanstvenih koncepata i znanja o sadržaju prirodnih znanosti. Shin (2013) je naveo da bi aktivnosti za razvoj viših razina vještina znanstvenoga procesa (SPS), kao što su prepoznavanje problema, pronalaženje problema i planiranje istraživanja, trebale biti zastupljenije. Ukazao je na činjenicu da bi aktivnosti trebale biti osmišljene na način koji podupire razvoj tih vještina. Važno je da učenici izraze detaljna mišljenja o tim procesima, koji čine osnovu SPS-a. Yıldız (2022) je naveo da STEM aktivnosti doprinose razvoju poddimenzija vještina znanstvenoga procesa darovitih učenika, kao što su određivanje varijabli, postavljanje hipoteza, provođenje eksperimenata te opažanje i predviđanje. Ova studija i navedene studije poklapaju se u tim aspektima. Rezultati polustrukturiranih intervjua s učiteljima u ovome istraživanju također potvrđuju kvantitativne nalaze i u skladu su s mišljenjima učenika. Osim toga, mišljenja učitelja pomogla su istražiti dimenzije razvoja darovitih učenika u SPS-u. U intervjuima učitelji su naveli da je aplikacija bila korisna za razvoj vještina rješavanja problema. Učenici su također izrazili slična mišljenja i naveli da je aplikacija posebno doprinijela u određivanju problema. Slično tome, u studijama koje su proveli Renzulli (1977), Chávez i suradnici (2009) i Tüysüz i suradnici (2024) utvrđeno je da je obogaćeni nastavni plan i program iz prirodnih znanosti pridonio vještinama rješavanja problema učenika. Elmas (2020) navodi da je alat obogaćenoga kurikula razvijen za darovite učenike bio koristan u pogledu uključivanja različitih nastavnih metoda (modeliranje, eksperiment, simulacija) i osiguravanja aktivnoga sudjelovanja. Slično tome, u intervjuima provedenima u okviru ovoga istraživanja nastavnici su često spominjali procese prikupljanja podataka koje provode njihovi učenici.

Kvalitativni podatci dobiveni iz izvještaja učenika potvrđuju i objašnjavaju kvantitativne rezultate. Ti podatci pokazuju longitudinalni razvoj SPS-a učenika tijekom cijeloga procesa. Podatci dobiveni putem intervjua s učenicima i nastavnicima također objašnjavaju kvantitativne podatke. Reis i suradnici (2021.) navode kako daroviti učenici putem obogaćenoga kurikula općenito razvijaju svoje vještine uključivanjem primijenjenih eksperimenata, interdisciplinarnih studija i nadilazeći standardni kurikul. Kvantitativni podatci dobiveni u ovoj studiji pokazuju da primjene obogaćenoga modula znanosti i inženjerstva pozitivno utječe na određivanje problema, stvaranje hipoteza, prikupljanje informacija, izradu popisa materijala, određivanje kontrolnih varijabli, izradu planova za opažanje, donošenje zaključaka o podatcima i ponavljanje testa, što su poddimenzije SPS-a.

## Zaključak

Ovo istraživanje pokazuje da pristup obogaćivanju koji integrira učenje temeljeno na istraživanju, STEM prakse i znanstveno pisanje može učinkovito razvijati vještine znanstvenoga procesa darovitih učenika. Rezultati ističu potencijal strukturiranih i interdisciplinarnih modula za razvoj SPS vještina i veće uključivanje u znanstvene misaone procese. Smještanjem obogaćivanja unutar okvira temeljenoga na dizajnu i usmjerenoga na učenika, studija pruža konkretan primjer kako se suvremeni pedagoški pristupi mogu operacionalizirati u kontekstu obrazovanja darovitih. U tom pogledu ovo istraživanje doprinosi literaturi premošćivanjem teorijskih perspektiva o istraživanju i obogaćivanju putem praktične provedbe u učioničkom okružju. Konačno, rezultati naglašavaju važnost sustavno osmišljenih iskustava obogaćivanja za razvoj znanstvenih kompetencija višega reda te nude temelj za daljnja istraživanja i praksu u ovome području.

### *Implikacije*

Ova studija pruža praktične implikacije za tvorce kurikula, edukatore i kreatore obrazovnih politika. Za tvorce kurikula rezultati sugeriraju integraciju strukturiranih, interdisciplinarnih modula za produbljivanje znanstvenih kurikula, s eksplicitnom integracijom faza znanstvenoga procesa unutar okvira temeljenih na istraživanju i orijentiranih na STEM. Za edukatore rezultati naglašavaju važnost praksi usmjerenih na učenika, uključujući praktične aktivnosti temeljene na problemima i strukturirane zadatke znanstvenoga pisanja koji uključuju učenike u osmišljavanje eksperimenata, identificiranje varijabli i tumačenje podataka. Za tvorce obrazovnih politika rezultati podupiru razvoj okvira usmjerenih na obogaćivanje obrazovanja darovitih učenika i naglašavaju potrebu za kontinuiranom obukom nastavnika za učenje temeljeno na istraživanju i integraciju STEM-a. Implikacije ovoga istraživanja sežu i izvan područja Turske jer pokazuju da se pristupi obogaćivanja temeljeni na modulima mogu prilagoditi različitim obrazovnim kontekstima kako bi se podržao razvoj znanstvenoga mišljenja i istraživačkih vještina.

## *Ograničenja*

Ovo istraživanje ima nekoliko ograničenja koja treba uzeti u obzir pri tumačenju rezultata. Prvo, relativno mala veličina uzorka (N = 69) i izostanak a priori analize statističke snage mogu ograničiti statističku moć i općenitost rezultata. Drugo, unatoč dokazima o početnoj ekvivalentnosti grupa, kvazieksperimentalni dizajn ograničava mogućnost izvođenja čvrstih uzročnih zaključaka zbog nedostatka nasumične dodjele i potencijalnoga pristranog odabira. Treće, iako je kontrolna skupina nastavila sa standardnim SAC kurikulom, ne mogu se u potpunosti isključiti nekontrolirane kontekstualne razlike između skupina. Četvrto, u obzir treba uzeti potencijalnu pristranost istraživača jer su procesi razvoja, provedbe i evaluacije provedeni unutar istoga istraživačkog okvira, unatoč naporima za povećanje valjanosti putem triangulacije i suglasnosti promatrača. Peto, pristup mjerenju imao je ograničenja; iako je SPS instrument pokazao prihvatljivu pouzdanost (KR-21 = 0,828) i valjanost sadržaja, upotreba različitih otvorenih pitanja u predtestovima i posttestovima izaziva zabrinutost s obzirom na ekvivalentnost mjerenja. Konačno, rezultati su vezani uz kontekst jer je studija provedena s darovitim učenicima u SAC-ovima u Turskoj, što ograničava veću mogućnost uopćavanja; dodatno, relativno kratko razdoblje intervencije (18 tjedana), ograničen broj provedenih modula te potencijalne varijacije u valjanosti provedbe i učincima vezanim uz učitelje u različitim centrima mogli su utjecati na rezultate i ograničiti dugoročno održive zaključke.

## *Napomena*

Ova je studija dio doktorske disertacije koju je napisao Nurettin Can Bodur pod mentorstvom izvanrednoga profesora dr. Cengiza Tuysuza i izvanrednoga profesora dr. Ilkera Ugulua.

Ova je studija provedena u skladu s etičkim smjernicama za istraživanja s ljudskim ispitanicima, uključujući načela koja je utvrdila Američka psihološka udruga (APA) i Helsinška deklaracija. Sudjelovanje je bilo potpuno dobrovoljno, a dobiven je informirani pristanak svih učenika i njihovih skrbnika prije prikupljanja podataka. Povjerljivost i anonimnost osigurane su tijekom cijeloga istraživačkog procesa, a sudionici su imali pravo odustati u bilo kojem trenutku bez ikakvih posljedica. Studija je osmišljena tako da se minimiziraju potencijalni rizici i provedena je poštujući etičke standarde koje su postavili institucionalna i međunarodna etička povjerenstva za istraživanja.