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STEAM MODEL BASED CRITERIA DEVELOPMENT IN NATIONAL AND GLOBAL SCIENCE EDUCATION POLITICS

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Abstract. *The main research question of this research study is how to design a valid and reliable holistic rubric to be used as a criterion for the comparison of the STEAM model by analyzing different countries' science curricula. Considering this question, STEAM model rubrics was created by examining the ways of shaping science education policies. The research was qualitative, and the design of this research was descriptive. Document analysis was carried out for data collection process. Content analysis was used for analyzing data. The raters selected conveniently from science education and measurement evaluation fields were asked to rate the Turkish and Finnish Science Curricula as documents through the developed rubric. The rating process was carried out by associating appropriate themes obtained from literature. Sub-dimensions of the rubric developed were examined by teachers and researchers who are experts in the STEAM fields, measurement and evaluation. For calculating the reliability, the researchers graded a content about the Turkish and Finnish Science Curricula from the STEAM learning areas with this rubric. Fleiss Kappa and Miles Huberman consistency statistics were used for providing inter-rater validity. It obtained valid and reliable criteria for making significant contributions and comparisons of the STEAM model in science education policies.*
Keywords: *STEAM model, holistic graded scoring key (rubrics), science education, educational politics*

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Introduction

The interdisciplinary skills-based curriculum approach aims to educate individuals with integrated higher-order thinking competencies such as technological literacy, scientific process, and computational thinking in accordance with the characteristics of the 21st century. The concept of interdisciplinarity was developed by combining at least two disciplines and creating integrated learning areas (Kline, 1995). This concept, which is also referred to as an approach, addresses the trans-disciplinary fields and skills that are integrated while indicating a problem situation or an outcome in curricula. When the literature on the concept of interdisciplinarity is examined, it is seen that with the flexible programming approach, subjects belonging to different fields and related to each other are integrated, and a development path is followed in which lesson plans and processing styles are at the forefront with appropriate learning and teaching models. In the interdisciplinary learning approach, learners use higher-level thinking skills such as analysis, synthesis, reflective, creative, critical and computational thinking while integrating information from different fields in the process of structuring knowledge (Yeni et al., 2024). This approach is very important in terms of revitalizing the learning environment, enabling learners to use their creativity, ensuring that they are interested in the lesson and, as a result, realizing meaningful learning (Hart, 2019; Reynders et al., 2020).

In the context of its interdisciplinary conceptual framework, STEM (Science-Technology-Engineering-Mathematics), as it is commonly known, includes mathematics, natural sciences, engineering/engineering technologies and computer/information fields (Chen, 2009; English, 2016). In the context of education, STEM includes research, inquiry and project-based approaches instead of traditional teaching methods (Breiner et al., 2012). With this feature, STEM is important for science education due to its structure that supports skill development by integrating disciplines in the focus of concepts and skills specific to the relevant disciplines (Çepni & Ormancı, 2018; Takeuchi et al., 2020; Wan et al., 2023). Multidisciplinarity means studying a topic in more than one discipline at the same time. Perspectives from different disciplines provide a broader understanding of a topic. In interdisciplinary thinking and working, you take an extra step: you try to integrate perspectives or insights

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from different perspectives through interaction to better understand a complex phenomenon. Integration can take place, for example, at the level of methods, tools, concepts, theories or understandings. In this way, you can do more together than you can do alone (Huutoniemi et al., 2010; Gao et al., 2020). Interdisciplinarity involves not only students or academics but also other (societal) partners in researching a complex problem. For instance, constructing co-creativity between students and municipalities, companies, or other societal organizations, covers the term of interdisciplinarity. It is, therefore, about bringing together knowledge from science and practice to arrive at a specific integrative approach or solution that also has an impact on society (Klein, 2010). In this context, the STEM model is a form of modeling that is more suitable for the concept of interdisciplinarity. It is seen that STEM is associated with different patterns in studies conducted in the field of science education. Studies in which the concept of approach is associated with STEM (Arslan, 2021; Güler, 2023; Sutaphan & Yuenyong, 2019) studies in which STEM is associated with engineering and design concepts (Galanti & Holincheck, 2024; Roehrig et al., 2021) are frequently studied in the literature. In addition, in the context of the doctoral dissertation conducted by Bekereci (2022), a systematic research study conducted by Rochim et al. (2021) was found in which STEM was associated with a learning model, which is a more inclusive concept.

Science education is an interdisciplinary area which provides meaningful transitions between different fields and skills. Educational philosophy and psychological paradigms identify the visions and missions of curricula. The most radical change in the historical development process of science curricula in Turkey occurred in 2004-2005 with the reflection of the constructivist learning theory, which is based on the process of linking learners' prior learning with their new learning, and the spiral programming approach brought by this theory. The concept of learning domain was emphasized for the first time, and the five disciplines of science (physics, chemistry, biology, astronomy and earth science) were positioned at every level from third to eighth grade in a way to observe the principles from simple to complex, from concrete to abstract, from known to unknown, from recent past to distant past, and science and technology literacy and the skills it covers were defined in this curriculum (MEB, 2005).

When the reflections of the STEM model on Science Curricula in Turkey were examined in the 2013 Science Curriculum, it was aimed to develop the science process skills of learners through open-ended hypothesis-based experimental activities by emphasizing the inquiry-based learning approach (MEB, 2013). In the 2018 Science Curriculum, STEM emerged as a separate learning area that integrates science and technology literacy with science, technology, mathematics and engineering areas (MEB, 2018). In the revised Science Curriculum (MEB, 2024) based on multiculturalism and interdisciplinarity, these concepts were addressed by integrating them with values and skills education. Since the implementation of the 2024 program will start to be implemented in the fifth grades in the 2024-2025 academic year, the scoring content was created by evaluating the vision and theoretical dimension of the program, since the scoring educators did not have implementation experience. The place of STEM in the education policy of Finland, one of the countries with high success in PISA and TIMSS assessments, is clearly stated in the Finnish National STEM Strategy and Action Plan (Finnish National STEM Strategy and Action Plan-Experts in Natural Sciences, Technology and Mathematics in Support of Society's Welfare and Growth) with its vision and goals for 2030 (MEC, 2023).

Throughout the phenomenological definition of STEM, different approaches were recognized on the basis of countries. The STEM model has an important place in the socio-economic development of countries, competition in the international arena, and supporting the career journey of individuals (Nungu et al., 2023). In the report published by the National Research Council (NRC-National Research Council, 2011), the three goals of the United States in STEM education are: increasing the number of students pursuing careers in STEM, expanding the workforce with STEM competencies, and increasing students' STEM literacy. NRC (2014) contributed to the field by providing a comprehensive structure for integrating STEM disciplines at the K12 level. Gough (2015) drew attention to the reflective aspects of the STEM approach of various governments, namely increasing science literacy and orientation towards STEM education, developing manpower with the skills covered by the high-level STEM approach, and enacting an economic policy agenda for STEM competencies. In addition, the fact that most of the science questions in the Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS), which are international assessment projects, are developed from STEM-focused activities emphasizes the global importance of STEM (Çepni & Ormacı, 2018).

The United States of America, which influences the majority of countries in the world with its science education standards, interprets STEM from a more mechanistic, populist perspective and emphasizes technological literacy as the use of effective educational tools and equipment in the development processes of learners. On the other hand, Far Eastern countries such as Japan, Singapore and South Korea add the A (Art) dimension to the model and focus on the integration of the STEAM (Science, Technology, Engineering, Art, Mathematics) model in terms of science,

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technology, mathematics and engineering disciplines into a philosophy of life and focus on the learners solving problems in daily life situations with the science process and life skills they have gained. Beyond the A as an art dimension represented in this model, it is based on the adaptation of the knowledge and skills acquired through human knowledge and skills to daily life situations (Bodner & Elmas, 2020; Brown et al., 2011; Elmas & Geban, 2016; Sungur et al., 2006). Blackley and Howell (2015) pointed out that high-performing Asian countries with emerging economies, such as Korea, Japan, China and Taiwan, have national policies that prioritize universities and industry in the light of science and technology considering humanistic paradigms.

When the national and international literature is examined, it is stated that the theoretical framework of the engineering design process (EDS) of the STEM model should be used in educational settings (Aranda et al., 2020; Atman et al., 2007; Crismond & Adams, 2012; Moore et al., 2014). The engineering design process constitutes the theoretical framework of the STEM model. In the literature, it is seen that instead of integrating STEM disciplines, these disciplines are taught independently of each other through science activities (Bybee, 2013; Johnston et al., 2019).

Due to the multidimensional structure of the STEM concept, it was concluded that it was associated with different concepts in accordance with the problems addressed by the researchers. It is seen that some of the frequently associated concepts are reflected in the literature as engineering design, robotic applications and technology-related concepts (Gencer et al., 2019; Özkul & Özden, 2020; Sen et al., 2021). In addition, in the context of skills, STEM is associated with computational thinking skills based upon their common similarities due to the presence of engineering and technology dimensions (Sarı & Karaşahin, 2020), and STEM is inclusive of 21st-century skills (Bircan & Çalışıcı, 2022; Mäkelä et al., 2022). When this situation is considered on the basis of the curriculum, which is the only factor affecting educational policies, the use of the term model with a holistic approach instead of limited expressions was preferred in the current study on the grounds that it is more inclusive.

Özcan and Koca (2019) and Zascerinska et al. (2023) emphasized the importance of comparative education studies since the differences reflected in the STEM education practices of each country cause variability in the outcomes obtained. As a result of the literature review, various studies comparing the curricula of various countries in the context of STEM were found. Han and Buchmann (2016) examined students' science achievement and expectations of focusing on STEM in the future through the analysis of International Student Assessment Program data, and Rezaei et al. (2022) conducted comparative research on the integrated STEM curriculum in Finland, Singapore and the United States. In addition, in another study conducted by Dostal (2023), six criteria were identified within the scope of technology and engineering dimensions of STEM, and a comparative analysis of national curricula in the Czech Republic, Slovakia and Poland was conducted based on curriculum development studies in the Czech Republic. The examination of STEM with its limited dimensions in the examined research reveals the need for standardization in comparative analysis studies. Based on this determination, the need to create a list of standardized, valid and reliable criteria in international comparison studies constitutes the main focus of this research.

Examining the way the STEM model is handled in curricula at all levels with standardized criteria provides the opportunity to provide measurable, observable, concrete and efficient suggestions for improving educational practices in this context. Rubrics are a preferred tool in contemporary assessment and evaluation approaches because of their emphasis on the process and their ability to determine levels, instead of evaluation forms where the correct result is sought with definite judgements (Andrade, 2005; Panadero & Jonsson, 2020). Çepni (2015) stated that there are many rubric development studies in the literature related to the STEM model in science education. According to their scope, studies aiming to evaluate pre-service teachers' activities (Marshall & Harron, 2018; Baş, 2023; Sungur Gül & Saylan Kırmızıgül, 2023) and studies aimed at teachers' evaluation of student activities (Cirkony & Kenny, 2022; Yakob et al., 2021) are the majority. Although there are studies in which document review method was adopted for the evaluation of programs in the context of education (Bahar et al., 2018; Li et al., 2022), limited studies were found in which program evaluation was carried out within the rubric in accordance with the scope determined by the researchers (Gelmez Burakgazi & Karsantık, 2023; Huang & Yong, 2020) and limited studies on the evaluation of official documents that represent the STEM policies of states in science education with rubrics (Estévez-Mauriz & Baelo, 2021). As a result of the literature review, it is thought that the development of a valid and reliable rubric through standardized criteria will contribute to the field in terms of both self-evaluation of the STEAM model in science education within the scope of educational policies and objectivity in cross-country comparison. Approaches from a humanistic perspective and sharing the expansions of a model puts them at the center. In this research, beyond the association of the concept pointing to dimension A with pure art education, the reasons for using the STEAM model include sharing the expansions of a model that focuses on progressive philosophy (Keskin & Şahin, 2018; Quigley et al., 2017), which has a student-centered education approach at its core, and reconstructionist educational philosophy (Bati et al., 2018; Coşkun & Taneri, 2021). Researchers identified

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seven key dimensions that are expected to be developed through the STEAM model in this study. The aim was to develop a valid and reliable holistic rubric for in-depth analysis of educational policies, which includes criteria appropriate to the identified dimensions. For this purpose, the research conducted by Estévez-Mauriz and Baelo (2021), which is similar to the current study, evaluated the institutional structure without the aim of evaluating the performance of individuals in order to evaluate the programs of STEM centers in Spain and to improve quality. The rubric planned to be developed by the researchers within the scope of the current study is not specific to a particular country but differs in its capacity to provide more general and global results with the opportunity to see the place of the STEAM model in the comparative science education policies of different countries. Research studies handling the creation process of a criterion list for assessing STEM education, the effectiveness of interdisciplinary project-based learning in science degree programs, socio-scientific issues of the STEAM approach, and STEAM teachers' grading practices (DeLuca et al. 2024; Hart, 2019; Mang et al. 2023; Wang, 2014).

This research is important in terms of defining the STEAM concept as a model in terms of different sub-variables, starting with the Turkish and Finnish context, and providing researchers with criteria that provide in-depth and objective insights in both national and intercultural education policy analysis in the perspective of the specific goals of countries' distant, general, disciplinary curricula.

Research Problem

Throughout the importance of providing a criterion-based standardized tool for both defining the term STEAM and its global implications in science education, the question of this research study is how to design a valid and reliable holistic rubric that can be used to evaluate the STEAM model in science programs of different countries. STEAM is an interdisciplinary term and approach which is defined, interpreted and implied in a different manner by different countries that is why, to create a standardized tool for comprehending the meaning of STEAM and accreditation of global science programs related to STEAM implications. Researchers analyzed contemporary literature under the STEAM model characteristics and their reflections to K12 science curricula throughout this research problem.

Research Focus

In the focus of the research question, it was aimed to develop a valid and reliable holistic rubric that can be used as a list of criteria in national and global science education policy development studies by investigating which dimensions of the STEAM model will be evaluated in the science curricula of different countries.

Research Aim and Research Questions

The purpose of this study is to develop a reliable and valid holistic rubric that can be used as a criterion for evaluating the STEAM model in the contexts of general objectives, vision, mission, standards, content structuring, learning-teaching processes and assessment aspects in science programs of different countries. The research questions of the study are stated below:

1. Did the rubric adequately measure STEAM model aspects of science curricula?
2. Could different raters utilize the rubrics to have consistency scores?

Research Methodology

General Background

The purpose of using holistic rubrics is stated as an assessment based on level determination (Kilgour et al. 2020). For Fraenkel et al. (2013), reliability, which is one of the first conditions to be met in scientific research, means that the measurement is free from random errors. Kutlu et al. (2023), on the other hand, addressed the concept of reliability in terms of rubrics and emphasized consistency by pointing out that scoring should not vary from person to person. The design of this study is structured as a descriptive study. In descriptive research, in which a situation is generally illuminated, evaluations are made within the framework of certain standards and the relationships between events are revealed, the main purpose is to define and explain the situation to be examined (Çepni, 2021). In other words, descriptive research is aimed at determining what is what, understanding the situation or event,

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and has the feature of providing insights into the creation of hypotheses for new research (Marshall & Jonker, 2010). In accordance with the research design, document analysis was carried out because the raters were asked to score on a certain document through the developed rubric. Document analysis is a qualitative method that involves the analysis of written documents containing information about the phenomenon or phenomena related to the research (Bogdan & Biklen, 2007; Yıldırım & Şimşek, 2018). Karasar (2013) has pointed out that in a successful document analysis, the rate of deviation between what is intended to be explained in the document and what the researcher understands should be reduced. According to Çepni (2021), syntheses made through document analysis have the quality of classifying the documents targeted to be examined within the scope of the research within certain characteristics in the field.

Study Group

While determining the study group in the research, the criterion sampling technique of purposeful sampling, one of the sampling methods of qualitative research, was used. In the criterion sampling technique, all situations that meet a set of predetermined criteria are investigated. During this research, the criteria or criteria can be prepared by the researcher, or a list of criteria can be used (Patton, 2005). Within the scope of this study, the researchers examined the 2018 Turkish Science Curriculum and the Finnish Science Curriculum and prepared a list of criteria. Objectives, domain-specific skills, science, engineering and entrepreneurship practices, teaching methods, techniques and strategies adopted in the curriculum, outcomes, assessment and evaluation strategies in the two programs were examined in the context of STEAM during the preparation process of rubrics. The study group of the research consists of the Science Curricula in Turkey and Finland. The 2018 version of the Turkish Science Curriculum is used at all levels of education. The vision of the program is based on a research-inquiry-based teaching approach, and the concept-based learning areas are Living Things and Life, Physical Phenomena, Matter and Change, Earth and the Universe, and the skill-based learning areas are Science Process Skills, Science Technology, Society Environment Relations, Scientific Attitudes and Values, Science Technology Mathematics and Engineering. STEM learning area was first included in the Science Curriculum in 2018. The Science Curriculum will be revised in 2024 and will be implemented in fifth grades in 2024-2025. The Science Curriculum was revised in 2024 and started to be implemented in fifth grades in 2024-2025. Values education was reinterpreted by integrating it with skills-based learning areas in new science curricula. In the Finnish Science Curriculum, from first to fourth grade, Environmental and Nature Studies are taught as an integrated subject covering biology, geography, physics, chemistry and health education. The teaching in this course group focuses on sustainable development. The aim of teaching is for students to recognize and understand nature and the man-made environment, themselves and other people, human diversity, health and disease. During the first four years, the main content of the studies in the field of environmental and nature studies includes the learning areas of organisms and their habitats, the immediate environment as the habitats of humans, the home region and the world, natural phenomena, substances in our environment, the individual and health and safety. From fifth to ninth grade, science is taught as a separate subject, including biology, geography, physics, chemistry and health. In grades 7-9, the core content of biology education includes nature and ecosystems, life and evolution, human beings, common environment; the core content of physics education includes motion and force, vibrations and wave motion, heat, electricity, natural structures; the core content of chemistry education includes air and water, raw materials and products, living nature and society; the core content of health education is structured under the learning areas of growth and development, healthy choices in daily life, resources and coping skills, health, society and culture.

Instrument and Procedures

As a result of the literature review, the scales developed by Çevik and Ata (2019), Chen and Ding (2023) for the STEAM model were examined, the STEAM visions and standards of the countries and the structure based on the goal, content, learning-teaching and measurement-evaluation dimensions of science education programs were examined, and themes and sub-dimensions under the themes were created with the content analysis technique. According to the results of the examinations, standardized criteria in the holistic rubric consisting of five stages were determined according to the level of meeting the standards related to each of the seven themes determined as distant goals (vision, mission, project and strategy plans), specific goals (achievements and standards), the relationship between achievements and values, ethics and attitudes in the STEAM model; in the content dimension, the skills and sub-dimensions related to/developed by the STEAM model; STEAM in the learning-teaching process

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and in the measurement-evaluation process. Within the scope of the determined criteria and the pilot application of the holistic rubric developed, a content consisting of the STEM Learning Area outcomes given as a separate learning area in the 2018 Science Curriculum was shared with the raters, and they were asked to score. The holistic rubric developed by the researchers within the scope of the research is given in Appendix-1.

Data Analysis

The analysis of the data obtained through document analysis within the scope of this research was carried out with the content analysis technique. Content analysis aims to reach the concepts and relationships that explain the data obtained (Çepni, 2021). In the research process, the STEAM Model holistic rubric created by the researchers was coded by four faculty members and four science teachers who are experts in the fields of science education and measurement and evaluation based on the 2018 Science Curriculum and the Finnish Science Curriculum. This coding process allows for checking rater reliability as well as clarifying definitions. By discussing the difficulties encountered during coding, definitions can be expanded, changed or made clearer (Miles et al., 2023). In order to check the reliability of the experts' coding, the formula "Reliability=Agreement/(Agreement+Disagreement)" proposed by Miles and Huberman (1994) was used.

The experts were asked to evaluate the Science Curriculum being implemented in Turkey (MEB, 2018) using the holistic rubric and to report their opinions about the rubric. The demographic characteristics of the scoring academics and teachers are given in Table 1.

Table 1
Rater Demographic Information on Turkish Science Curriculum According to STEAM Model

Demographical characteristics	**Graded degree and field**	Seniority year	Institution type	**Official title**	Worked city
Exp 1.1	M.S-Science Education	8	MEB-Science and Art Center	Teacher	Diyarbakır
Exp 1.2	PhD-Science Education	16	MEB-Science and Art Center	Teacher	Ankara
Exp 1.3	PhD-Measurement and Evaluation	22	YÖK-Academic staff	Assoc. Prof. Dr.	Ankara
Exp 1.4	M.S-Science Education	8	MEB-Public school	Teacher	Diyarbakır
Exp 1.5	M.S-Science Education	3	MEB-Art and Science Center	Teacher	Ankara
Exp 1.6	PhD-Measurement and Evaluation	21	MEB-Research and Development Center	Expert	Ankara
Exp 1.7	PhD-Science Education	16	YÖK-Academic staff	Assoc. Prof. Dr.	Kastamonu
Exp 1.8	PhD-Science Education	15	YÖK-Academic staff	Assoc. Prof. Dr.	Van

As seen in Table 1, it is seen that the three academics who made the ratings within the scope of the research, with seniority years of 15, 16 and 22, are faculty members working in universities affiliated to the Council of Higher Education (YÖK) in Kastamonu, Ankara and Van provinces. Two of the academics with the title of associate professor have a doctorate degree in Science Education, and one has a doctorate degree in Measurement and Evaluation. The science teachers who made the ratings were working in Diyarbakır and Ankara, and two of them were working at the Science and Art Center affiliated to the Ministry of National Education (MEB). Three of the raters working as teachers have master's degrees, and one has a doctorate degree in Science Education. The seniority of the teachers varied from a minimum of three years to a maximum of 16 years. It is stated in the table that an expert with 21 years of seniority among the raters has a doctorate degree in Measurement and Evaluation and works at the MEB Research and Development Center. The reason for the selection of expert teachers among the implementers of the Turkish program is that they are the implementers of the program themselves and can realistically evaluate the competencies in the program and the aspects that need to be improved.

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Table 2
Rater Demographic Information on Finland Science Curriculum According to STEAM Model

Demographical characteristics	**Graded degree and field**	Seniority year	Institution type	**Official title**	Worked city
Exp 2.1	PhD-Science Education/Curriculum and Instruction	22	YÖK-Academic staff	Assoc. Prof. Dr.	Ankara
Exp 2.2	M.S-Science Education	3	YÖK-Academic staff	Ress. Ass.	Balıkesir
Exp 2.3	PhD-Science Education	19	YÖK-Academic staff	Assoc. Prof. Dr.	Ankara
Exp 2.4	PhD-Science Education	12	YÖK-Academic staff	Assoc. Prof. Dr.	Kastamonu
Exp 2.5	PhD-Science Education	12	YÖK-Academic staff	Assoc. Prof. Dr.	Van
Exp 2.6	PhD-Science Education	14	MEB-Public school	Teacher	Ankara
Exp 2.7	PhD-Science Education	12	MEB-Public school	Teacher	Ankara
Exp 2.8	PhD-Science Education	13	MEB-Public school	Teacher	Ankara

As seen in Table 2, it is seen that the 5 academics who made the ratings within the scope of the research, with a minimum of 3 and a maximum of 22 years of seniority, are faculty members and lecturers working in universities affiliated to the YÖK in Kastamonu, Ankara, Van and Balıkesir provinces. Four of the academics with the title of associate professor have a doctorate degree in Science Education, and one of them has a doctorate degree in Curriculum and Instruction. One of the scoring research assistants is working in Balıkesir province. The reason why research academics and teachers have PhD were mainly chosen to score the Finnish science curriculum is that they have conducted research on Finnish science education, literacy and are qualified to evaluate the country's curriculum.

Validity, Reliability and Ethics

The draft holistic rubric designed by the researchers was first presented to the expert opinion in order to ensure the validity and reliability conditions. Semi-structured interviews were conducted by sending a form to three faculty members who are experts in the field of Measurement and Evaluation working in two different state universities in Turkey and two faculty members who are experts in the field of STEAM model in science education working in two different state universities in order to examine the draft rubric. As a result of the opinions received from five experts, it was stated as a common opinion that the rubric was in accordance with the theoretical framework. The rubric was finalized after some changes were made in accordance with the opinions (renaming the themes of content and measurement-evaluation and expressing the criteria for the objectives in a more functional and understandable way). In this way, the content validity of the research was ensured. Content validity is the extent to which the measurement tool represents the whole (universe) of the content targeted to be measured (Büyüköztürk et al., 2018). The current Science Curricula on the websites of the Ministries of National Education of Finland and Turkey were examined in detail, and the content under the headings of vision, mission, philosophy, learning areas, units, subjects, related skills of the curricula were created and given to the experts together with the rubric developed by the researchers and asked to score them. Thus, the rater reliability of the study was ensured. In order to ensure the ethical conditions of the study, the ethics committee exemption permission was obtained from Hacettepe University Institute of Educational Sciences by the responsible researcher.

Research Results

Using the holistic rubric prepared by the researchers, the Turkish Science Curriculum (MEB, 2018) was scored by a total of eight researchers, including four science teachers, three faculty members, and one expert, who completed their doctorates in the departments of measurement and evaluation and science education. The holistic rubric consists of seven themes: "Distant Goals in STEAM Model; STEAM Model in the Curriculum and Goal-Gain-

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Standard Relationship; Relationship between STEAM Model in the Curriculum and Outcomes, Values, Ethics and Attitudes; Positioning STEAM Model in the Content Dimension of the Curriculum; Skills and Sub-Dimensions Related to/Developed by STEAM Model in the Curriculum; STEAM Model in the Learning-Teaching Process of the Curriculum; STEAM Model in the Measurement-Evaluation Process of the Curriculum". Using the finalized STEAM Holistic Rubric, the scoring results of the experts regarding the Turkish Science Curriculum are presented in Table 3 for the seven themes.

Table 3
Scores Given to Turkish Science Curriculum Using STEAM Rubric

Themes	Exp 1.1	Exp 1.2	Exp 1.3	Exp 1.4	Exp 1.5	Exp 1.6	Exp 1.7	Exp 1.8
Distant Goals in STEAM Model (Vision, Mission, Project and Strategic Plans)	4	5	4	4	4	4	4	4
STEAM Model in the Curriculum and Target-Gain-Standard Relationship	5	5	4	5	5	5	5	5
The Relationship between the STEAM Model in the Curriculum and Outcomes, Values, Ethics and Attitudes	2	1	2	2	2	2	2	2
Positioning STEAM Model in the Content Dimension of the Curriculum	4	4	4	3	4	4	4	4
Skills and Sub-Dimensions Related to / Developed by the STEAM Model in the Curriculum	4	4	4	4	5	4	4	4
STEAM Model in the Learning-Teaching Process of the Curriculum	5	4	4	4	4	4	4	4
STEAM Model in the Measurement-Evaluation Process of the Curriculum	5	4	5	5	5	5	5	5

Through the STEAM Holistic Rubric, the scoring results of the experts for the seven themes of the Finnish Science Curriculum are given in Table 4.

Table 4
Scores Given to Finnish Science Curriculum Using STEAM Rubric

Themes	Exp 2.1	Exp 2.2	Exp 2.3	Exp 2.4	Exp 2.5	Exp 2.6	Exp 2.7	Exp 2.8
Distant Goals in STEAM Model (Vision, Mission, Project and Strategic Plans)	5	5	5	5	5	5	5	5
STEAM Model in the Curriculum and Target-Gain-Standard Relationship	3	2	3	3	3	3	3	3
The Relationship between the STEAM Model in the Curriculum and Outcomes, Values, Ethics and Attitudes	5	5	5	5	5	5	5	5
Positioning STEAM Model in the Content Dimension of the Curriculum	5	5	5	5	5	5	5	5
Skills and Sub-Dimensions Related to / Developed by the STEAM Model in the Curriculum	3	2	3	3	3	3	3	3
STEAM Model in the Learning-Teaching Process of the Curriculum	5	5	5	5	5	5	5	5
STEAM Model in the Measurement-Evaluation Process of the Curriculum	5	5	5	5	5	5	5	5

Table 3 and Table 4 show the scores given by eight experts for the seven themes of the holistic rubric.

The first theme of the holistic rubric is as follows: "The country's original vision and mission for STEAM model is defined, the place and importance of the strategic plan in the country's development is mentioned, the process

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timeline for the realization of this plan is created, the workforce, in-school and out-of-school facilities (design/production, information materials... etc.) required to realize the steps of the plan are specified, the framework of in-service trainings related to STEAM is clearly defined in a measurable and observable manner, and cooperation with non-formal education institutions is expressed. The framework of in-service trainings related to STEAM has been defined in a clear, measurable and observable way, and cooperation with non-formal education institutions has been expressed." While one expert gave four points for the first theme, seven experts gave five points.

The second theme of the holistic rubric, the STEAM model in the curriculum and the dimension of goal-achievement-standard relationship, is as follows: "STEAM is expressed as a separate learning area, standards and achievements are first explained in global, general terms and then classified with a national perspective considering the cultural context, STEAM and related competencies are associated with all units and subjects, and a holistic connection is established with the disciplines and subfields in which STEAM is integrated." As a result of the scoring in the second theme dimension, one expert gave four points, and seven experts gave five points.

In the dimension of the relationship between the STEAM model in the curriculum and outcomes, values, ethics and attitudes, which was determined as the third theme in the holistic rubric, the item expected to be given five full points by including all criteria in the scoring was determined as follows; "In each unit, the STEAM model has elements of developing awareness of intercultural and aesthetic values, inclusive and tolerant behavior, and has reflections on scientific, global and national attitude values." It is seen that one expert gave one point, and seven experts gave two points for this theme.

The fourth theme in the holistic rubric, which is expected to be given five points for the positioning of the STEAM model in the content dimension of the curriculum, is as follows; "The way the STEAM model is positioned as content in the curriculum is associated with the content organization approaches (linear, spiral, modular, project-centered, etc.) on which the curriculum is based, a relationship is established between the level of effectiveness of the STEAM teaching model use of cognition and affective-based learning areas, and suggestions are presented to the stakeholders of the program based on the relationship between content and model." It is among the findings that one expert gave five points, and seven experts gave four points regarding the related theme.

Within the scope of the fifth theme of the holistic rubric, the item containing the full score criteria for giving five points in the skills and sub-dimensions related to/developed by the STEAM model in the curriculum is as follows; "All of the 21st century skills (critical thinking, reflective thinking, creative thinking, information-processing thinking, design skills, production skills, problem solving skills, scientific process skills, innovative thinking skills, collaboration skills) related to the STEAM model are included." It was found that one expert gave five points, and seven experts gave four points for the specified theme.

As the sixth theme of the holistic rubric, the item containing the full score criteria for giving five points in the context of the STEAM model in the learning-teaching process of the curriculum is as follows; "The STEAM model is associated with various strategies, methods and techniques, enriched with various activity designs and different types of teaching materials are presented to support the teaching process, instructional design suggestions that address individual differences (different learning styles, different intelligence areas... etc.) are included in the instructional design." According to the scoring results of the experts for the related theme, it was found that one expert gave five points, and seven experts gave four points.

Finally, the seventh theme of the holistic rubric, the item containing the full score criteria, which is expected to be given five points for the STEAM model in the measurement and evaluation process of the curriculum, is as follows; "In the reflections of the STEAM model, result-based (multiple choice, true-false, fill-in-the-blank, matching, essay type written exam, oral exam, questionnaire, etc.) in the measurement of knowledge and skills in the reflections of the STEAM model. "Portfolio assessment, performance assessment, rubric (rubric) use, self-assessment, peer assessment, group assessment, etc. are all included in the process-based assessment approaches that include monitoring the student in the education process." In the scoring for the last theme of the holistic rubric, it was determined that one expert gave four points, and seven experts gave five points.

When the consistency calculation formula proposed by Miles and Huberman (1994) (Reliability=Consensus/(Consensus+Disagreement) was applied, the consistency between the raters was found to be 87.5% for the Turkish curriculum and 97% for the Finnish curriculum in the context of the individual and overall averages of all themes. Considering that inter-coder agreement should be between 80% and 90% (Miles et al., 2023), the coding is considered reliable.

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Table 5
Reliability Values Calculated with Kappa Statistics of the Scoring with Rubrics

Number of Scoring Experts	The Curriculum for Which Grading is Done	**Kappa Statistic Value (κ)**
8	2018 Turkish Science Curriculum	.586*
8	Current Finnish Science Curriculum	.832*

*$p < .001$

According to Table 5, the value of the Kappa statistic, which shows the agreement of the scoring of the 2018 Turkish Science curriculum by eight experts with the rubric, was calculated as 0.586, and 0.832 for the scoring of the Finnish Science curriculum by eight experts with the rubric. According to the percentages of agreement suggested by Landis and Koch (1977) (< .00, poor; .00-.20, slight; .21- .40, fair; .41- .60, moderate; .61- .80, substantial; .81-1.00, almost perfect), the Kappa value for Turkish curriculum was .586 for Turkey and moderate among the raters, while the Kappa value for Finnish Curriculum was calculated as .832 and it was seen that the raters showed a high level of agreement with each other.

It can be said that the reason for Finland's higher compliance is that the reflections of the STEAM model in the science programs are more clearly defined, and the academics who made the scoring had previously conducted research and investigations on the Finnish science program. The reason for the moderate level of agreement in the Turkish program is that although the program includes definitions related to the STEAM model, the level of agreement was one level lower compared to Finland due to the differences between the STEAM model competency levels of the graduate science teachers who scored and the infrastructure of the schools.

Discussion

Within the scope of the research, it was aimed to develop a STEAM model holistic rubric to be used in comparative science education policies. As a result of the document analysis of the standard setting and scale development studies related to the STEAM model in the literature, the researchers have developed the STEAM model holistic rubric that includes distant goals (vision, mission, project and strategy plans), objectives (outcomes and standards), the relationship between outcomes and values, ethics and attitudes, STEAM in the content dimension, The standardized criteria in the holistic rubric consisting of five stages were determined according to the level of meeting the standards related to each of the seven themes determined as STEAM related/developed skills and sub-dimensions, STEAM in the learning-teaching process, STEAM in the measurement-assessment process (Aranda et al., 2020; Atman et al., 2007; Baş, 2023; Cirkony & Kenny, 2022; Crismond & Adams, 2012; Gelmez Burakgazi & Karsantık, 2023; Sungur Gül & Saylan Kırmızıgül, 2023; Marshall & Harron, 2018; Moore et al., 2014; Yakob et al., 2021). In the first stage, the holistic rubric obtained was evaluated in terms of language-narrative, operational definition, standardized comprehensibility by everyone, compatibility with the items to be compared by taking expert opinions and the final version of the rubric was given by making arrangements in the themes and sub-dimensions of the rubric. In order to ensure the rater reliability of the finalized tool, four academicians and four science teachers with expertise in the fields of science education, STEAM and measurement and evaluation were asked to score based on the science education standards in Turkey and the 2018 Science Curriculum. According to Miles and Huberman (1994), the inter-rater reliability coefficients of the Turkish and Finnish science curricula were found to be highly consistent. When the results of the Fleiss Kappa statistic, which is a second alternative preferred in cases where there are more than 2 raters in the calculation of inter-rater reliability, were examined, the kappa values of 0.586 for Turkey and 0.832 for Finland were reached. These values indicate a moderate level of agreement for the Turkish science program and a high level of agreement for the Finnish science program (Landis & Koch, 1977). In terms of both statistics, the STEAM model rubric indicates that it is a valid and reliable list of criteria that examines the reflections of the STEAM model in science programs within the scope of national and global science policy development studies. In line with these results, the fact that the Fleiss Kappa rater reliability coefficient of the Turkish program is at a moderate level can be explained in the perspective of certain reasons. In the 2018 Turkish science program, STEAM is included as a separate learning area, but the principles for implementation in the dimensions of objectives, content, learning-teaching process and measurement-evaluation are not sufficiently included. For this reason, the raters were able to make determinations about the existence of the STEAM model based on the acquisition sentences in the program.

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The reason for the higher inter-rater agreement coefficient for the Finnish program is that there are more concrete and operational expressions in terms of the sub-elements of the STEAM model. In addition, the sub-dimensions of the STEAM model were defined in detail in the vision and mission of the Finnish science program.

When the national and global literature on the concept of STEM in science education is examined, it is found that there are certain disagreements in the phenomenological sense. For example, the American school of science education approaches STEM from a more populist and materialist perspective and associates the concept directly with the design of activities and tools. In this context, the STEM model becomes a tool of the learning-teaching platform where direct behavioral acquisitions are developed mechanically rather than learners gaining experiences by doing and living. On the other hand, in Far Eastern countries such as Japan, South Korea, Singapore and some European countries such as Finland, Sweden and Germany, it is seen that the concept of STEM is more visionary by adding the "A" (Art) dimension to the concept of STEM, deepened by associating the processual development of the skills that form the basis for the solution of the problems that people face in their daily lives with educational philosophy approaches, and interdisciplinary program development projects are included with the aim of integrating with different disciplines from seven to seventy (Dostal, 2023; European Schoolnet, 2017; European Schoolnet, 2023; Martinez Ortiz et al., 2018; Rezaei et al., 2022). Dimension A of STEAM was important for researchers in creating the STEM culture of countries in terms of humanistic and progressive educational approaches in this context.

This research aimed to construct a standardized thematic graded scoring key for assessing different science education curricula in terms of STEAM model characteristics. Similarly, Amelia et al. (2024) focus on the process of developing and validating a systematic measurement tool to assess pre-service teachers' ability to design experiments related to the STEAM model. They made important contributions to the field of science education from both theoretical and practical perspectives.

Arslan and Arastaman (2021), in a comparative study examining the STEM policies of various countries with developed economies, pointed out that STEM has an important place in the management of the human resources that countries raise. At this point, it is important to understand the depth of the concept of STEM and especially STEAM in a global perspective and to express its phenomenological definition in a workable manner in line with observable and measurable standards. Although there are STEM curriculum development studies (Kocaman, 2021; Saçan, 2018) that have achieved effective results for certain grade levels in the literature, the applicability of official curricula as a reflection of educational policies and the accessibility of their content holistically at all grade levels where science education is given and in the whole country remains limited. Within the scope of this research, the concept of STEAM was examined in the perspective of the teaching model used in science education and a holistic rubric was developed that allows for a gradual and in-depth examination of the components of the model in line with the vision, mission, educational philosophy approaches on which the model is based, and the four main elements of the curriculum: objectives, content, learning-teaching, and measurement-assessment. Although the purpose of this study is similar to Estévez-Mauriz and Baelo's (2021) research on the design of a rubric for the evaluation of the programs of STEM centers in Spain, it differs from the evaluation of the official Science Curricula of countries globally without being specific to a specific institution, standardized based on the conceptual and theoretical framework, and the evaluation tool developed in this research in terms of providing the opportunity to make comparisons between countries. Supported this finding, Pérez Torres et al. (2024) examined how project-based learning (PBL) contributes to the development of 21st century skills in students, specifically addressing the relationship between STEM and STEAM pedagogy. The study explores the extent to which STEAM-based instructional designs align with STEM practices and how these designs support them. Few research studies were identified in accordance with the criteria development of the STEAM model in science curricula. Those were limited only for one country depending on one instructional design model. Implications of this study offered valuable insights for generating standardized criteria related to the STEAM model and its reflections on different countries' science curricula.

Conclusions and Implications

In order for the STEAM concept to be effectively reflected in educational environments, full integration between disciplines and skills should be ensured and should be among the general and distant goals of countries. The need for predetermined valid and reliable criteria in research studies that employ cultural adaptation and intercultural interaction dimensions in the context of STEAM in program development and evaluation stages reveals the importance of the research and the developed rubric once again.

Based on the results of this study, the following recommendations were made:

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This research study indicated emphasis on interdisciplinarity in newly developed rubrics. In order for curricula to integrate the STEAM approach, strategies to increase interdisciplinary collaboration could be designed. In future research, studies can be conducted on how to strengthen interdisciplinary ties in curricula.

The STEAM model rubric developed in this study is important for showing the assessment procedure of middle school science curricula. Field studies could be conducted to examine how rubric designs are applied in practice. Test the effectiveness of rubrics appropriate for different age groups, cultural contexts and educational levels. For instance, the development of STEAM-focused teacher education programs and the long-term evaluation of their impact can increase teachers' competencies in STEAM pedagogy.

This research is valid for investigating and assessing how cultural context plays a role in STEAM practices. This could be useful for the adaptation of curricula in a national and global context. It is recommended that the rubric, which can be used in comparative educational policy analysis, should be compared in future studies by examining the STEAM vision and curriculum reflections of different countries, and that comparative policy analysis and scale development studies should be carried out that integrate the STEAM concept with transdisciplinary program development and evaluation studies in the context of cultural adaptation and transcultural interaction, and investigate the effects of students living in different cultures on different skill areas.

Developing flexible program development models in line with needs analysis studies that integrate the STEAM Education Model with different disciplines, especially science and mathematics education, based on the results of educational policy analysis, and making field adaptations will increase the level of understanding and application of the concept by the masses.

Qualitative and cross-cultural research determines the perceptions of teachers, students, academics and practitioners about the phenomenological understanding and application of the STEAM model, and learning-teaching processes will be effective in determining the culture established in this field and raising the level of awareness of the model.

This research is qualitative and based on a descriptive model. Experimental studies should be conducted to understand how STEAM rubrics affect student performance. Practical and scale development studies related to the longitudinal analysis of variables such as different grades, age, gender, discipline, learning style, attitude, motivation, problem solving, creativity and critical thinking skills etc., related to the STEAM model will provide theories and practitioners with a vision on how the model should be used.

Rubrics constructed in this study focused on some instructional strategies and educational materials related to the STEAM model. Future research studies could examine how STEAM rubrics can be applied on digital platforms and how technology can be integrated into these processes.

The scale development and standardization studies to be carried out for the evaluation of the STEAM model applications will be a precursor for the international accreditation studies to be organized at different education levels in the future.

The uniqueness of rubrics development studies is the participation of the students in the grading process. The impact of rubrics on students could be evaluated by examining student feedback and their level of participation in STEAM projects for further research studies.

Determining the STEAM cultures of countries at the macro level and of universities, primary and secondary schools at the micro level with valid and reliable measurement tools that provide in-depth operational information will contribute to the development of national and international science education policies of countries.

Declaration of Interest

The authors declare no conflict of interest.

References

Amelia, R. N., Listiaji, P., Dewi, N. R., Heriyanti, A. P., Atmaja, B. D., Shoba, T. M., & Sajidi, I. (2024). Developing and validating a rubric for measuring skills in designing science experiments for prospective science teachers. *Jurnal Inovasi Pendidikan IPA, 10*(1), 32–46. http://doi.org/10.21831/jipi.v10i1.65853

Andrade, H. G. (2005). Teaching with rubrics: The good, the bad, and the ugly. *College Teaching*, *53*(1), 27–31. https://doi.org/10.3200/CTCH.53.1.27-31

Aranda, M. L., Guzey, S. S., & Moore, T. J. (2020). Multidisciplinary discourses in an engineering design-based science curricular unit. *International Journal of Technology and Design Education*, *30*, 507–529. https://doi.org/10.1007/s10798-019-09517-5

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Arslan, S., Y. (2021). *STEM approach for achieving sustainable development goals: A policy proposal for Turkish education system* (Publication No. 685870) [Doctoral dissertation, Hacettepe University]. Council of Higher Education Thesis Center.

Arslan, S. Y. & Arastaman, G. (2021). Stem policies around the world: Implications and recommendations for Turkey. *Nevşehir Hacı Bektaş Veli Üniversitesi SBE Dergisi, 11*(2), 894–910. https://doi.org/10.30783/nevsosbilen.903115

Atman, C. J., Adams, R. S., Cardella, M. E., Turns, J., Mosborg, S., & Saleem, J. (2007). Engineering design processes: A comparison of students and expert practitioners. *Journal of Engineering Education*, *96*(4), 359–379. https://doi.org/10.1002/j.2168-9830.2007.tb00945.x

Bahar, M., Yener, D., Yılmaz, M., Hayrettin, E., & Gürer, F. (2018). The changes of standards in the 2018 science curriculum and STEM integration. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, *18*(2), 702–735. https://doi.org/10.17240/aibuefd.2018..-412111

Bati, K., Yetişir, M. I., Çalişkan, I., Güneş, G., Gül Saçan, E., & Chapman, D. L. (2018). Teaching the concept of time: A steam-based program on computational thinking in science education. *Cogent Education*, *5*(1). https://doi.org/10.1080/2331186X.2018.1507306

Baş, Ş. (2023). *Investigation of the process of preparing STEM-based activities and the effect of activities on STEM awareness of science teacher candidates* (Publication No. 846116) [Master dissertation, Ordu University]. Council of Higher Education Thesis Center.

Bekereci, Ü. (2022). *The effect of the use of project-based learning methods and station technique in STEM learning model on students' academic achievement, retention, towards attitudes to STEM* (Publication No. 734595) [Doctoral dissertation, Gazi University]. Council of Higher Education Thesis Center.

Bircan, M. A. & Çalışıcı, H. (2022). The effects of STEM education activities on fourth grade students' attitudes to STEM, 21st-century skills and mathematics success. *Education & Science, 47*(211), 87–119. http://dx.doi.org/10.15390/EB.2022.10710

Blackley, S. & Howell, J. (2015). A STEM narrative: 15 Years in the making. *Australian Journal of Teacher Education, 40*(7), 102–112. http://dx.doi.org/10.14221/ajte.2015v40n7.8

Bodner, G. & Elmas, R. (2020). The impact of inquiry-based, group-work approaches to instruction on both students and their peer leaders. *European Journal of Science and Mathematics Education*, *8*(1), 51–66. https://doi.org/10.30935/scimath/9546

Bogdan, R. C. & Biklen, S. K. (2007). *Research for education: An introduction to theories and methods*. New York Pearson.

Breiner, J. M., Harkness, S. S., Johnson, C. C., & Koehler, C. M. (2012), What is STEM? A discussion about conceptions of STEM in education and partnerships. *School Science and Mathematics, 112*, 3–11. https://doi.org/10.1111/j.1949-8594.2011.00109.x

Brown, R., Brown, J., Reardon, K., & Merrill, C. (2011). Understanding STEM: Current perceptions. *Technology and Engineering Teacher*, *70*(6), 5–9. https://www.researchgate.net/profile/ChrisMerrill/publication/234659554_Understanding_STEM_Current_perceptions/links/618c0dce61f09877207bc812/Understanding-STEM-Current-perceptions.pdf

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2018). *Bilimsel araştırma* yöntemleri [Methods of scientific research]. (24th Ed.). Pegem Academy.

Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities.* NSTA Press.

Chen, S. & Ding, Y. (2023). Assessing the psychometric properties of STEAM competence in primary school students: A construct measurement study. *Journal of Psychoeducational Assessment, 41*(7), 796–810. https://doi.org/10.1177/07342829231186685

Chen, X. (2009). Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education. Stats in Brief. NCES 2009-161. *National Center for Education Statistics*. https://eric.ed.gov/?id=ED506035

Cirkony, C. & Kenny, J. D. (2022). Using formative assessment to build coherence between educational policy and classroom practice: A case study using inquiry in science. *Australian Journal of Teacher Education*, *47*(10), 77–105. http://dx.doi.org/10.14221/ajte.2022v47n10.5

Coşkun, S. & Taneri, P. O. (2021). Evaluation of prospective teachers' educational approaches within the framework of educational philosophies. *Dört Öge*, (19), 29–49. https://dergipark.org.tr/en/pub/dortoge/issue/64535/888929

Crismond, D. P. & Adams, R. S. (2012). The informed design teaching and learning matrix. *Journal of Engineering Education, 101*(4), 738–797. http://doi.org/10.1002/j.2168-9830.2012.tb01127.x

Çepni, S. (2021). *Araştırma ve proje çalışmalarına giriş* [Introduction to research and projects] (9th Ed.). Celepler Matbaacılık Yayın ve Dağıtım.

Çepni, S. (2015). Performansların değerlendirilmesi. [Evaluation of performances]. E. Karip (Ed.), *Ölçme ve değerlendirme* [*Measurement and evaluation*], (pp. 233-292). Pegem Academy.

Çepni, S., & Ormancı, Ü. (2018). Geleceğin dünyası. [The world of the future]. S. Çepni (Ed.), *Kuramdan uygulamaya STEM*$_{+E}^{+A}$ *eğitimi* [STEM$_{+E}^{+A}$ education from theory to practice], (pp. 1–52). Pegem Academy.

Çevik, M., & Ata, R. (2019). Turkish validation of STEAM scale and examination of relations between art attitudes, STEM awareness, and STEAM attitudes among pre-service teachers. Inquiry in Education, 11(2), 1–25 . https://digitalcommons.nl.edu/ie/vol11/iss2/3

DeLuca, C., Dubek, M., & Rickey, N. (2024). How hermeneutics can guide grading in integrated STEAM education: An evidence-informed perspective. *British Educational Research Journal*, 50, 1263–1280. https://doi.org/10.1002/berj.3979

Dostál, J. (2023). Comparison of the national curriculum from the STEM perspective with focus on technologies and engineering in the Czech Republic, Poland and Slovakia. *TEM Journal*, *12*(1), 566–577. https://doi.org/10.18421/TEM121-67

Elmas, R. & Geban, Ö. (2016). The effect of context based chemistry instruction on 9th grade students' understanding of cleaning agents topic and their attitude toward environment. *Education & Science*, *41*(185). https://doi.org/10.15390/EB.2016.5502

English, L. D. (2016). STEM education K-12: Perspectives on integration. *International Journal of STEM education*, *3*(3), 1–8. https://doi.org/10.1186/s40594-016-0036-1

Estévez-Mauriz, L. & Baelo, R. (2021). How to evaluate the STEM curriculum in Spain?. *Mathematics*, *9*, 236. https://doi.org/10.3390/math9030236

European Schoolnet. (2017, August 7). *Scientix*. European Schoolnet. http://www.eun.org/projects/detail?articleId=676930

European Schoolnet. (2023, June 26). *EmpowerED.* European Schoolnet. http://www.eun.org/projects/detail?articleId=10199809

Fraenkel, J., Wallen, N., & Hyun, H. (2013). *How to Design and Evaluate Research in Education* (8th Ed). McGraw-Hill Education.

https://doi.org/10.33225/jbse/25.24.19

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Galanti, T. M. & Holincheck, N. (2024). Developing integrated STEM teacher identity using guided curation of K-12 engineering activities. *Research in Integrated STEM Education*, *2*(1), 31–55. https://doi.org/10.1163/27726673-bja00010

Gao, X., Li, P., Shen, J., & Sun, H. (2020). Reviewing assessment of student learning in interdisciplinary STEM education. *International Journal of STEM Education*, *7*(24), 1–14. https://doi.org/10.1186/s40594-020-00225-4

Gelmez Burakgazi, S. & Karsantık, Y. (2023). Development of a meta-evaluation rubric and meta-evaluation of initial teacher education programs. *Education & Science*, *49*(217). https://doi.org/10.15390/EB.2023.11755

Gencer, A. S., Doğan, H., Bilen, K., & Can, B. (2019). Integrated STEM education models. *PAU Journal of Education, 45*, 38–55. https://doi.org/10.9779/PUJE.2018.221

Gough, A. (2015). STEM policy and science education: Scientistic curriculum and sociopolitical silences. *Cultural Studies of Science Education*, *10*, 445–458. https://doi.org/10.1007/s11422-014-9590-3

Güler, H. (2023). *STEM approach in achieving 21st century skills preschool education* (Publication No. 828913) [Doctoral dissertation, Ordu University]. Council of Higher Education Thesis Center.

Han, S. & Buchmann, C. (2016). Aligning science achievement and STEM expectations for college success: A Comparative study of curricular standardization. *RSF: The Russell Sage Foundation Journal of the Social Sciences*, *2*(1), 192–211. https://doi.org/10.7758/RSF.2016.2.1.09

Hart, J. (2019). Interdisciplinary project-based learning as a means of developing employability skills in undergraduate sciencedegree programs. *Journal of Teaching and Learning for Graduate Employability*, 10(2), 50–66. https://search.informit.org/doi/abs/10.3316/informit.585956751973202

Huang, B. & Jong, M. S. (2020). Developing a generic rubric for evaluating students' work in STEM education. In *2020 International Symposium on Educational Technology (ISET)* (pp. 210–213). IEEE. https://doi.org/ 10.1109/ISET49818.2020.00053

Huutoniemi, K., Klein, J. T., Bruun, H., & Hukkinen, J. (2010). Analyzing interdisciplinarity: Typology and indicators. *Research policy, 39*(1), 79–88. https://doi.org/10.1016/j.respol.2009.09.011

Johnston, A. C., Akarsu, M., Moore, T. J., & Guzey, S. S. (2019). Engineering as the integrator: A case study of one middle school science teacher's talk. *Journal of Engineering Education*, *108*(3), 418–440. https://doi.org/10.1002/jee.20286

Karasar, N. (2013). *Bilimsel araştırma yöntemi* [Scientific research methodology]. Nobel.

Keskin, M. & Şahin, M. (2018). Progressivism in education. *Journal of Research in Education and Teaching*, *7*(3), 50–74. http://www.jret.org/FileUpload/ks281142/File/06.mustafa_keskin.pdf

Kilgour, P., Northcote, M., Williams, A., & Kilgour, A. (2020) A plan for the co-construction and collaborative use of rubrics for student learning. *Assessment & Evaluation in Higher Education, 45*(1), 140–153. https://doi.org/10.1080/02602938.2019.1614523

Kline, S. J. (1995). *Conceptual foundations for multidisciplinary thinking*. Stanford University Press.

Klein, J. T. (2010). A taxonomy of interdisciplinarity. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 15–30). Oxford, UK: Oxford University Press

Kocaman, B. (2021). *Developmet of an analytical thinking based online STEM curriculum and investigation of its efficiency* (Publication No. 723749) [Doctoral dissertation, Afyon Kocatepe University]. Council of Higher Education Thesis Center.

Kutlu, Ö., Doğan, C., D., & Karakaya, İ. (2023). *Ölçme ve değerlendirme performansa ve portfolyaya dayalı durum belirleme* [Assessment and evaluation based on performance and portfolio]. (6th Ed.). Pegem Academy.

Landis, J, R. & Koch, G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33,* 159–174. https://doi.org/10.2307/2529310

Li, Y., Xiao, Y., Wang, K., Zhang, N., Pang, Y., Wang, R., Qi, C., Yuan, Z., Xu, J., Nite, S. B., & Star, J. R. (2022). A systematic review of high impact empirical studies in STEM education. *International Journal of STEM Education, 9*(1), 72. https://doi.org/10.1186/s40594-022-00389-1

Mäkelä, T., Tuhkala, A., Mäki-Kuutti, M., & Rautopuro, J. (2023). Enablers and constraints of STEM programme implementation: An external change agent perspective from a national STEM programme in Finland. *International Journal of Science and Mathematics Education*, *21*(3), 969–991. https://doi.org/10.1007/s10763-022-10271-9

Mang, H. M. A., Chu, H. E., Martin, S. N., & Kim, C. J. (2023). Developing an evaluation rubric for planning and assessing SSI-based steam programs in science classrooms. *Research in Science Education*, *53*(6), 1119–1144. https://doi.org/10.1007/s11165-023-10123-8

Marshall, G. & Jonker, L. (2010). An introduction to descriptive statistics: A review and practical guide. *Radiography*, *16*(4), e1–e7. https://doi.org/10.1016/j.radi.2010.01.001

Marshall, J. A. & Harron, J. R. (2018). Making learners: A framework for evaluating making in STEM education. *Interdisciplinary Journal of Problem-Based Learning, 12*(2). https://doi.org/10.7771/1541-5015.1749

Martinez Ortiz, A., Garcia-Torres, S., Rodriguez Amaya, L., & Thompson, M., (2018). *The NASA Family Backpack Initiative – leveraging STEM interactive educational activities to bridge school and home* (LBJ Institute 2018 STEM Resources Collection). Texas State University: LBJ Institute for STEM Education and Research.

Miles, M. B. & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. SAGE.

Miles, M. B., Huberman, A. M., & Saldana, J. (2023). *Nitel veri analizi* [*Qualitative data analysis*]. (G. Öztürk, Trans.; S. Akbaba Altun & A. Ersoy, Eds.). Pegem Academy.

Milli Eğitim Bakanlığı. (2005). *Fen ve teknoloji dersi öğretim programı* [*Science and technology curriculum*]. Ankara.

Milli Eğitim Bakanlığı. (2013). *İlköğretim kurumları fen bilimleri dersi öğretim programı* [*Elementary school science curriculum*]. Ankara.

Milli Eğitim Bakanlığı. (2018). *Fen bilimleri dersi öğretim programı* [Science education curriculum]. https://mufredat.meb.gov.tr/Dosyalar/201812312311937fen%20bİlİmlerİ%20öğretİm%20programi2018.pdf

Milli Eğitim Bakanlığı. (2024). *Fen bilimleri dersi öğretim programı* [Science education curriculum]. https://cdn.eba.gov.tr/icerik/GorusOneri/2024ProgramlarOnayli/2024programfen345678OnayliKod.pdf

Ministry of Education and Culture. (2023). *Finnish national STEM strategy and action plan: experts in natural sciences, technology and mathematics in support of society's welfare and growth.* https://julkaisut.valtioneuvosto.fi/handle/10024/164953#:~:text=The%20aim%20of%20the%20strategy,socially%2C%20ecologically%20and%20economically%20sustainable.

https://doi.org/10.33225/jbse/24.23.19

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Moore, T. J., Stohlmann, M. S., Wang, H. H., Tank, K. M., Glancy, A. W., & Roehrig, G. H. (2014). Implementation and integration of engineering in K-12 STEM education. In *Engineering in pre-college settings: Synthesizing research, policy, and practices* (pp. 35–60). Purdue University Press.

National Research Council. (2011). *Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics.* Committee on highly successful science programs for K-12 science education. Board on Science Education and Board on Testing and Assessment, Division of Behavioral and Social Sciences and Education. The National Academies Press.

National Research Council. (2014). *STEM Integration in K-12 Education: Status, prospects, and an agenda for research*. Washington, DC: The National Academies Press. https://doi.org/10.17226/18612.

Nungu, L., Mukama, E., & Nsabayezu, E. (2023). Online collaborative learning and cognitive presence in mathematics and science education. Case study of university of Rwanda, college of education. *Education and Information Technologies*, *28*(9), 10865–10884. https://doi.org/10.1007/s10639-023-11607-w

Özcan, H. & Koca, E. (2019). Turkish adaptation of the attitude towards STEM scale: A validity and reliability study. *Hacettepe University Journal of Education, 34*(2), 387–401. https://doi.org/10.16986/HUJE.2018045061

Özkul, H. & Özden, M. (2020). Investigation of the Effects of Engineering-Oriented STEM Integration Activities on Scientific Process Skills and STEM Career Interests: A Mixed Methods Study. *Education & Science*, *45*(204). https://doi.org/10.15390/EB.2020.8870

Panadero, E. & Jonsson, A. (2020). A critical review of the arguments against the use of rubrics. *Educational Research Review, 30*, 100329. https://doi.org/10.1016/j.edurev.2020.100329.

Patton, M. Q. (2005). *Qualitative research*. John Wiley & Sons.

Pérez Torres, M., Couso Lagarón, D., & Marquez Bargalló, C. (2024). Evaluation of STEAM Project-Based Learning (STEAM PBL) Instructional Designs from the STEM Practices Perspective. *Education Sciences, 14*(1), 53. https://doi.org/10.3390/educsci14010053

Quigley, C. F., Herro, D., & Jamil, F. M. (2017). Developing a conceptual model of STEAM teaching practices. *School Science and Mathematics, 117*(1–2), 1–12. https://doi.org/10.1111/ssm.12201

Rezaei, M., Emamjomeh, S. M. R., Ahmadi, G. A., Assareh, A., & Niknam, Z. (2022). A comparative study of integrated STEM curriculum in Finland, Singapore and the United States to provide recommendations for Iranian curriculum planners. *Iranian Journal of Comparative Education*, *5*(1), 1765–1788. https://doi.org/10.22034/IJCE.2022.251947.1227

Reynders, G., Lantz, J., Ruder, S. M., Stanford, C. L., & Cole, R. S. (2020). Rubrics to assess critical thinking and information processing in undergraduate STEM courses. *International Journal of STEM Education 7*(9). https://doi.org/10.1186/s40594-020-00208-5

Rochim, R. A., Prabowo, P., Budiyanto, M., Hariyono, E., & Prahani, B. K. (2022). The use of STEM-integrated project-based learning models to improve learning outcomes of junior high school students. In *Proceedings of the Eighth Southeast Asia Design Research (SEA-DR) & the Second Science, Technology, Education, Arts, Culture, and Humanity (STEACH) International Conference (SEADR-STEACH 2021)* (Vol. 627, pp. 211–218). Advances in Social Science, Education and Humanities Research. https://doi.org/10.2991/assehr.k.211229.034

Roehrig, G. H., Dare, E. A., Ring-Whalen, E., & Wieselmann, J. R. (2021). Understanding coherence and integration in integrated STEM curriculum. *International Journal of STEM Education*, *8*, 1–21. https://doi.org/10.1186/s40594-020-00259-8

Saçan, E. (2018). *STEM-based curriculum proposal and effectiveness for science applications course* (Publication No. 494333) [Doctoral dissertation, Hacettepe University]. Council of Higher Education Thesis Center.

Sarı, U. & Karaşahin, A. (2020). Computational thinking in science education: evaluating a teaching activity . *Turkish Journal of Primary Education*, *5*(2), 194–218. https://dergipark.org.tr/en/pub/tujped/issue/58028/825217

Sen, C., Ay, Z. S., & Kiray, S. A. (2021). Computational thinking skills of gifted and talented students in integrated STEM activities based on the engineering design process: The case of robotics and 3D robot modeling. *Thinking Skills and Creativity*, *42*, 100931. https://doi.org/10.1016/j.tsc.2021.100931

Sutaphan, S. & Yuenyong, C. (2019). STEM education teaching approach: Inquiry from the context based. In *IOP Conf. Series: Journal of Physics: Conf. Series, 1340, p 012003*. https://doi.org/10.1088/17426596/1340/1/012003

Sungur Gül, K. & Saylan Kırmızıgül, A. (2023). Algodoo based STEM education: A case study of pre-service science teachers. *Education and Information Technologies*, *28*, 4203–4220. https://doi.org/10.1007/s10639-022-11348-2

Sungur, S., Tekkaya, C., & Geban, Ö. (2006). Improving achievement through problem-based learning. *Journal of biological Education*, *40*(4), 155–160. https://doi.org/10.1080/00219266.2006.9656037

Takeuchi, M. A., Sengupta, P., Shanahan, M. C., Adams, J. D., & Hachem, M. (2020). Transdisciplinarity in STEM education: a critical review. *Studies in Science Education, 56*(2), 213–253, https://doi.org/10.1080/03057267.2020.1755802

Wan, Z. H., English, L., So, W. W. M., & Skilling, K. (2023). STEM integration in primary schools: Theory, implementation and impact. *International Journal of Science and Mathematics Education*, *21*(Suppl 1), 1–9. https://doi.org/10.1007/s10763-023-10401-x

Wang, J. (2014). A Comparative Evaluation of STEM education Indicators in the Era of Accountability. *International Journal of Education*, *6*(1), 1. http://dx.doi.org/10.5296/ije.v6i1.4406

Yakob, M., Hamdani, H., Sari, R. P., Haji, A. G., & Nahadi, N. (2021). Implementation of performance assessment in STEM-based science learning to improve students' habits of mind. *International Journal of Evaluation and Research in Education*, *10*(2), 624–631. https://doi.org/10.11591/ijere.v10i2.21084

Yeni, S., Grgurina, N., Saeli, M., Hermans, F., Tolboom, J., & Barendsen, E. (2024). Interdisciplinary Integration of Computational Thinking in K-12 Education: A Systematic Review. **Informatics in Education**, **23**(1), 223–278. https://doi.org/10.15388/infedu.2024.08

Yıldırım, A. & Şimşek, H. (2018). *Sosyal bilimlerde nitel araştırma yöntemleri* [*Qualitative research methods in social sciences*]. Seçkin Publishing.

Zascerinska, J., Emet, S., Usca, S., & Bikova, A. (2023). STEM education: A comparative study of platforms in selected countries. In *2023 International Interdisciplinary PhD Workshop (IIPhDW)* (pp. 1–6). IEEE. https://doi.org/10.1109/IIPhDW54739.2023.10124402

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Appendix-1

STEAM MODEL HOLISTIC RUBRIC IN COMPARATIVE SCIENCE EDUCATION POLICIES

Below is a holistic rubric for the STEM/STEAM model vision and policies in the education systems of countries. In this context, there are seven themes in the rubric, namely distant goals in STEAM education (vision, mission, project and strategy plans), Goal (outcomes and standards), Relationship between outcomes and values, ethics and attitudes, STEAM in the content dimension, Skills related to/developed by STEAM and its sub-dimensions, STEAM in the learning-teaching process, STEM/STEAM in the measurement-assessment process, and each theme consists of five stages according to the level of meeting the standards it is related to. Comparative education reports, especially the curricula of the countries, comparative education reports, and documents obtained from ministry websites, will be subjected to document analysis and will be examined comparatively in line with the standardized criteria in the holistic rubric.

DISTANT GOALS IN STEAM MODEL (VISION, MISSION, PROJECT AND STRATEGIC PLANS)	
5	Countries' specific future visions and missions for STEM and STEAM education are defined, the place and importance of strategy plans in the development of the country are mentioned, an action plan for the realization of strategy plans is created, the workforce, in-school and out-of-school facilities (design/production, information materials... etc.) required to realize the steps of this plan, the framework of in-service trainings on STEAM are clearly and clearly defined, and cooperation with non-formal education institutions is expressed.
4	Countries' specific future visions and missions for STEAM education are defined, the place and importance of strategy plans in the development of the country are mentioned, an action plan for the realization of strategy plans is created, the workforce, in-school and out-of-school facilities (design/production, information materials... etc.) required to realize the steps of this plan, but the framework of in-service trainings on STEAM is not specified and/or cooperation with non-formal education institutions is not established.
3	Countries' unique future visions and missions for STEAM education were defined, the place and importance of strategy plans in the development of the country were mentioned, but the action plan for the realization of the strategy plans and the content for implementation were not specified.
2	Countries have defined their own future visions and missions for STEAM education, but the importance of the realization of the strategy plans in the development of the country is not mentioned.
1	Countries do not have their own future visions, missions and strategic plans for STEAM education.
TARGET-GAIN-STANDARDS	
5	In the curriculum, STEAM is expressed as a separate learning area, achievements and standards are designed in a national and global context, STEAM and related competencies are associated with all units and subjects, and a holistic connection is established with the disciplines and sub-fields in which STEAM is integrated.
4	STEAM is expressed as a separate learning area, but the outcomes are not categorized in national and global dimensions.
3	STEAM is expressed as a separate learning area, but there are no learning outcome statements related to the STEM model.
2	STEAM is not a separate learning area in the curriculum, but it is holistically linked to the disciplines and sub-fields in which STEAM is integrated.
1	There is no STEAM orientation in the curriculum.
THE RELATIONSHIP BETWEEN ATTAINMENT AND VALUES, ETHICS AND ATTITUDES	
5	In the STEAM learning areas in each unit in the curriculum, there are elements of developing awareness of intercultural and aesthetic values, inclusive and tolerant behavior, and scientific, global and national attitudes are reflected in values.
4	The curriculum includes developing awareness of intercultural and aesthetic values in STEAM learning areas in each unit and reflects scientific, global and national attitudes on values, but there is no clear definition of inclusive and tolerant behavior elements.

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3	In the curriculum, there are reflections on scientific, global and national attitudes and values in STEAM learning areas in each unit, but there is no clear definition of developing awareness of intercultural and aesthetic values and inclusive and tolerant behavior elements.
2	In the curriculum, the reflection of STEAM learning areas on scientific, global and national attitudinal values in each unit is implicit (informal learning environment, performance activities, etc.), but there is no explicit definition of developing awareness of intercultural and aesthetic values and inclusive and tolerant behavior elements.
1	STEAM fields have no reflection on the elements of inclusive and tolerant behavior and developing awareness of scientific, global and national attitudinal values, intercultural and aesthetic values.
STEM/STEAM IN CONTENT DIMENSION	
5	The content organization approaches (linear, spiral, modular, project-centered, etc.) on which the program is based were associated with the STEAM teaching model, a relationship was established between the level of effectiveness of the STEAM teaching model use of cognition and affective-based learning areas, and suggestions were presented to the stakeholders of the program based on the relationship between content and model.
4	The content organization approaches (linear, spiral, modular, project-centered, etc.) on which the program is based were associated with the STEAM teaching model, and a relationship was established between the level of effectiveness of the use of STEAM teaching model in cognition and affective-based learning areas, but no recommendations were presented to the stakeholders of the program based on the relationship between content and model.
3	The content organization approaches (linear, spiral, modular, project-centered, etc.) on which the program is based were associated with the STEAM teaching model, and an implicit relationship was established between the level of effectiveness of the STEAM teaching model use of cognition and affective-based learning areas, but no recommendations were presented to the stakeholders of the program based on the relationship between content and model.
2	The content organization approaches (linear, spiral, modular, project-centered, etc.) on which the curriculum is based were implicitly associated with the STEAM teaching model, but there was no implicit relationship between the level of effectiveness of the STEAM teaching model use of cognition and affective-based learning areas, and no recommendations were presented to the stakeholders of the program based on the relationship between content and model.
1	No relationship was established with the STEAM teaching model in the content dimension of the program.
SKILLS AND SUB-DIMENSIONS RELATED TO/DEVELOPED BY STEM/STEAM	
5	The curriculum includes all 21st century skills (critical thinking, reflective thinking, creative thinking, computational thinking, design skills, production skills, problem solving skills, scientific process skills, innovative thinking skills, collaboration skills) related to STEM and STEAM.
4	In the curriculum, information-process thinking, innovative thinking skills, design skills, production skills, problem solving skills, critical thinking skills, scientific process skills were included in the 21st century skills related to STEAM, while creative thinking and collaboration skills were partially included.
3	In the curriculum, 21st century skills related to STEAM include computational thinking, innovative thinking skills, design skills, production skills, problem solving skills, critical thinking skills, scientific process skills, but not creative thinking and collaboration skills.
2	In the curriculum, 21st century skills related to STEAM include computational thinking, innovative thinking skills, design skills, production skills, problem solving skills, critical thinking skills, scientific process skills, but not creative thinking and collaboration skills.
1	The curriculum does not include 21st century skills that STEAM is related to.
STEM/STEAM IN THE LEARNING-TEACHING PROCESS	
5	In the Science curriculum, STEAM teaching model is associated with various strategies, methods and techniques, supported with various activity designs and rich teaching materials are presented to support the teaching process, and instructional design suggestions to address individual differences (different learning styles, different intelligence areas, etc.) are included in the instructional design.

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4	In the Science curriculum, the STEAM teaching model was associated with various strategies, methods and techniques, supported by various activity designs and limited teaching materials were presented to support the teaching process.
3	In the Science curriculum, the STEAM teaching model was associated with various strategies, methods and techniques, supported by various activity designs, and teaching materials to support the teaching process were not presented.
2	In the Science curriculum, the STEAM teaching model was partially associated with strategies, methods and techniques and supported with limited activity designs.
1	In the Science curriculum, the STEAM teaching model was not associated with strategies, methods and techniques, teaching materials were not presented to support the teaching process, and it was not supported by activity designs.
STEM/STEAM IN MEASUREMENT AND EVALUATION PROCESS	
5	In the reflections of the STEAM teaching model in the curriculum, "Portfolio assessment, performance assessment, rubric use, self-assessment, peer assessment, group assessment" are all included in the process measurement and evaluation approaches in the measurement of knowledge and skills.
4	In the reflections of the STEAM teaching model in the curriculum, portfolio assessment, performance assessment, rubric (rubric use) and self-assessment were included in the measurement of knowledge and skills, and peer and group assessment were partially included.
3	In the curriculum, in the reflections of the STEAM teaching model, portfolio assessment, performance assessment, rubric (the use of rubrics) were included in the measurement of knowledge and skills, self-assessment was partially used, peer and group assessment were not included.
2	In the curriculum, the importance of the use of process assessment and evaluation approaches in the measurement of knowledge and skills in the reflections of the STEAM teaching model is implicitly included, but portfolio assessment, performance assessment, rubric (rubric use), self-assessment, peer and group assessment are not included.
1	In the reflections of the STEAM teaching model in the curriculum, "Portfolio assessment, performance assessment, rubric use, self-assessment, peer assessment, group assessment" were not included in all of the process measurement and evaluation approaches in the measurement of knowledge and skills.

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