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Teaching characteristics based on the Integrated STEM approach in the scientific departments at the College of Science and Humanities at Prince Sattam bin Abdulaziz University: Views from the faculty members

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ABSTRACT

The purpose of this study was to examine the extent to which teaching traits are available according to the integrated STEM approach in the scientific departments of the College of Science and Humanities at Prince Sattam bin Abdulaziz University, from the perspective of faculty members. The researcher employed a descriptive-analytical methodology. A questionnaire was developed based on the global framework for STEM education prepared by the New York Academy of Sciences. The questionnaire consisted of 86 indicators, distributed across three dimensions: basic competencies, (which included core skills and supporting traits), instructional design, and implementation. The study sample comprised 77 faculty members (39 males & 38 females). The results revealed that the extent to which teaching characteristics based on the integrated STEM approach are available, from the perspective of faculty members, was moderate across all dimensions and in the total score. Significant differences were found between male and female faculty members in favor of males regarding the availability of teaching attributes according to the integrated STEM approach. However, no significant differences were observed in the availability of these traits according to academic specialization across all dimensions or their total score. The study recommends enhancing professional development programs for faculty members in the scientific departments in line with STEM requirements, including training in essential skills such as critical thinking, problem-solving, creative thinking, and the use of digital technologies and computer sciences. It also emphasizes providing specialized training programs on designing integrated STEM units, including inquiry-based teaching, project-based learning, and linking concepts from science, engineering, and mathematics to real-world applications relevant to the local context.

KEYWORDS: Integrated approach, science teaching, Kingdom of Saudi Arabia.

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Introduction

University education in the current era is witnessing rapid cognitive and educational transformations, driven by successive scientific and technological developments, and the new requirements imposed by the Fourth Industrial Revolution in the labor market. In the face of these transformations, it has become necessary for higher education institutions to reconsider their programs and teaching methods, to ensure the development of 21st century skills and enable students to build a deep understanding of the interdisciplinary relationships between scientific disciplines. In this context, the Integrated STEM Approach stands out as one of the most reliable approaches to create deep learning based on the integration of STEM, and on the development of higher competencies and productive thinking in learners (Bybee, 2013).

The educational literature indicates that the application of STEM education requires a reformulation of the role of the faculty member, so that his/her role is not devoted to the transfer of specialized knowledge, but also extends to the design of integrative learning environments, the management of research, experimentation, and problem-solving, and guiding students toward producing knowledge rather than consuming it (Kelley & Knowles, 2016). Hence, the need to determine the characteristics of teaching according to the STEM approach, and to know the extent of their availability among faculty members in scientific departments, especially in colleges where basic and applied sciences are based on academic programs.

The core competencies of the STEM approach are the central pillar of integrated teaching, and they are regarded as a complex set of personal and professional skills and the traits that a faculty member should have. Studies have shown that these competencies form the basis of the ability to manage a learning process based on integration, application, and research (Vasquez, Sneider, & Comer, 2013) and include core competencies, core skills, and supportive attributes.

The basic skills include skills that enable a faculty member to lead classroom practices associated with a STEM approach, most notably: critical thinking, which reflects the ability to analyze problems, data, and ideas, and to judge scientific evidence in making judgments. Research suggests that critical thinking is at the core of STEM education because of its association with scientific research and inquiry (Breiner et al., 2012), and problem-solving, which is an essential component of STEM education. STEM, where students are directed toward real-world challenges that require systemic analysis and interdisciplinary linkages (Honey, Pearson, & Schweingruber, 2014), and evidence shows that integrated teaching promotes creative production through engineering design challenges and applied projects (Kelley & Knowles, 2016).

Core skills include communication, where the effectiveness of STEM education depends on the faculty member's ability to demonstrate interdisciplinary relationships, manage scientific dialogue, and guide students to present their ideas using accurate scientific language (Bybee, 2013), and collaboration, where the literature confirms that integration between STEM disciplines entails cooperative learning that allows for the exchange of experiences and the analysis of phenomena from a group work perspective (Vasquez et al., 2013), and a culture of dealing with data where true integration begins when a faculty member has the ability to analyze data and employ statistics, mathematical models, and software (Portillo-Blanco et al., 2024)., digital culture and computer science where recent trends indicate that STEM has become closely linked to computer science, modeling and simulation, and programming (Bybee, 2013)

In addition to basic skills, a faculty member needs a set of professional characteristics that directly affect the quality of STEM applications, which are supportive ones, including a STEM mindset, a holistic view that enables them to pertain to the relationships among different sciences. Effectiveness and perseverance: STEM projects require resilience to problems, and the ability to experiment continuously. and social and cultural awareness, which is reflected in the faculty member's ability to link learning to the context of the local community.

Supportive characteristics also include leadership, as managing an integrative or research project requires leadership skills related to conflict resolution and work organization. Professional ethics: These include scientific integrity, responsible use of data, and respect for the values of the scientific community.

Instructional design of the STEM approach represents the structure on which integrative teaching is based. Studies indicate that good design is the cornerstone of the success of STEM application within university institutions (Kelley & Knowles, 2016), and the most prominent elements of instructional design are: inquiry-based teaching, and the integration of STEM content by linking concepts and applications between disciplines, Real-world Applications, Project/Problem-based Learning, Scaffolding, Assessment, Cultural Relevance, and Technology Integration.

The literature suggests that the integrated instructional design provides an environment rich in hands-on experience, enabling students to set a deeper understanding of scientific concepts by applying them in engineering, technological, and environmental contexts (Honey et al., 2014), and the actual implementation of STEM practices is the practical aspect that reflects the faculty member's ability to apply the designed integrative practices. Studies have shown that the success of STEM teaching depends to a large extent on the quality of implementation, rather than the quality of planning alone (Breiner et al., 2012), the requirements for successful implementation include: accessibility and simplicity, adaptability to local context and university environments, professional development and institutional support, evidence of effectiveness, provision of educational materials and resources, and flexibility and continuous development.

The literature suggests that the absence of these elements is the most prominent challenge to STEM application at the university, where lack of resources or poor professional development leads to inadequate application and a gap between planning and implementation (Portillo-Blanco et al., 2024)

It is clear from above that teaching according to the STEM approach is not just a formal integration of disciplines, but rather an integrated system that requires the availability of a wide range of skills, attributes, designs, and executive practices. In light of less literature that dealt with the availability of these characteristics among faculty members in the faculties of science in Arab universities, there was a need to study the reality of these traits at the College of Science and Humanities at Prince Sattam bin Abdulaziz University, and analyze them from the point of view of faculty members to determine the level of The college's readiness to shift towards integrated teaching, and to prioritize academic and professional development.

Problem of the Study:

Educational practices in higher education have witnessed a growing shift towards adopting integrative learning models that enhance students' mastery of 21st century skills, foremost of which are critical thinking, problem-solving, creativity, communication, and collaboration, in addition to digital culture and the ability to deal with data. Recent literature indicates that the STEM approach is one of the most important educational approaches capable of supporting these skills by integrating science, technology, engineering, and mathematics into real-world project-based learning experiences Scientific Investigation (Bybee, 2013; Moore et al., 2014).

The proposed STEM approach is effective in developing generative thinking and excellence (Salem, 2021). A number of studies have shown that the success of STEM application in higher education depends to a large extent on the availability of a set of teaching characteristics among faculty members, including core competencies, the ability to design integrative learning, and implementation skills within an educational environment based on application and innovation (Honey et al., However , the literature shows that many institutions of higher education suffer from a lack of STEM activation due to poor interdisciplinary integration, lack of training, and limited awareness of appropriate instructional design to implement this approach (Breiner et al., 2012; El-Deghaidy & Mansour, 2015).

In light of this, there seems to be an urgent need to assess the availability of the teaching characteristics necessary to activate STEM among faculty members in scientific departments, especially since the College of Sciences and Humanities includes disciplines that can be effectively integrated, but in practice it may face challenges related to the absence of an integrative work culture, the weakness of the educational structure that supports innovation, or the limited employment of projects and technology in university teaching.

The literature also suggests that the absence of these characteristics leads to the limitation of teaching to traditional models, limiting students' ability to acquire real STEM skills, while their availability enables faculty members to employ scientific research, content integration, project-based learning, authentic assessment, effective use of technology and relevance to cultural and societal context (Kennedy & Odell, 2014; Capraro et al., 2013)

Based on the above, the problem of the current research is the lack of clarity on the level of availability of teaching characteristics according to the STEM approach among the faculty members in the scientific departments at the College of Science and Humanities at Prince Sattam Bin Abdulaziz University, and the extent to which they possess the basic competencies, their ability to design integrative instruction, and their actual practices in implementing this approach.

Hence, the research problem can be stated in the following main question:
What is the availability of teaching characteristics according to the integrated STEM approach among faculty members in the scientific departments of the College of Sciences and Humanities at Prince Sattam Bin Abdulaziz University from their point of view?
Hence the main problem of the research, which can be formulated through the following questions:

- What is the availability of teaching features according to the STEM approach in the scientific departments at the College of Sciences and Humanities at Prince Sattam Bin Abdulaziz University from the perspective of the faculty members?
- Does the availability of teaching characteristics according to the STEM approach in the scientific departments at the College of Sciences and Humanities at Prince Sattam Bin Abdulaziz University differ from the perspective of the faculty members according to gender?
- Does the availability of teaching characteristics according to the STEM approach in the scientific departments at the College of Sciences and Humanities at Prince Sattam Bin Abdulaziz University differ from the point of view of the faculty members according to the specialization?

Objectives of the Study:
The study aims to identify:

1) The Availability of Teaching Features According to the Integrated STEM Approach in the Scientific Departments at the College of Sciences and Humanities at Prince Sattam Bin Abdulaziz University from the Viewpoint of the Faculty Members.
2) Differences in the level of availability of teaching characteristics according to the integrative approach according to gender (male and female).
3) Differences in the level of availability of teaching features according to the integrative approach according to the specialization (biology, chemistry, physics, mathematics).

Limitations of the Study:
Objective Limits: The study deals with the availability of teaching features according to the integrated STEM approach in the scientific departments at the College of Sciences and Humanities at Prince Sattam bin Abdulaziz University from the perspective of the faculty members.
Spatial Limits: The study was administrated at the College of Science and Humanities in Al-Kharj.
Time Limits: The research was applied during the academic year 1445 A.H.

Terms of the Study:
Teaching Characteristics
The set of competencies, skills, and practices that a faculty member should have when applying the STEM approach, including core competencies, instructional design skills, and implementation skills. It is a set of characteristics that demonstrate a faculty member's ability to manage integrative learning based on project, inquiry, and technology, as reported in the literature (Bybee, 2013; Honey et al., 2014)

Integrative STEM Approach
It is defined in the literature as an educational approach that integrates science, technology, engineering, and mathematics disciplines into integrative learning situations, based on real-world applications, projects, and problem-solving activities, with the aim of developing higher thinking skills and creativity (Bybee, 2010; English, 2016)

In this study, it means procedurally: the educational environment in which science, technology, engineering and mathematics are integrated through core competencies, instructional design and effective implementation as measured by questionnaire items.

Core Competencies STEM Core Competencies
It refers to a set of skills and traits that are fundamental to STEM learning, including critical thinking, problem-solving, creativity, communication, collaboration, digital culture, data handling, STEM mindset, leadership,

ethics, and others cited in the literature (Honey et al., 2014).

Instructional Design

It is the process of planning and developing educational situations in accordance with STEM principles, so that they integrate the content of scientific disciplines, employ projects, achieve relevance to the real context, integrate technology, and use performance-based assessment (Moore et al., 2014; Capraro et al., 2013)

Implementation

It refers to the practical practices that a faculty member performs in the classroom when implementing STEM, including accessibility, contextualization, learning support, evidence of effectiveness, availability of instructional resources, and flexibility in application (Shernoff et al., 2017).

Theoretical Framework

Integrative STEM Approach

The STEM approach has emerged as a global trend that responds to the rapid developments in science and technology, and to the need for a workforce that possesses innovative thinking and problem-solving skills. Scientific reports have confirmed that the integration of science, technology, engineering, and mathematics (STEM) has become an urgent necessity for the development of contemporary education (National Research Council, 2014).

The STEM approach is defined as an educational framework that integrates STEM disciplines into problem- and project-based learning modules and situations, so that learning is integrated and linked to real-life contexts (Bybee, 2013). This trend aims to move beyond the traditional separation of disciplines, and to build learning based on application and discovery.

STEM is based on a number of theoretical foundations, most notably constructivism, which emphasizes that knowledge is built through interaction and experience, problem-based learning that focuses on dealing with real-life situations (Hmelo-Silver, 2004), and cognitive j that allows mathematical, scientific, engineering, and technological concepts to overlap into a single activity (Moore et al., 2014). The literature suggests that STEM adoption contributes to the development of higher thinking skills, creativity, and innovation (Shernoff et al., 2017).

STEM Introduction to College Education

The application of STEM in university education is one of the main trends that enhance the competitiveness of academic institutions, as international reports indicate that the integration of scientific disciplines contributes to the development of graduates' skills and links their learning to professional reality (OECD, 2019).

The importance of STEM in university education is highlighted by:

- **Developing scientific research skills** through applied projects that require data analysis and model building (Breiner et al., 2012).
- **Promote 21st century skills** such as communication, critical thinking, creativity, and teamwork (Honey et al., 2014).
- **Support innovation and entrepreneurship** through the design of engineering and technical products and solutions (Sanders, 2009).
- **Reducing the gap between theory and practice** through integrative activities (English, 2016).

The literature also indicates that the application of STEM contributes to raising motivation towards scientific disciplines, increasing the effective participation of students in research and development projects (El-Deghaidy & Mansour, 2015), and leads to a significant improvement in academic achievement and self-efficacy in solving complex problems.

Teaching Characteristics According to the STEM Approach

The process of teaching according to the STEM approach requires a set of factors or characteristics that should be available to the faculty member, the most prominent of which is the true integration of disciplines, and this includes the integration of science, engineering, mathematics and technology concepts and skills into a single learning situation, away from the traditional fragmentation (Moore et al., 2014).

The employment of project-based learning is also an essential focus of STEM, and it is an important feature of it, because it moves learning from the theoretical to the practical level, and enables the design of real solutions (Capraro et al., 2013).

On the other hand, the use of technology in teaching should be done in a systematic manner, including the use of simulation, digital modeling, scientific software, 3D printing, and other tools of science education technology (Roberts, 2013).

An important feature of STEM education is performance-based assessment, where STEM requires the use of multiple tools such as achievement files, rubrics, presentations, projects, and scientific notes, rather than just achievement tests (Honey et al., 2014).

Another feature of STEM is the enhancement of higher thinking skills, as it focuses on the skills of analysis, interpretation, and the generation of new ideas, which entails asking open-ended questions and encouraging students to investigate and experiment (Kennedy & Odell, 2014).

Finally, the connection to real-life contexts is clearly highlighted in the context of STEM education, as it emphasizes the activation of scientific and engineering practices through the linking of content to real-world environments (Bybee, 2010) and this contributes to increasing students' motivation and clarity of their learning goal.

Challenges of Implementing STEM Approach in university education

Studies show that the application of STEM faces a range of challenges in university education environments, most notably: lack of specialized training for faculty members (Shernoff et al., 2017), poor deep understanding of the philosophy of interdisciplinary integration (Breiner et al., 2012), scarcity of resources and technologies in some university institutions (El-Deghaidy & Mansour, 2015), as well as the tendency that some individuals may show towards resistance to change due to the habituation of traditional teaching (Sanders, 2009), and time constraints and content density limit the ability to implement large-scale projects (Moore et al., 2014). The literature suggests that overcoming these challenges requires ongoing training programs, administrative support, and the provision of technologically rich laboratory learning environments.

The Role of the Faculty Member in Promoting STEM Application

The faculty member plays a pivotal role in the success of STEM application, as it requires a shift from the role of "delivering of content" to facilitator, supporter, and mentor. Designing integrated educational attitudes based on projects and surveys. and cooperation among scientific departments to enhance integration between disciplines. Systematic use of technology to support learning. and the development of authentic performance assessment tools. And enhancing students' higher thinking skills.

Studies show that a faculty member who has a positive attitude toward STEM is better able to design innovative and effective learning environments (Kennedy & Odell, 2014).

Literature Review

During the last decade, educational literature has witnessed a significant widespread study that have dealt with STEM education, whether in terms of analyzing instructional design models, the effectiveness of applied programs, or the professional competencies required to implement this approach.

Moore et al. (2014) provided a broad analytical review of instructional design models in STEM and concluded by defining an integrative framework that focuses on content integration, project-based learning, real-world applications, performance-based assessment, and technology integration, emphasizing that the success of STEM application requires content reorganization beyond the traditional arrangement of topics. The study of Honey et al. (2014) addressed the challenges facing the application of STEM in higher education, and showed that the effectiveness of the application is related to the availability of core teaching competencies, such as classroom leadership and the management of complex learning environments, and that the lack of resources and infrastructure is a major barrier to effective implementation.

Rizk's (2015) study aimed to employ the integrative approach to develop 21st century skills and decision-making skills among students of the Faculty of Education, and the results showed a clear effectiveness of the approach in developing targeted skills. In contrast, Shernoff et al. (2017) focused on analyzing the practices of STEM teachers in integrative learning environments, she revealed that effective application requires critical thinking skills, project-based learning management, support for scientific inquiry, in addition to communication and collaboration skills, stressing that the lack of training represents one of the most prominent challenges.

Interest in the application of STEM continued in the various stages of education, as Mohammed (2018) used the STEM approach supported by cloud computing to develop life skills, mathematical cohesion, and the tendency towards scientific study among middle school students, and the results showed a remarkable superiority for the experimental group. The study of Asr (2018) also aimed to reveal the effectiveness of the STEM interdisciplinary approach in the development of sports excellence and twenty-first century skills among middle school students, and the results showed significant differences in favor of the experimental group. Robinson, Kolodner, & Stiles (2018) looked at how to integrate real-world technology and applications into STEM teaching and emphasized that the quality of the application depends on the teacher's ability to design real-world learning experiences that are relevant to the local context. Lawrie & Ott (2018) also compared the levels of middle school teachers' ownership of STEM competencies. According to professional experience, it showed that the most experienced teachers possess higher skills in scientific communication, digital culture, and engineering design.

Bybee & Ormell (2019) analyzed the core features of STEM education in universities, emphasizing the importance of teachers having critical thinking, problem-solving, and creative thinking skills, as well as a STEM mindset that supports interdisciplinary integration. Kilpatrick & Steinberg (2019) also showed that the success of the application of STEM modules in science faculties depends on the availability of learning materials, professional development, institutional support, and adaptation to the local context.

The study of Jad Al-Haq (2020) sought to prepare a training program based on STEM to develop teaching performances and productive thinking skills among students of the Faculty of Education, and the results showed significant differences in favor of the dimensional application. Al-Montashiri and Al-Farani (2020) also investigated the effect of three-dimensional design according to STEM on the development of the skill of fluency among female middle school students, and the results showed a significant improvement in favor of the dimensional application. In the same year, it was revealed by Rutledge & Seelbach (2020) that the most important professional competencies needed for STEM application are problem-solving abilities, scientific communication, and creative thinking, as well as a STEM mindset, and that the lack of vocational training is a major barrier to application.

The study of (2021) students aimed to develop mathematical literacy and reduce mathematics anxiety among middle school students using a STEM-based program, and the results showed the superiority of the experimental group. Salem (2021) also aimed to find out the effectiveness of a STEM-based educational unit in developing generative thinking and excellence in mathematics among second-grade middle school students, and the results showed significant differences in favor of the dimensional application. The study by Schwartz, Lee, & Taber (2021) showed the effectiveness of STEM designs based on the integration of science and engineering in developing higher thinking skills, especially critical thinking and project-based learning.

Mohamed's (2022) study focused on developing entrepreneurial thinking and scientific culture among female student teachers in the kindergarten division using a STEM-based program, and the results showed a clear positive impact. Bouzghaya and Shenna (2022) also conducted a dimensional analysis of 16 studies on STEM, and the results showed a large impact size of (1.73) of the STEM approach on the development of thinking skills. Peralta & Stohlmann's (2022) study looked at the impact of STEM teacher traits on student motivation, and showed that classroom leadership, professional ethics, cultural awareness, and technology integration are the most impactful.

Khairy's (2023) study sought to identify the professional competencies needed for a science teacher according to STEM, and to build a distance training program, and the results showed a significant impact of the program amounting to (4.9). The study of Salem et al. (2023) also presented a proposed program in space technology based on STEM to develop scientific concepts and future thinking among science teachers before service. While Al-Assimi's study (2023) investigated the effect of a STEM-based enrichment program on the development of creative thinking and problem-solving among outstanding students, and the results showed significant differences in favor of the experimental group.

In 2024, Salem's (2024, a) study tested the effectiveness of a STEM-based program in space technology to develop scientific concepts in pre-service science teachers, and the results showed high effectiveness. Finally, Al-Jarwan (2025) explored the effectiveness of a STEM-based program in space technology; the role of AI in the development of talented coordinator training programs in light of STEM, and showed that AI contributes to the personalization of training and the improvement of STEM application.

This span of previous studies represents a clear evolutionary trajectory in the treatment of STEM, but at the same time it reveals a knowledge gap represented by the limited studies that have dealt with the teaching characteristics of university faculty members, the paucity of studies that have dealt with the faculties of science in Arab universities, and the absence of studies that combine core competencies, instructional design, and actual implementation practices In one framework, with the possibility of analyzing differences between genders and disciplines and linking the results to the local context, which reinforces the importance of the current study, which seeks to diagnose the level of availability of teaching attributes according to the STEM approach among faculty members in the scientific departments of the College of Sciences and Humanities at Prince Sattam Bin Abdulaziz University.

Methodology of the Study:

The present study adopted the descriptive-analytical approach as the most appropriate for the nature of the goal of diagnosing the availability of teaching attributes according to the STEM approach among faculty members in the scientific departments of the College of Sciences and Humanities at Prince Sattam Bin Abdulaziz University. A questionnaire addressed to faculty members was developed to collect the necessary data and analyze it quantitatively.

Group of the Study:

The research community consists of all faculty members in the scientific departments of the College of Science and Humanities at Prince Sattam bin Abdulaziz University in Al-Kharj Governorate in the Kingdom of Saudi Arabia, representing various basic scientific disciplines.

Participants of the Study

The study included a survey sample of (50) faculty members (25) males and (25) females, which were used to verify the primary psychometric characteristics of the study tool. The main sample consisted of (77) faculty members, including (39) males and (38) females, distributed in the disciplines of biology, chemistry, physics, and mathematics, with varying levels of experience and scientific ranks, as shown in Table (1).

Table (1) Distribution of the basic study sample, according to gender, specialization, scientific rank and teaching experience

Variable	Classification	Issue	Percentage
Gender	Male	39	50.6
	Female	38	49.4
Special-ization	Biology	15	19.5
	Chemistry	21	27.3
	Physics	20	26
	Mathematics	21	27.3
Teaching Experi-ence	Five years and less	7	9.1
	More than 5 years and less than 10 years	20	26
	More than 10 years and less than 15 years	15	19.5
	15 years and above	35	45.5

Variable	Classification	Issue	Percentage
Academic Rank	Assistant	1	1.3
	Lecturer	10	13
	Assistant Professor and above	66	85.7
Total		77	**100%**

Table (1) shows the distribution of the basic sample according to gender, specialization, teaching experience, and scientific rank, where a clear balance between the sexes appears, and a close representation of scientific disciplines, in addition to the fact that the majority of the sample participants have more than ten years of teaching experience, and a large percentage of them are assistant professors or higher, which enhances the reliability of the data obtained from the sample.

Instrument of the Study:

The study adopted a questionnaire prepared by the researcher to measure the availability of teaching characteristics according to the integrative approach STEM among faculty members. The questionnaire was based on theoretical frameworks and previous studies, especially the Global STEM Alliance for STEM Education issued by the Academy of Sciences in New York. (n.d.) The questionnaire included (86) items distributed in three main parts:

1) **Core competencies include:**
   - **Basic Skills**: Critical Thinking, Problem Solving, Creative Thinking, Communication, Collaboration, Data Culture, Digital Culture and Computer Science.
   - **Supporting Traits**: STEM Mindset, Effectiveness and Perseverance, Social and Cultural Awareness, Leadership, Professional Ethics.

2) **Instructional design,** including research-based teaching, STEM content integration, real-world applications, project-based learning or problem-solving, instructional reinforcement, assessment, cultural relevance, and technology integration.
3) **Implementation,** including accessibility and simplicity, adaptability to local context, professional development and learning support, evidence of effectiveness, availability of learning materials, flexibility and scalability.

The questionnaire used a four-tier scale (high, medium, low, and unavailable) with scores (3, 2, 1, and 0), respectively.

Psychometric Characteristics of the Instrument

Face and Content Validity:

The questionnaire was initially presented to a group of natural science and science education professionals to verify the relevance, linguistic and conceptual accuracy of the items, and the extent to which they were representative of the dimensions of the global STEM framework and necessary adjustments were made based on their feedback.

Internal consistency

The correlation coefficients (Pearson) were calculated between each item and the total score of the dimension to which it belongs, and between the dimensions of the resolution and the total score. The correlation coefficients ranged between (0.64) and (0.88), all of which are a function at the level of (0.01), which indicates a high internal consistency.

Reliability:

Cronbach's alpha coefficient was calculated for the total score of the resolution, which was (0.89), which is a high value that reflects a good level of stability and reliability of the measurement.

Statistical Analysis Procedures

The study used descriptive and inferential statistical methods appropriate to the nature of the data, including arithmetic averages and standard deviations, in addition to testing (T) for the differences between the averages, to determine the level of availability of teaching attributes according to the STEM approach, and to detect possible differences according to gender and specialization variables.

Results of the Study:

Answering Research Questions:

The first question:

What is the availability of teaching characteristics according to the STEM approach in the scientific departments at the College of Sciences and Humanities at Prince Sattam Bin Abdulaziz University from the faculty members' point of view?

The answer to this question was based on the analysis of the questionnaire data by calculating the mean averages, standard deviations, hypothetical averages, test values (T), and the order of the three main dimensions. Table (3) shows the detailed results.

Table (3): The level of availability of teaching attributes according to the STEM approach in the study sample - (n=77) *

m	Dimensions and Features		Number of indicators	Mean Dimension	Total Phrase Averages	Total deviations of phrases	Hypothetical Average	Value (T)	Significance Level	Dimension Level	**Ranking**
	Part I: Basic Competencies	Basic Skills	26	2.11	54.84	12.58	39.26	10.87	0.01	Medium	
		Supporting Features	16	2.17	34.66	9.19	24.16	10.02	0.01	Medium	
		Total Core Competencies	42	2.13	89.50	20.93	63.42	10.93	0.01	Medium	3
	Part Two: Instructional Design		28	2.25	63.19	14.59	42.28	12.57	0.01	Medium	2
	Part III: Implementation		16	2.33	37.22	8.57	36.16	1.08	0.28	Medium	1
The total number of teaching attributes available according to the integrative approach			86	2.21	189.92	42.30	129.86	12.46	0.01	Medium	

*The levels for each indicator were calculated as follows: High (2.26-3), Average (1.51-2.25), Low (0.76-1.50), Unavailable (0-0.75)

The results showed that the general level of the availability of teaching characteristics according to the STEM approach came at an average level, where the overall average reached (2.21), which indicates that the faculty members possess an acceptable amount of characteristics related to teaching according to this approach, without reaching a high level that ensures the advanced application of the integrative approach.

At the dimensional level, implementation ranked first with an average of (2.33), followed by instructional design with an average of (2.25), and then core competencies with an average of (2.13). This ranking reflects that faculty members are more able to implement STEM practices than they can design integrated modules or possess the core competencies needed for this type of teaching.

Analysis of the First Dimension: Basic Competencies

The results showed that the core competencies – including core skills and supporting traits – were at an average level. The supporting traits (e.g., effectiveness and perseverance, social awareness, leadership, and professional ethics) achieved a slightly higher average (2.17) compared to the core skills (2.11) which include critical thinking, problem-solving, creative thinking, communication, collaboration, and digital culture.

This suggests that faculty members are more able to demonstrate personal and behavioral traits than cognitive, procedural, and applied skills associated with STEM education, which is consistent with some studies that have confirmed that core competencies require ongoing professional training, and that personality traits naturally manifest themselves in daily academic practice (Shernoff et al., 2017; Bybee & Ormell, 2019). The values of (v) at the significance level of (0.01) also showed that there are significant differences between the mean averages and the hypothetical averages, which confirms the availability of these traits to a moderate degree among the faculty members.

Analysis of the Second Dimension: Instructional Design

Instructional design came with an average availability level of STEM entrance features with a mean score of (2.25), which indicates the ability of faculty members to an acceptable degree to integrate STEM content, employ research-based learning and projects, and link the content to real-world applications, but deep integration between disciplines still needs to be developed, and this result is consistent with what studies have reported) that confirmed that instructional design according to STEM It represents one of the most challenging aspects for teachers, especially in light of limited experience or lack of resources (Moore et al. 2014; Peralta & Stohlmann, 2022).

Third Dimension Analysis: Implementation

The implementation came in first place with the highest average (2.33), which indicates that faculty members are well able to apply STEM practices, manage inquiry-based and project-based educational activities, employ technology, and provide an active learning environment, but the significance value (0.28) indicates that there are no significant differences between the mean score and the hypothetical average, which means that the level of implementation is not statistically different from the expected level, this reflects the need for greater institutional support to promote this aspect, as indicated by some studies (Honey et al. 2014; Schwartz et al. 2021).

The results of the study reveal an average level of availability of teaching attributes according to the STEM approach among faculty members, which is consistent with the literature that indicates that STEM effectiveness is highly correlated with teacher possession of core competencies and integrated instructional design.Bybee & Ormell, 2019; Peralta & Stohlmann, 2022) that the success of the application depends on the teacher's professional competencies and his or her ability to design integrative learning. The current findings are consistent with what Shernoff et al. (2017) have pointed out about the need to strengthen vocational training and improve interdisciplinary integration, as the intermediate level reflects a clear gap in core competencies and instructional design.

The results indicate that the availability of STEM teaching attributes among faculty members in scientific departments is generally at the intermediate level, with a relative superiority of the executive dimension. Although this is partially consistent with some previous studies, it highlights the urgent need to develop quality training programs that enhance core competencies and instructional design in line with global frameworks for STEM education, and to ensure a more effective and inclusive application in Saudi universities.

The intermediate level of core competencies has several implications: it reflects that faculty members possess core skills such as critical thinking, problem-solving, and creative thinking, but this possession does not reach an advanced level. It also indicates that support skills—such as effective communication, collaborative work, and time management—are moderate, which may be related to limited professional development programs or a lack of ongoing training in STEM. The literature supports this interpretation, as Salem's (2024) study showed that STEM projects contribute to the development of higher thinking skills, but they require continuous support to reach advanced levels, and Khairi's (2023) study confirmed that distance training improves professional competence but needs continuous enhancement.

The order of dimensions shows a relative superiority of the executive dimension compared to core competencies and instructional design, which is consistent with Rutledge & Seelbach (2020) about the tendency of experienced teachers to master the applied aspects more than to have design and integration competencies. This discrepancy indicates the need to invest in the development of core competencies, particularly critical thinking, communication, and collaborative work skills, which appeared to be moderate, which is supported by the results of Salem (2024) and Khairy (2023) that confirmed that the development of these skills. It requires continuous and guided training.

In the instructional design dimension, the results showed an acceptable ability of faculty members to integrate STEM content, but this integration is still limited, which is consistent with what Moore et al. (2014) and Shernoff et al. (2017) have stated about the challenges teachers face in achieving full integration due to lack of expertise or resources.

In terms of the implementation of STEM modules, the intermediate level reflects the ability of faculty members to apply the core principles of the approach, but it also indicates that there are constraints related to infrastructure, curriculum pressure, class size, and lack of intensive hands-on training, which is confirmed by the Schwartz, Lee, & Taber (2021) study that indicated that the quality of implementation depends on institutional support, infrastructure, and a deep understanding of STEM principles.

Overall, the results reveal that the implementation of the STEM approach in the College of Sciences and Humanities has not yet reached an advanced level, which calls for the promotion of continuous professional development programs, the provision of a supportive learning environment, the development of infrastructure and technical equipment, and the raising of awareness of the importance of STEM in university education. The results indicate that faculty members possess the necessary fundamentals, but they need in-depth practical training and expanded practical experiences to enhance interdisciplinary integration and achieve Higher levels of professional competencies.

Answer to the second question:

Does the availability of teaching characteristics according to the STEM approach in the scientific departments at the College of Sciences and Humanities at Prince Sattam Bin Abdulaziz University differ from the perspective of the faculty members according to gender?

To answer this question, the researcher calculated the "T" test for two independent samples to measure the significance of the differences between the averages of males and females in the sub-and main dimensions of the questionnaire. Table (4) presents the results of the statistical analysis.

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able (4) Values (v) and levels of statistical function for the members of the two groups (males and females) in the variable of the availability of teaching attributes according to the integrative approach (n=77)

Dimension		Number of indicators	Mean Dimension	Gender	Issue	Category Arithmetic Average	Total mean averages	Total standard deviations	Value T	Significance Level
Part I: Basic Competencies	Basic Skills	26	2.11	Male	39	2.22	57.79	10.47	2.13	0.04
				Female	38	1.99	51.82	13.91		
	Supporting Features	16	2.17	Male	39	2.28	36.51	7.74	1.82	0.7
				Female	38	2.05	32.76	10.23		
	Total Competencies	42	2.13	Male	39	2.25	94.31	17.15	20.8	0.04
				Female	38	2.01	84.58	23.41		
Part Two: Instructional Design		28	2.26	Male	39	2.39	66.97	12.01	2.37	0.02
			Female	38	2.12	59.32	16.09			
Part III: Implementation		16	2.33	Male	39	2.43	38.90	7.93	1.76	0.08
			Female	38	2.22	35.50	8.95			
Availability of STEM teaching characteristics as a whole		86	2.21	Male	39	2.33	200.18	35.79	2.21	0.03
			Female	38	2.09	179.39	46.20			

Table (4) shows the results of the (T) test for the variable of the availability of teaching characteristics according to the STEM approach between male and female faculty members across the sub-and main dimensions of the questionnaire. The preliminary results indicate that there were no statistically significant differences between the sexes in the implementation dimension, while differences appeared in favor of males in the dimension of basic competencies, instructional design, as well as in the overall degree of attribute availability.

Looking at the basic competencies as a whole, we find that the average male was 2.25 vs. 2.01 for females, and the value of the test (T) was equal to 20.8 at the significance level of 0.04, which indicates that there are statistically significant differences between males and females in the availability of basic competencies, this means that gender affects the level of availability of basic competencies among faculty members, although both males and females may be They have a convergent estimate of supporting traits, which is partially consistent with the results of some previous studies (Shernoff et al. 2017; Bybee & Ormell, 2019) found that basic competencies are usually available to similar degrees among teachers regardless of gender, and therefore these competencies require ongoing training to ensure the effectiveness of the application for both males and females.

In the instructional design dimension, males scored a higher average (2.39) than females (2.12), the value of the test (v) was equal to 2.37 at the significance level of 0.02, which indicates that there are statistically significant differences between males and females in the availability of instructional design attributes, and this may be due to the degree of possession of basic skills, which showed that the results in the competency dimension showed the superiority of males over females. However, there is a need for training in instructional design skills for both genders and raising the level of the ability to design modules STEM is integrated to integrate science, engineering, technology, and mathematics, including project-based learning, and linking content to real-world applications. The literature confirms (Moore et al., 2014; Rutledge & Seelbach, 2020) argue that instructional design is a critical component of STEM success, and that possessing essential skills is not enough without specialized training in learning design.

After implementation, the average male was 2.43 vs. 2.22 For females, since the difference between the two averages is not statistically significant, this indicates a convergence of the level of males and females in the ability to implement practical STEM modules, use instructional techniques, and apply active learning strategies, which is consistent with the findings of Schwartz et al. (2021) and Robinson et al. (2018) that emphasized that implementation is more associated with institutional support than with individual gender differences.

At the macro level, the average availability of STEM teaching characteristics for males was (2.33) vs. (2).9.0) for females, which is statistically significant, suggesting that gender-related factors may be a barrier to the application of STEM in the university environment. The slight superiority of males in some dimensions – especially basic skills and instructional design – may be explained by occupational and cultural factors, such as longer work experience, more available training opportunities, or greater involvement in applied activities, which are important aspects indicated by some studies (Honey et al., 2014; Lawrie & Ott, 2018; Peralta & Stohlmann, 2022).) as factors influencing the development of STEM skills in teachers.

The findings on core competencies can be explained by the fact that personality traits – such as effectiveness, perseverance and social awareness – are more clearly manifested in the academic work environment, while core skills require continuous systematic application, as confirmed by the studies of Rutledge & Seelbach (2020) and Bybee & Ormell (2019). That may hinder STEM applications related to other factors such as the results of a study by Shernoff et al. (2017) that showed that some of the challenges in STSTEM are related to training and institutional support than gender.

Overall, the results confirm that the characteristics of STEM teaching are moderately available among faculty members, with gender differences, and this draws attention to the need to strengthen professional development programs, expand specialized training opportunities, and provide a supportive learning environment to ensure a more effective application of the STEM approach in line with global frameworks.

Answer to the third question:

Does the availability of teaching features according to the STEM approach in the scientific departments at the College of Sciences and Humanities at Prince Sattam Bin Abdulaziz University differ from the viewpoint of the faculty members according to the specialization (biology, chemistry, physics, mathematics)?

To answer this question, the differences between the average scores of the sample members in the availability of teaching characteristics according to the integrative approach according to the specialization variable were calculated, using the analysis of variance as shown in Table (5).

Table (5): Analysis of the Variance for the Significance of the Differences between the Mean Scores of the Sample in Teaching characteristics According to STEM in Different Scientific Disciplines at the College of Science and Humanities at Prince Sattam Bin Abdulaziz University

Dimensions or variables		Source of Contrast	Total Squares	Degrees of Freedom	Average Squares	Value of "P"	Significance Level
Part I: Basic Competencies	Basic Skills	Between groups	906.87	3.00	302.29	1.99	.12
		Within Groups	11111.26	73.00	152.21		
		Total	12018.13	76.00			
	Supporting Features	Between groups	282.54	3.00	94.18	1.12	.35
		Within Groups	6138.69	73.00	84.09		
		Total	6421.22	76.00			
	Core competencies as a whole	Between groups	2133.13	3.00	711.04	1.67	.18
		Within Groups	31146.11	73.00	426.66		
		Total	33279.25	76.00			
Part Two: Instructional Design		Between groups	459.72	3.00	153.24	.71	.55
Within Groups		15738.36	73.00	215.59			
Total		16198.08	76.00				
Part III: Implementation		Between groups	95.32	3.00	31.77	.42	.74
Within Groups		5481.92	73.00	75.09			
Total		5577.25	76.00				
Availability of STEM teaching attributes as a whole		Between groups	135963.53	76.00	302.29	1.11	.35
Within Groups		906.87	3.00	152.21			
Total		11111.26	73.00				

Table (5) reveals the results of the study related to the extent to which the availability of teaching characteristics according to the STEM approach differs among faculty members in the scientific departments (biology, chemistry, physics, mathematics) and a clear picture of professional homogeneity within the College of Science and Humanities at Prince Sattam bin Abdulaziz University. and the overall average of competencies.

In the total sum of the basic competencies, it appears that the value of the "P" test = 1.67, at the significance level = 0.18, while its value in the basic skills is equal to 1.99, at the significance level is 0.1, and in the supporting traits it is equal to 1.12, at the significance level is 0.35. As for instructional design, its value was 0.71, at the significance level of 0.55, and in the erasure of implementation, it reached 0.42 at the significance level of 0.74. In the total mean scores of the availability of STEM teaching characteristics, the value of the "P" test = 1.11, at the significance level of 0.35.

The results indicate that scientific specialization does not affect the level of availability of STEM teaching characteristics, whether in core competencies, instructional design, or implementation, and this result is consistent with the findings of some studies (Honey et al., 2014; Peralta & Stohlmann, 2022) that individual differences and subdisciplines are not a barrier to STEM application, and that success is more dependent on the availability of professional development programs, educational resources, and internship opportunities, and the results support what studies have indicated (Shernoff et al., 2017; Bybee & Ormell, 2019), which confirmed that the effectiveness of STEM application is more related to professional training, work experience, and institutional support, than to scientific discipline. Moore et al.'s (2014) study also showed that effective instructional design of a STEM approach can be applied across multiple disciplines when teachers have the core competencies available.

The absence of differences between disciplines may be attributed to several factors, including:

- **The Interdisciplinary Nature of the STEM Entrance**

The STEM approach is inherently an integrative approach that goes beyond the traditional boundaries of scientific disciplines, as it relies on the integration of science, technology, engineering, and mathematics into a single framework. Therefore, the skills required to apply it—such as critical thinking, problem solving, engineering design, and project-based learning—are common to all scientific disciplines. This explains why there are no differences between different scientific departments, as these skills are not exclusive to a particular discipline, but can be developed by all faculty members. Moore et al. (2014) found that effective instructional design for a STEM approach can be applied across multiple disciplines where teachers have the core competencies available.

- **Homogeneity of professional competencies among faculty members**

The absence of differences between disciplines largely reflects a homogeneity in the professional and training backgrounds of faculty members, and most of them may have undergone similar training programs during their graduate studies or through professional development programs within the university, which has led to a convergent level of core competencies related to the application of STEM, especially since the results of some studies (Shernoff et al., 2017) indicated that the success of the STEM application It relies more on training and professional experience, rather than on the exact scientific specialization. A study (Bybee & Ormell, 2019) further confirmed that the competencies required for STEM application are general in nature and can be acquired through training and practice, regardless of specialist background.

- **A unified global framework**

The questionnaire used in the study was based on the Global Framework for STEM Education developed by the New York Academy of Sciences, which focuses on common competencies across disciplines, such as creative thinking, linking scientific concepts to reality, science communication skills, and inquiry-based learning. Since these competencies are not tied to a specific discipline, it is natural for results to appear to be similar between different scientific departments. The study of Honey et al. (2014) supports this trend, noting that the criteria Global STEM focuses more on interdisciplinary competencies than on rigorous specialist knowledge.

- **Similarity of Institutional Environment and Educational Resources**

The science departments within the college have a converged learning environment in terms of infrastructure, laboratories, instructional technologies, and digital resources, providing equal opportunities for faculty to apply STEM practices. The literature suggests that the institutional environment plays a pivotal role in the success of STEM implementation, as the availability of resources and administrative support affects teachers' ability to integrate STEM into their teaching practices (Peralta & Stohlmann, 2022). Thus, the similarity of the institutional environment between the scientific departments explains the absence of differences between disciplines.

- **Focus on general teaching competencies**

The results of the study suggest that general teaching competencies – such as managing project-based learning, directing students towards inquiry, designing collaborative activities, and employing technology – are more influential factors in the application of STEM than scientific discipline. Various studies have confirmed (Rutledge & Seelbach, 2020; Schwartz, Lee, & Taber, 2021) found that the success of a STEM application depends largely on general teaching skills and practical experience, rather than on specialized knowledge alone. This is consistent with the results of the current study, which showed that faculty members in all disciplines possess a similar level of these competencies.

In summary, based on the previous presentation of the results of this study and other studies, it confirms that scientific specialization was not an influential factor in the availability of teaching characteristics according to the STEM approach among faculty members, and that general professional competencies, teaching experience, institutional support, and educational environment are the most influential factors in the success of STEM application, and these results are in line with global trends in STEM education, which reinforces the importance of investing in the development of teachers' skills and providing a supportive learning environment to ensure the effective and sustainable application of the integrative approach.

Recommendations of the Study:

The study recommends the need to enhance the professional development programs of faculty members in scientific departments in accordance with the requirements of the STEM approach, by training them in critical thinking, problem-solving, creativity, and employing digital technologies, in addition to providing qualitative training programs in the design of integrated STEM units based on research and projects, and linking scientific concepts to real-world applications relevant to the local context. It also emphasizes the importance of improving the educational environment by providing high-quality educational resources and developing infrastructure Supporting the use of technology and digital data within scientific curricula and adopting authentic assessment methodologies that are commensurate with the nature of STEM education, such as evaluating practical performance, projects, and problem-solving tasks. The study calls for enhancing cooperation between faculty members from various disciplines to develop integrated educational units, consolidate the culture of teamwork, and develop their cultural and social awareness and classroom leadership in a way that contributes to raising the efficiency of implementation and activating the role of the student, in addition to harmonizing the application of STEM with the characteristics of the students and the local context to ensure that learning is connected to the community environment and achieve greater flexibility in teaching practices.

Recommendations of the Study

The study proposes a number of future research recommendations that can deepen the understanding of the application of the STEM approach in university education, most notably conducting empirical studies to measure the effect of STEM-based training programs on the development of the basic competencies of faculty members, and comparative studies between science faculties in Saudi universities to monitor institutional differences in the level of availability of teaching attributes according to STEM. There is also a need for analytical studies to examine the extent to which STEM principles and indicators are included in the curricula of scientific departments to develop them, as well as qualitative studies that explore faculty members' experiences in applying project-based learning and scientific research within the STEM framework. Future directions also include developing STEM-based instructional design models and field-testing them on faculty and students, measuring the impact of STEM application on student achievement, developing critical and creative thinking and problem-solving skills, in addition to studying the relationship between a teacher's digital competencies and the level of application of STEM features in the university environment.

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