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Identifying the Dimensions and Components of Sciences Education based on an Interactive Approach with Emphasis on the Nature of Science

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Sciences education, interactive approach, nature of science, quality of formal education system, efficiency of the educational system.

Purpose: The using an interactive approach in sciences education can improve its learning. Therefore, the current research was conducted with the aim of identifying the dimensions and components of sciences education based on an interactive approach with an emphasis on the nature of science.

Methodology: This study in terms of purpose was applied and in terms of implementation method was qualitative. The current research population was university students and teachers of basic sciences who were familiar with the subject, which number of 15 people of them were selected as a sample according to the principle of theoretical saturation and with the purposive sampling method. The data was collected by the in-depth semi-structured interview method and its validity was confirmed by the triangulation method and its reliability was obtained by the agreement coefficient method between two coders 0.86. The data were analyzed by open, axial and selective coding method in MAXQDA software.

Findings: The findings showed that for sciences education based on an interactive approach with an emphasis on the nature of science were identified 48 concepts in 16 categories and 4 themes; So that 4 themes were included quality-orientation in the sciences education system (with 3 categories of quality evaluation in the educational system of formal education, efficiency of the educational system for science education and lack of effectiveness of science education programs in the formal education system), strategic management of the education system of formal education (with 6 categories of trust to abilities and plans of policymakers, institutionalizing the principles of science education, intra-group and institutional collectivism, developing the structure of an educational implementation system for logical thinking, keeping pace with global developments and designing science education programs for students), proposed solutions for designing the science education system based on the interactive approach (with 3 categories of students' participation in education, emphasis on strengthening the spirit of independence of students and logical education and its place in modern education) and challenges of the formal education system in the field of sciences education (with 4 categories of identity and its place of science in the educational system, argument-oriented and having a critical view, macro structure and institutional level of formal education and criticism to the educational system of current education structure in schools.

Conclusion: Based on the results of the current research and the identified dimensions and components for sciences education based on an interactive approach with an emphasis on the nature of science, experts and planners of the educational system can take an effective step towards improving the sciences education based on an interactive approach by improving its dimensions and components.

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1. Introduction

The challenges of the 21st century, such as the spread of pandemics, diminishing energy resources, global warming, and drought, demonstrate the essentiality of scientific understanding for humanity. Many of our daily decisions, like adhering to hygiene practices, dietary choices, and energy consumption, relate to scientific concepts. The more these decisions are scientifically supported, the greater the benefits, highlighting the importance of science education (Asadpour, Assareh, Ahmadi & Emamjome, 2022). The dynamics and severe environmental changes of the current era have made planning to face these transformations more critical than ever. Thus, science education policy-making must adopt a comprehensive and systemic approach, considering all different economic, social, cultural, political, and environmental processes. Consequently, policymakers must engage with the issue through their ontological and epistemological viewpoints, envision future horizons, and undertake planning and policy-making (Aqatabar Roudbari & Enayati, 2019). The phenomenon of information explosion and rapid technological advancement has confronted societies with a volatile and unstable world. In adapting to this, science education can play a significant role by providing the knowledge, skills, and attitudes that enable us to address problems and challenges through scientific methods (Lazarou, Sutherland & Erduran, 2016). The globalization of science education in the era of information explosion is an undeniable reality. This phenomenon should be leveraged as an opportunity for change and transformation in the face of existing challenges in the educational system and for utilizing new sciences and technologies to address deficiencies and improve educational quality (Trna & Trnova, 2015). Nowadays, few teachers can appropriately teach science, and many obstacles and challenges render efforts to improve the quality of science education ineffective. In other words, the continuous improvement of science education quality emphasizes the comprehensive participation of all stakeholders and planners in education to satisfy learners, focusing on changes in individual and collective cognition and attitudes, and the incorporation and application of educational technology in educational programs (Barahuimoghadam & Kahrazehi, 2020).

Today's societies require the nurturing of creative, thoughtful, and curious learners with lifelong learning abilities, and educators must focus on training a workforce capable of scientific research and informed decision-making. For this purpose, traditional teaching methods, which involve direct transmission of concepts from teacher to learners, are no longer suitable for cultivating creative, thoughtful, and curious learners. Therefore, the adoption of new educational approaches, including exploratory, interactive, and constructivist methods, is essential (Golian, 2021). An appropriate approach for science education is the interactive approach, which aligns best with the goals of the educational system. This is because one of the critical objectives of the educational system is to strengthen learners' minds for reasoning and critical thinking for understanding theories, identifying credible scientific sources, producing science within society, and transforming learners into lifelong learners (Yazdani Kashani & Tamannayifar, 2013). The traditional approach to learning focuses on individual work and mastering the text, aiming for exam success, specifically limited to the ability to recall or recognize textual information. In contrast, the interactive approach is a learning type that individuals perform as part of daily life, focusing on how to use information. Here, interaction and collaboration are paramount, and information serves as a resource for use and application rather than mere mastery (Rahbardar & Fardanesh, 2012). The interactive approach can lead to increased quality and effectiveness of education. In this approach, education is not seen as formulaic and predetermined but as a dynamic flow, emphasizing interpretation, action, information exchange, and interaction between individuals, the system, and the environment. According to this approach, planning is an effort to mediate between action and theory and is not merely a set of logical methods with a regular sequence, but rather involves interaction, interpretation, decision-making about curriculum components, re-interaction, interpretation, and decision-making (Tajdar & Mohammadi Zenouzagh, 2022). Interaction is a two-way event that occurs between at least two individuals or actions and happens when individuals and actions mutually influence each other. Interaction is a determinant element of the educational process, where learners transform comprehensive information transferred from others into knowledge of personal and individual value and application (Singh, Dhillon & Kothari, 2018). The interactive approach facilitates an exchange and

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mutual communication between curriculum, teachers, and learners. Educational planners and specialists using this approach might start with content selection and organization rather than objectives, emphasizing the learning process and learners more (Tajdar & Mohammadi Zenouzagh, 2022).

Very few studies have been conducted on the dimensions and components of science education, and none have explored it through an interactive approach, which this research aims to address. Aqatabar Roudbari and Enayati (2022) identified components of a transformation and innovation program in medical science education, including futurism and capacity building for scientific authority, entrepreneurship development within third-generation universities, responsive and justice-oriented education, strategic and mission-oriented development of higher health education programs, mission orientation, and enhancement of universities' capabilities within territorial planning, professional ethics elevation, internationalization, and the development of virtual education. Seydi and Behrangi (2022) identified seven components of self-directed learning principles applicable to the management model of religious science education: self-direction in learning, self-regulation, independence, innate talent, commitment and responsibility, motivation and affection, and thinking and reasoning. Akbari, Amini, Mahmoudi Meimand, and Moradi (2019) concluded that 37 concepts in the form of 11 components and 2 constructs were identified for the interactive model of conventional approach challenges in strategy and organizational teaching; constructs included challenges of the conventional approach in strategy (with 6 components defining the playing field, strategy creation idea, sustainable competitive advantage, time horizon selection, environmental coordinates setting, and process rigidity) and organizational learning (with 5 components flexibility, rapid response, pragmatism, realism, and foresightedness).

Regarding the importance and necessity of the present research, in the information age, no society can survive without information, and the primary need of every society is access to information for progress in all political, economic, social, and cultural areas. The nature of science as an objective activity has a dynamic process that considers necessity, delicacy, flexibility, and ethics from an inner belief perspective, as well as human interaction. Contemporary and postmodern ideas about science portray it as a human effort stemming from theory and culture, based on empirical observations, and subject to change, with some categories like ontology and epistemology still not universally accepted. Generally, addressing the nature of science and understanding it from various aspects, including utility, democracy, culture, ethics, and science learning, is of great importance. Reviews indicate that research has not explored the dimensions and components of science education, leaving significant gaps, and none have examined it through an interactive approach. The researchers of the current study seek to fill these gaps. The results of this study could assist experts and educational planners in better understanding the dimensions and components of science education based on the interactive approach, emphasizing the nature of science, enabling them to take effective steps to improve science education. Utilizing the interactive approach in science education could lead to enhanced learning. Therefore, the present study was conducted with the aim of identifying the dimensions and components of science education based on the interactive approach, emphasizing the nature of science.

2. Methodology

This study was applied in aim and qualitative in execution. The research population consisted of students and basic science teachers familiar with the topic, from which 15 individuals were selected as samples based on theoretical saturation and purposive sampling. In purposive sampling, samples are chosen based on criteria including familiarity with the research topic or field, a minimum of a master's degree for basic science teachers, willingness to participate in the research, agreement to record interviews, etc.

To conduct this study, initial questions for interviews with students and basic science teachers were prepared based on theoretical foundations with the assistance of professors. Next, sampling was conducted, and the importance and necessity of the research, including conditions such as recording interviews, were explained to the samples. After their agreement to participate, coordination regarding the time and place of the

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interview was made. Interviews were conducted individually, with each lasting approximately 40 to 50 minutes. At the end, participants were thanked and appreciated for agreeing to participate, accepting interview conditions, including recording, and sharing information with the researcher.

The research instrument was a semi-structured in-depth interview with five questions designed for interviewing experts, namely students and basic science teachers, based on theoretical foundations and with the help of professors. Each expert individually answered each interview question, and the researcher, besides noting important and key points, recorded the interviews. The researcher would ask the first question, and after the respondent answered, if they strayed from the question, the researcher would repeat the question or use guiding and helper questions. The researcher also noted important and key points, and after finishing each question, read the noted contents to the respondent for verification or correction if needed. This process was repeated for all five questions from each expert, and the important contents and the audio of the interviews were recorded for further analysis. Interviews continued until new respondents could not add any new information or findings to those of previous respondents. It's worth mentioning that the validity of the interviews was confirmed by triangulation, and their reliability was achieved with a concordance coefficient of 0.86 between two coders.

Data from the semi-structured in-depth interviews were analyzed using open, axial, and selective coding methods in MAXQDA software.

3. Findings

The sample of this study consisted of 15 basic science students and teachers who underwent semi-structured in-depth interviews. The results of open and axial coding analyses for science education based on an interactive approach with an emphasis on the nature of science are visible in Table 1.

Table 1. Open and Axial Coding Results for Science Education Based on an Interactive Approach with Emphasis on the Nature of Science

Category Number	Category Title	Concepts
1	Trust in the Abilities and Programs of Policymakers	- Scientific policymakers' ability - Coordination among policymakers - Consistency of speech and behavior among policymakers
2	Institutionalization of Science Education Principles	- Alignment of curricular programs with science education - Attention to individuals' psychological conditions - Attention to individuals' environmental conditions - Attention to individuals' ethical evaluations
3	Reasoning and Critical Viewing	- Considering the complexities of life in the modern age - Reduction of teacher authority and emphasis on student dialogue
4	Collectivism Within Groups and Institutions	- Personal and partisan benefit-seeking - Collective insight and convergence among student group members - Ability to create a team and form the concept of 'us'
5	Student Participation in Education	- Using in-class subjects - Recognizing and listening to each student individually
6	Logical Education and Its Place in Modern Education	- Autonomy and freedom - Perfectionism
7	Emphasis on Strengthening Students' Independence Spirit	- Responsibility

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		- Loyalty and trusteeship
8	Identity and Position of Science in the Educational System	- Clear definition of student, teacher, and school roles and the purposefulness of the educational system structure - Status and position of teachers and students in society
9	Criticisms of the Current Educational Structure in Schools	- Lack of preparation for the realization of higher-level programs - Unilateral and linear teachings
10	Quality Evaluation in the Formal Educational System	- Lack of a vision and strategic plan for quality evaluation in student training - Lack of a common language and understanding of concepts such as quality - Neglect of the educational evaluation field as a specialized area - Overlooking internal and social barriers to ethical living and adherence
11	Efficacy of the Educational System for Science Teaching	- Application of science in society - Empowerment of school outputs
12	Ineffectiveness of Science Education Programs in the Formal Education System	- Necessity of revising programming methods - Utilization of teacher, parent observations, self-assessment, individual and group projects in evaluation
13	Macrostructure and Institutional Level of Formal Education	- Coordination of the educational system with other systems - Conflict between the macrostructure of the formal education system and development program features
14	Development of the Executive Educational Structure for Logical Thinking	- Advancing programs towards the ethical identity of students - Holistic and systematic outlook overcoming fragmentary thinking - Decision-making focused at the macro level
15	Alignment with Global Advancements	- Changing approach to ethical education for living, not just ethics of science - Attention to developmental and gender stages of learners - Use of evaluation methods based on individual and group projects
16	Designing Science Education Programs for Students	- Teaching ethics in other subjects such as social studies, literature, and even mathematics - Utilizing childhood and adolescence potentials for practicing logical thinking

As seen in Table 1, for science education based on an interactive approach with an emphasis on the nature of science, 48 concepts in 16 categories were identified, including trust in the abilities and programs of policymakers, institutionalization of science education principles, reasoning and critical thinking, intra-group and institutional collectivism, student participation in education, logical education and its place in modern education, emphasis on fostering students' independence spirit, the identity and position of science in the educational system, criticisms of the current educational structure in schools, quality evaluation in the educational system, the efficacy of the educational system for science education, the ineffectiveness of current science education programs, the macrostructure and institutional level of formal education, development of the executive educational structure for logical thinking, alignment with global advancements, and designing science education programs for students. The results of axial and selective coding analyses for science education based on an interactive approach with an emphasis on the nature of science are visible in Table 2.

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Table 2. Axial and Selective Coding Results for Science Education Based on an Interactive Approach with Emphasis on the Nature of Science

Theme	Categories
Theme 1: Quality Orientation in the Science Education System	- Quality Evaluation in the Formal Educational System - Efficacy of the Educational System for Science Teaching - Ineffectiveness of Science Education Programs in the Formal Education System
Theme 2: Strategic Management of the Formal Education System	- Trust in the Abilities and Programs of Policymakers - Institutionalization of Science Education Principles - Collectivism Within Groups and Institutions - Development of the Executive Educational Structure for Logical Thinking - Alignment with Global Advancements - Designing Science Education Programs for Students
Theme 3: Suggested Strategies for Designing a Science Education System Based on an Interactive Approach	- Student Participation in Education - Emphasis on Strengthening Students' Independence Spirit - Logical Education and Its Place in Modern Education
Theme 4: Challenges of the Formal Education System in Science Education	- Identity and Position of Science in the Educational System - Reasoning and Critical Viewing - Macrostructure and Institutional Level of Formal Education - Criticisms of the Current Educational Structure in Schools

As seen in Table 2, for science education based on an interactive approach with an emphasis on the nature of science, 16 categories in 4 themes were identified; the themes included quality orientation in the science education system (with 3 categories: quality evaluation in the formal educational system, the efficacy of the educational system for science education, and the ineffectiveness of science education programs in the formal educational system), strategic management of the formal educational system (with 6 categories: trust in policymakers' abilities and programs, institutionalization of science education principles, intra-group and institutional collectivism, development of the executive educational structure for logical thinking, alignment with global advancements, and designing science education programs for students), suggested strategies for designing a science education system based on an interactive approach (with 3 categories: student participation in education, emphasis on fostering students' independence spirit, and logical education and its place in modern education), and challenges of the formal education system in science education (with 4 categories: the identity and position of science in the educational system, reasoning and critical viewing, the macrostructure and institutional level of formal education, and criticisms of the current educational structure in schools).

4. Conclusion

Given the importance of identifying the dimensions and components of science education based on an interactive approach, this study aimed to identify the dimensions and components of science education emphasizing the nature of science. The findings of this study revealed that for science education based on an interactive approach with emphasis on the nature of science, 48 concepts in 16 categories and 4 themes were identified. These four themes included quality orientation in the science education system (with three categories: quality evaluation in the formal educational system, the efficacy of the educational system for science teaching, and the ineffectiveness of science education programs in the formal education system), strategic management of the formal education system (with six categories: trust in the abilities and programs of policymakers, institutionalization of science education principles, intra-group and institutional collectivism, development of the executive educational structure for logical thinking, alignment with global

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advancements, and designing science education programs for students), suggested strategies for designing a science education system based on an interactive approach (with three categories: student participation in education, emphasis on fostering students' independence spirit, and logical education and its place in modern education and training), and challenges of the formal education system in science education (with four categories: the identity and position of science in the educational system, reasoning and critical thinking, the macrostructure and institutional level of formal education, and criticisms of the current educational structure in schools).

While limited research has been conducted in this area, the findings of the present study are somewhat consistent with the findings of Aqatabar Roudbari and Enayati (2022), Seydi and Behrangi (2022), and Akbari et al. (2019). These findings suggest that to improve science education based on an interactive approach with emphasis on the nature of science, particularly within the theme of quality orientation in higher education, one could utilize quality evaluation in the formal educational system with concepts such as the lack of a vision and strategic plan for quality evaluation in student training, the absence of a common language and thought for such concepts and terms including quality, neglect of the educational evaluation field as a specialized area, overlooking the internal and social barriers to ethical living and adherence to it, the lack of connection between the management functions of the educational system i.e., planning and evaluation, and not fully adhering to a comprehensive evaluation model and a limited perception of the scope of science education. In the theme of strategic management of the formal education system, concepts include the ability of scientific policymakers, coordination among policymakers, and coherence between the speech and behavior of policymakers, alignment of curricular programs with science education, attention to individuals' psychological and environmental conditions, and attention to individuals' ethical evaluations, personal and partisan benefit, collective insight and convergence among student group members, and the ability to create teams and form the concept of 'us', moving programs towards the ethical identity of students, holistic and systematic outlook overcoming fragmentary thinking, decision-making focused at the macro level considering contemporary necessities like internal, interpersonal, social, and technological barriers, changing approach to ethical education for living not just science ethics, attention to developmental and gender stages of learners, and using evaluation methods based on individual and group projects. Additionally, in the theme of proposed strategies for designing a science education system based on an interactive approach, concepts include using in-class subjects and seeing and hearing each student individually, responsibility, loyalty, and trusteeship, and in the theme of challenges of the formal education system in science education, concepts include defining the identity of the student, teacher, and school, the purposefulness of the educational system structure, and the status and position of teachers and students in society, considering the complexities of life in the modern age and reducing the authority of the teacher and emphasizing dialogue among students, the coherence of the educational system with other systems, and the conflict between the macrostructure of the formal education system and the features of development programs, and not preparing for the requirements to realize higher-level programs and unilateral and linear teachings.

The significant limitations of this study included difficulties in accessing experts, weak cooperation from some of them, a limited research background making it challenging to compare the results of this study with previous research findings, and the lengthy duration of the research. Therefore, further research on the dimensions and components of science education based on an interactive approach and comparing the results with those of the present study is recommended. Since this research was based on interviews with students and basic science teachers, it is suggested that future research on science education based on an interactive approach with an emphasis on the nature of science should consider the perspectives of other experts such as faculty members, and managers and officials of organizations and the Ministry of Education or the Ministry of Science. Based on the results of this study and the identified dimensions and components for science education based on an interactive approach with an emphasis on the nature of science, experts and educational planners can take effective steps to improve science education through enhancing these dimensions and components.

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Ethical Considerations

Ethical principles and points were observed in this study, especially in interviewing students and basic science teachers.

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Authors' Contributions

The student's role in this study was conducting interviews, collecting data, and drafting the article, while the professors' contributions were in analysis and writing the final article.

Conflict of Interest

There was no conflict of interest in this study.

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