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RECENT TRENDS IN CURRICULUM AND TEACHING METHODS IN SCIENCE EDUCATION

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Abstract

This study aimed to explore modern trends in the field of curriculum research and science teaching methods. To achieve this aim, the research reviews the literature that is closely related to these trends, with a focus on contemporary Arab and foreign studies during the last ten years. Six main axes are identified that comprehensively represent contemporary global trends in curriculum research and science teaching methods: reform movements in teaching and learning science, modern scientific fields and their various branches, methods and strategies for teaching science, science education technology, evaluation of teaching science, and science teacher preparation. This study provides a complete breakdown of the main thrust of the research trends in each axis, while citing solid studies that reflect these trends. This study also provides a set of practical recommendations for developing curricular research and methods of teaching science, especially in terms of research plans and their specific directions in the Saudi context.
Keywords: *science education, science curriculum, trends in science, teaching science.*

Introduction

The current era is characterized by rapid cognitive and technical development that imposes a responsibility on educational decision-makers to positively align with changes and developments and establish a scientific-culture perspective with its various dimensions. Therefore, the educational field has witnessed a series of programs and projects for reforming the teaching and learning of science. Development programs have diversified over the past decades. The United States has led the educational reformation process, although many different modern trends in teaching and learning science have emerged in various areas.

In light of massive developments in knowledge, technology, and the economy, advancements in science curricula and teaching methods became necessary in order to align with societal aspirations for science teaching, prepare a generation capable of deep scientific thinking, and develop science applications in all aspects of life via appropriate technology tools. Due to the resulting great expansion in the field of curriculum research and teaching methods, a specific scientific vision is required to monitor research trends and develop a modern general framework for these trends, given the lack of research work on monitoring these trends and continuously updating them. This is an important starting point for research trends and their development, and for linking together the various components of curriculum research and methods of teaching science. It is essential to determine contemporary trends in curriculum and science teaching methods in order to:

1. Enrich researchers' attitudes in the field of curricula and methods of teaching science based on contemporary trends;
2. Support academic research activities on preparing scientific research plans regarding curricula and science teaching methods;
3. Evaluate actual research activity on curricula and science teaching methods in comparison with contemporary trends;

4. Direct policymakers in developing curricula and science teaching methods based on qualitative scientific research in order to develop all components of the science education system; and
5. Offer a comprehensive intellectual framework for accelerating changes in the field of curricula and methods of teaching sciences that can act as a starting point to be continuously developed and updated in order to enrich research in this field.

This study of modern trends in science education research over the last decade examined six main axes: reform movements in teaching and learning science, modern scientific fields and their various branches, methods and strategies of teaching science, science teaching technology, evaluation of science education, and science teacher preparation.

Recent Reformation Trends in Teaching and Learning Science

Standards-Based Science Education: Next Generation Science Standards (NGSS)

The Standards Movement has emerged as a recent trend aimed at reforming education in general, resulting in an increasing demand for science education based on specialized standards. The U.S. National Academy of Sciences established the National Science Education Standards (NSES) in 1996 to reform science teaching. The NSES were then revised and renewed in 2013 through mutual cooperation between the National Research Council (NRC), the American Association for the Advancement of Science (AAAS), and the National Science Teachers Association (NSTA), producing what are known as the Next Generation Science Standards (NGSS) 2013. The original NSES describe what a scientific intellect should be and provide science education criteria to assess the quality of educational opportunities, methods of teaching science, assessment methods, and quality management of science teacher education of science teachers (National Academy of Science, 1996).

The NGSS include:

1. Science Content Standards for Grades 1–12;
2. Science Teaching Standards;
3. Science Assessment Standards;
4. Science Education Program Standards;
5. Science Education System Standards; and
6. Professional Development for Teachers.

The NGSS serve as a detailed science-learning plan for students from kindergarten to Grade 12 (K–12) to help students understand science and engineering in order to live successfully as productive citizens. These standards are rich in content and practice and are coherently arranged into various disciplines and degrees in order to provide science education for all students and achieve a vision of science and engineering education (Next Generation Science Standards, 2013). The NGSS focus on engineering and technology and form a set of performance expectations that describe what learners should know and be able to do in the fields of “the nature of science, space and earth, biology, engineering, technology, and applications of life sciences for Grades K–12. These standards were developed to improve science education for all students and to prepare students for admission to colleges, career paths, and jobs (Hassanein, 2016). The NGSS lay down three main dimensions that underpin science education in Grades K–12 (Next Generation Science Standards, 2013):

First dimension: Science and engineering practices. Science practices describe the behavior of scientists during scientific investigation and when building models and theories about the world, whereas engineering practices describe the behavior of engineers when designing and building models and systems.

Second dimension: Crosscutting concepts. These are a means of connecting various scientific fields, and include patterns, similarity, diversity, cause and effect, size, proportion and quantity, systems and system models, energy and material, structure and function, and stability and change. Crosscutting concepts are important because they provide an organized and coherent scheme in different fields and disciplines of science.

Third dimension: Disciplinary core ideas. Disciplinary core ideas (DCIS) are the core ideas within or across multiple disciplines in science or engineering. These ideas build upon each other as students' progress through levels of education and are grouped into the following four areas: physical sciences, biology sciences, earth and space sciences, and engineering design.

Research on science education has focused on the importance of developing science education based on standards, including standards of science education for the next generation (Al-Ahmad et al., 2018; Al-Ahmad & Buqami, 2017; Al-Subai, 2018; Boesdorfer & Staude, 2016; Hassanein, 2016; Fulmer et al., 2018; Isa & Ragheb, 2017; Isabelle, 2017; Rwaqah & Momani, 2016; Umar, 2017).

Teaching Science through STEM
(Science, Technology, Engineering, and Mathematics)

Science education has undergone a development based on a change in the understanding of the nature of science, in which it has become integrated with fields of knowledge. The problem of the specialization and integration of knowledge fields has caused widespread controversy among educators. Educators consequently realized that learning is more effective if the learner's knowledge is linked and their ideas are organized accurately within an integrated view. The integrated experience allows the learner to realize the mutual relationships among the different fields of scientific knowledge; here, the dominant trend is a focus on the unity and integration of science as expressed by STEM (science, technology, engineering, and mathematics) education.

This type of education has come into focus as a reform movement for science education that treats the effects of economic stagnation, as educating students according to the specializations offered by STEM prepares them for a future as engineers and scientists, and thus contributes to the production of innovative ideas that will lead to economic development. STEM predicates on the fact that those who begin studying early in these scientific and technological fields will be more prepared to for future scientific careers (Fan & Ritz, 2014).

STEM education operates within the context of a complex phenomenon or problem, with tasks that require learners to use their knowledge and skills from various systems (science, technology, mathematics, and engineering design) (Honey et al., 2014).

STEM conforms to many standards, including the NSES prepared by the National Academy of Sciences (National Academy of Science, 1996), the National Mathematics Standards prepared by the National Council of Teachers of Mathematics (NCTM, 2000), and the Standards for Technology Literacy prepared by the National Association for Technology Education (International Technology Education Association, 2000). The

Maryland State Department of Education Office of STEM Initiatives (2012) has provided indicators that enable the identification of the concepts and issues that can be addressed using the STEM integration approach in Grades 6–12.

Many modern science curricula still depend on the philosophy of "science for science," which presents scientific facts in a fragmented form, and does not develop students' thinking skills or their understanding of the mutual relationship among science, technology, and mathematics within an integrative conceptual framework. Therefore, it is necessary to show the functional role of science and technology in the life of individuals and in society, in order to engage students in finding solutions and making decisions in situations and problems that arise in daily life (Project MSTe, 2001).

Research on science education has focused on reviewing the importance of science education at the curriculum level and within the programs that prepare and train science teachers (Al-Muhaisen & Khuja, 2015; ; Abdulqadir, 2017; Abdul Raouf, 2017; Anzi & Jabr, 2017; Christensen & Knezek, 2017; Erdogan & Stuessy, 2016; Ismail, 2017; Sulaiman, 2017; Yildirim & Türk, 2018).

Teaching science through STEAM
(Science, Technology, Engineering, Arts, and Mathematics)

STEAM (science, technology, engineering, arts, and mathematics) is an educational curriculum for learning that takes science, technology, engineering, arts, and mathematics as the main axes to direct students' inquiries through dialogue and critical thinking during experimental learning practices, in order to solve real live problems not hypothetical situations, and adopt methods of cooperation in creative works. Ultimately, STEAM focuses on preparing innovators for life in the 21st century (STEAM Community, 2018).

The STEAM approach was first developed by Georgette Yakman at the Virginia Institute of Applied Arts, after joining STEM (science, technology, engineering and mathematics) at Virginia State University (2012). Georgette Yakman (2012) is also considered to be the founding researcher and creator of STEAM Education, during her professional career in 2006 as a teacher of engineering and technology at a middle and high school in Virginia. The main idea of her thesis was that science and technology are interpreted through engineering and arts (social, linguistic, physical, and musical), all of which are based on the elements of mathematics (Steam Education, 2018).

Among institutional efforts to officially implement STEAM Education, the Korean experience is highlighted. STEAM Education in Korea was expanded in 2011 due to efforts by the Korean Ministry of Education, Science, and Technology (MEST) (Oh, et al., 2013). The general foundations of the conceptual framework for the STEAM approach are as follows:

1. In general, the artistic component enriches and refines the personal construction.
2. Art is an excellent way to practice distinct types of thinking.
3. Artistic activities are an appropriate field for building mental perceptions and imagination.
4. Art represents a tangible transformation of theoretical perceptions of scientific knowledge and its applications in various fields of science.
5. Artistic activities allow the formation of a common field of understanding and communicating among learners according to their preferences .

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6. The applied aspects of artistic activities are compatible with the foundations of scientific thinking.
7. Art activities provide an opportunity for free, unrestricted innovative practices, which is a major requirement for studying integrated disciplines in science, mathematics, engineering, and technology (Keane & Keane, 2016).

A number of studies have focused on reforming science education through the STEAM approach within teacher training programs and in the development of programs and curricula (DeJarnette, 2018; Hernandez, 2018; Herro et al., 2018; Keane, L & Keane, M, 2016; Rabalais, 2014; Tantawi & Salim, 2017).

Teaching Science with 21st Century Skills

A new movement known as "21st Century Skills" emerged in 2002 with the aim of supporting students in their life career and university studies by enabling them to masterboth content and skills. Educators' tendency to focus on developing these skills in all disciplines has increased through the foundation of the Partnership for 21st Century Skills, which was established through cooperation between educational institutions in the United States, a group of commercial institutions including Microsoft, and the National Education Association. The Partnership prepared five guides for knowledge systems supporting education, which includes standards, evaluation, professional development, curricula and teaching methods, and learning environments. These guides help learners and teachers develop the cognitive abilities, skills, and emotional experiences they need to succeed in life (Partnership for 21st Century Skills, 2009).

In cooperation with the NSTA, the Partnership for 21st Century Skills developed a map showing how to integrate 21st century skills into science education from Grades K–12. Learning outcomes were prepared for each of the 21st century skills that students must achieve by the end of Grades 4, 8, and 12. Examples were also provided for how to achieve these outcomes within science teaching activities inside and outside the classroom (National Science Teachers Association, 2011).

Many studies have focused on 21st century skills as a recent trend in the development of science curricula and in science teacher training programs, while other studies have examined them as a dependent variable that must be developed by learners through various science curricula and programs (Alhtaibi, 2018; Alozie et al., 2012; Arsada et al., 2011; Claro et al., 2012; Duran et al., 2011; Musabi, 2017; Rizk, 2015; Shalaby, 2014; Vebrianto, 2016; Yasin et al., 2018).

Modern Trends in Scientific Fields and Their Various Branches

Research on science education has recently focused on several modern scientific fields and has sought to develop science programs and curricula and to propose programs or modules that include various areas such as nanotechnology, bioinformatics, green chemistry, the human genome, genetic engineering, earth and space sciences, and the universe. This study examined two of these areas: nanotechnology and green chemistry.

Nanotechnology

Nanotechnology is a scientific revolution that has been applied in many fields, including medicine, electronics, construction, chemistry, and space. Educational curricula and programs should respond to the advances caused by nanotechnology and move to incorporate new knowledge, ideas, and programs, while working to develop teaching strategies in line with the challenges of nanotechnology .

The term "nanotechnology" is composed of two words; "nano" means "infinitesimal" and represents a part of a billion (e.g., a nanometer is one billionth of a meter). "Technology" refers to the practical application of knowledge in any field to make and produce useful things. Thus, nanotechnology is concerned with studying and manufacturing materials and devices with nanoscale dimensions that have new and different properties, while nanoscience is interested in studying the composition and properties of materials at the nanometer scale (Alhebshi, 2011; Hingant & Albe, 2010). Nanotechnology is a multidisciplinary field that relies on concepts from various fields, the most important of which are physics, chemistry, and biology. As nanotechnology depends on the processes of science, science curricula are the most suitable places to focus on nanotechnology education. Accordingly, science teachers should be trained in nanotechnology, as it will become an integral part of future science curricula (Stanford International Research Institute, 2005). Furthermore, the inclusion of nanotechnology in science curricula helps learners to assess the current and future applications of nanotechnology and their effects on and risks for society, and may prompt them to choose careers in the field of nanotechnology (Abdel Fattah, 2013; Trybula, 2009).

Nanoscience presents learners with an abstract world, since all the scientific phenomena associated with nanotechnology are intangible. An understanding of nanoscience thus requires learners to have a higher level of thinking based on significant scientific knowledge. Therefore, it is necessary to use various methods and strategies in teaching this science, including simulations, models, and scientific analogies, to clarify the scientific facts, concepts, and phenomena associated with nanotechnology and increase learners' ability to absorb them (Xie & Pallant, 2011) .

A number of studies have focused on educating learners in the science of nanotechnology at various levels, either through the preparation of special programs and curricula for nanotechnology, or by showing how nanotechnology can be included in current science curricula and in science teacher training (Ahmad, 2015; Ahmed, 2013; Ban & Kocijancic, 2011; Blonder, 2010; Helenthal, 2010; ; Masehah, 2016; Saleh, 2013; Saleem, 2015; Shalabi, 2011; Skonchal, 2011).

Green Chemistry

Green chemistry, also known as sustainable chemistry, is a field that combines chemistry and chemical engineering to reduce the emissions from chemical manufacturing processes to the greatest degree possible and to create new and alternative chemicals, products, and processes that do not harm–or even benefit–the environment. Unlike environmental chemistry, which is concerned with the effects of chemical pollutants on the environment, green chemistry focuses on technological approaches to prevent pollution and reduce the consumption of non-renewable resources and harmful substances (Al Gharbi, 2018; Hassan, 2018).

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Green chemistry aims to produce chemicals that do not pollute the environment and to design chemical reactions that efficiently consume all reactants and/or avoid undesirable byproducts, while reducing production costs, time, and effort (Abu Al-Wafa, 2018). It is related to three aspects of sustainability: economics, in that it has a lower economic cost than ordinary chemistry; materials, in that it involves the optimal use of raw materials and their recycling; and waste, in that it reduces unwanted and harmful secondary chemical products and their release to the environment (Manahan, 2006).

Studies on science education have focused on the inclusion of green chemistry in science curricula and the development of its concepts among pre- and in-service science teachers (Salmi, 2010; Andraos & Dicks, 2012; Marteel-Parrish, 2014; Kennedy, 2016); Duarte el al., 2017; Barcena et al., 2017; Timmer et al., 2018; Abu Al-Wafa, 2018) .

Modern Trends in Science Teaching Methods and Strategies

Multiple teaching strategies have recently emerged, based on science education research, which align with the requirements of the current era. Such strategies rely on the use of educational technology to teach science and enhance students' opportunities for self-learning and meaningful learning. Examples include: teaching strategies based on Web 2.0 technologies, integrated learning, and flipped learning; strategies that rely on visual stimuli such as the thinking maps strategy, mind maps, the fishbone strategy, and the circular house shape strategy; and strategies that focus on individual differences, such as differentiated teaching and adaptive education.

Flipped Learning

Flipped learning is a form of combined learning that involves both e-learning and direct learning; it reshapes the educational process, and the roles of both school and home change as they replace each other, to some extent. The learner uses technology at home (e.g., video clips, audio clips, and so forth) to learn the concepts and the basic ideas associated with them. Then, s/he goes to school to apply and solve problems associated with these concepts with the help of her/his teacher, and her/his peers participate in carrying out activities related to the lesson (Ng, 2014) .

Flipped learning targets teaching in the classroom to make learning easier and more fun and makes it possible for the teacher to use class time to share in learner-centered interaction rather than in dumping information on students. This type of learning can convert class time into home through recorded videos (Demirel, 2016).

Flipped learning is important in that it ensures an appropriate investment of class time that allows more time for investigation. The teacher spends most of the time in the classroom guiding, motivating, and assisting students and building stronger relationships with them. In this way, students are transformed into researchers of information resources, which promotes critical thinking and self-learning. This method also provides freedom for students to choose their own time and speed for learning; students receive feedback from the teacher during class, which provides remedial teaching for late students (Mazur et al., 2015, 5–6).

Because flipped learning depends on technology to keep pace with current developments , it has been used in some science education research in order to support the teaching and learning of science (Al-Sayed & Ahmed, 2018; Al-Shami, 2018; Baz, 2016; Heyborne et al., 2016; Keshtah, 2016; Ojennus et al., 2016Rashid, 2017; Srinivasan et al., 2018; Tully, 2014).

Differentiated Education

It is clearly one of the goals of science education to take into consideration the individual differences among learners. This is done by searching for teaching strategies that help to achieve meaningful learning and assist science teachers in creating educational situations for learners of different levels. Therefore, a new trend known as differentiated education has emerged in science education, which calls for the diversification of teaching strategies according to the nature of learners in the classroom.

Differentiated education is defined as an integrating approach in teaching that satisfies the diversity of skill levels and students' abilities in a single classroom (Drapeau, 2004). That is, the teacher changes and modifies the elements of the curriculum to correspond with the characteristics of the learners, in order to raise the level of all students (Kojak et al., 2008; Obaidat and Abu Al-Semid, 2009). The importance of differentiated education is that it helps the teacher to consider differing students' abilities and to realize the needs of all students, including those who excel and those with learning difficulties. Moreover, differentiated learning helps to promote students' human right to receive a good-quality education without discrimination (Kojak et al., 2008; Tomlinson, 2001, p. 11).

A number of studies have focused on differentiated education as a recent trend in teaching science according to the diversity of learners (Al-Baltan, 2017; Al-Khatib, 2017; Al-Nabhan & Al-Kanaani, 2016; Al-Rashidi, 2015; Maeng, 2017; Sentürk & Sari, 2018; Turner et al., 2017;).

Adaptive Learning

Many educational institutions around the world rely on e-learning programs. However, students' adaptation to e-learning receives little attention. Therefore, e-learning must be designed according to the needs and capabilities of students. Education must also be adapted to the nature of learners' abilities. An adaptive learning environment is a personal electronic system that supports adaptive interaction; the system receives data, creates a model of its own, and then performs adaptation according to that model (Ashqar & Aql, 2009).

Recent studies in the field of learning technology have focused on the possibility of adapting e-learning to learners according to different learning styles, which introduces a new pedagogical model based on adaptive methodology. The adaptive methodology provides content for learners in a unified way while allowing them to choose from the different learning elements according to various standards that suit each of them separately. Adaptive learning depends on three basic elements: a learner's primary knowledge, the learning objectives, and the learner's preferred learning methods (Matar, 2014).

Adaptive e-learning is a new approach to education that makes an e-learning system more flexible in displaying information to build links for each learner to fit with their knowledge and capabilities. This type of learning depends on the distinct characteristics of each learner which must be observed within the learning environment. Thus, what is appropriate for one learner may not be appropriate for another. Therefore, adaptive e-learning helps to develop learning processes and thus improve students' results (Esichaikul et al, 2011) .

Certain considerations were observed when building an adaptive educational system:

1. The educational content should fit the learner's level; thus, a learner's initial level is first identified, and educational activities are then presented that align with their needs and abilities.
2. Content elements should be organized in a specific manner, from easy to difficult.
3. Learners' characteristics previous experiences should be determined.
4. Learners should be given the opportunity to practice the required behavior through repetition, and different methods should be used to provide feedback (Serce, 2008 & Azmy, 2015).

A number of studies have focused on adaptive e-learning as a modern teaching strategy that relies on technology while taking into account the individual differences among learners (Dziuban et al., 2018; ; Khamis, 2015;; Liu et al., 2017a, 2017b; Remod, 2014; Shelle et al., 2018; Squires, 2014).

Modern Trends in Science Education Technology

Virtual Reality Technology

Several forms of virtual learning environments have emerged that support science teaching in various ways. Virtual reality involves special helmets and/or gloves with sensors and is a computer-simulated three-dimensional environment that people can interact with by examining the contents of this environment through sounds, images, and graphics. The degree of interaction with virtual reality varies from contemplating what the reality contains to interactions that enable learners to influence and change the environment or its contents (Subramanian & Marsic, 2001).

Virtual learning environments include virtual laboratories, which are defined as simulated laboratory experiments that take place without an actual physical laboratory. A virtual laboratory allows learners link theoretical and practical aspects of content without the use of real laboratory tools. They are programmed electronically to simulate real experiences (Harry & Edward, 2005). Similarly, virtual museums rely on digital audiovisual technology to provide a "walk-through" or other presentation of a museum or its contents on the Internet (Tarng et al., 2009).

It is worth noting that virtual visits and trips over the Internet provide interactive environments that include a set of various digital tools and allow learners to "visit" a wide variety of places and learn from them using different forms of media. Such experiences allow learners to explore interesting places and topics without the restrictions of time or space (Adedokun et al., 2011).

Many studies on science education have examined virtual reality technology in various forms, including virtual laboratories, virtual museums, and virtual trips (Al-Mutairi, 2017; Brinson, 2017; Burkett & Smith, 2016; Chao et al., 2016; Darrah et al., 2014; Ghashm, 2017; Goudsouzian et al., 2018; Shammary, 2017).

Infographic Technology

An infographic is a visual representation of data and ideas that quickly conveys complex information to a target audience in a simple, attractive, and easily understood way (Mohamed Shaltout, 2014; Smiciklas, 2012). Many researchers in the field of science education have been interested in using infographics to present scientific concepts in a focused and attractive way without losing content. The aim of such infographics is to improve students' understanding of scientific information, ideas, and concepts in order to enhance their learning experiences, improve their ability to retain and retrieve information, and enhance the irability to think, develop ideas, and organize their ideas logically. Infographics contain visual stimuli that directly affect a learner's motivation to look at the visual content, assess its components, and perceive the relationships among its various elements (Smiciklas, 2012).

A number of studies have focused on using infographics to teach science at different educational levels and on measuring the impact of infographics on objectives such as student achievement, visual thinking, and contemplative thinking; students' motivation for achievement; and students' motivation to study science. These studies show an improvement in the level of learners using various types of infographics (Lamb et al., 2014; Davidson, 2014; Gebre & Polman, 2016; Omar, 2016; Ibrahim, 2017; Gebre, 2018; Al-Dosari & Al-Sayad, 2018) .

Augmented Reality

Augmented reality allows the blending of realistic synchronous digital content from software and computer objects with the real world (Dunleavy & Dede, 2014). An augmented reality system offers a dual display that combines the real scene a user is looking at with a computer-generated virtual scene that enhances the real scene with additional information (Obary, 2015). Augmented reality has been used to teach science in scientific laboratories. It has been used to conduct different experiments in real classrooms, which help motivate learners to participate by simultaneously combining fun with learning. Augmented reality does not separate learners from their real world; rather, it realistically transmits the real world into the digital world, which is liable to increase learners' curiosity and encourage scientific inquiry (Moro et al., 2017).

Many studies have focused on the use of augmented reality technology to teach science at various educational stages, and have shown that this method is effective in enriching science education goals such as student achievement, creative thinking, and motivation (Hamada, 2017; Goff et al., 2018; McMahon et al., 2016; Moro et al., 2017; Omar, 2017;Salmi et al., 2017).

Modern Trends in Evaluating Teaching and Learning Science

Alternative Evaluation

Alternative evaluation uses diversified strategies related to the realities of learners' lives that increase students' motivation to learn while reducing the time required by the teacher to evaluate students. The teacher facilitates learning for her or his students and directs them to use self-evaluation methods. Alternative assessment is an ongoing process in which both teacher and student participate in making judgments about the learner's performance and improvement using various methods and strategies including performance tasks, interviews, tests, an achievement file, reports, peer evaluation, and cooperative activities (Wikström, 2007). Alternative evaluation focuses on the learner's performance of real and meaningful tasks that help to develop his/her cognition and skills. The learner's performance is assessed according to specific tools and standards in order to improve his/her performance and provide feedback. The teacher uses alternative evaluation in three stages: planning evaluation, using evaluating tools, and following up with alternative evaluation (Al-Khaldi, 2014) .

Alternative evaluation is based on authentic and realistic performance tasks, and on certain expectations and performance indicators for educational material. It provides the teacher and learner with feedback to be used in a reviewing the learner's performance. It is also a scientific, comprehensive, economic, and democratic evaluation (Allam, 2004). Alternative evaluation strategies include: performance-based evaluation strategies, pen and paper evaluation strategies, observation strategies, communication evaluation strategies, and self-review strategies. Alternative evaluation tools can also be adopted, such as checklists, grade scales, verbal grading scales, learning progress description records, and storybooks (Tsagari, 2004) .

The application of alternative evaluation strategies present several difficulties, including: teachers' lack of mastery of the tools and strategies of alternative evaluation, teachers' resistance to change, the difficulty of covering all students' tasks due to large numbers of students, and the fact that alternative evaluation has many requirements that increase the economic cost and require more time and effort than traditional evaluation. Furthermore, some teachers, students, and parents do not accept alternative evaluation (Allam, 2004; Tsagari, 2004).

Various studies have focused on the use of alternative evaluation across different stages of science education (Aselwi, 2017; Harahsheh, 2016; Khalidi, 2014; Kirikkaya & Vurkaya, 2011; Kolomuç, 2017; Sasmaz Oren et al., 2011; Serin, 2015; Stears & Gopal, 2010; Maashi, 2017; Turkey, 2017).

International Tests

The evaluation of academic achievement in science and mathematics occupies a great place in educational systems due to its relationship to scientific development and progress in each country. International tests are an important measure used on a global level to evaluate the educational levels of science, mathematics, and reading in different countries. Most Arabic countries have engaged with international tests such as the Trends of the International Mathematics and Science Studies (TIMSS) and the Programme for International Student Assessment (PISA).

Trends in the International Mathematics and Science Studies (TIMSS)

Many international and local organizations and bodies have undertaken international efforts to develop science education and reduce the gap between scientific progress and science education in schools. TIMSS aim to assess the level of student achievement in science and mathematics. They are carried out under the supervision of the International Association for the Evaluation of Educational Achievement (IEA), which is located in the Netherlands .

TIMSS tests are defined as a global project designed to compare the teaching of science and mathematics in public education schools around the world. Their aim is to allow countries to learn educational practices from each other, and to develop science and mathematics curricula in order to achieve a higher level of achievement (Abdul Salam et al., 2007). TIMSS tests assess students' achievement in mathematics and science in Grades 4 and 8. In addition to student achievement, a broad background is collected on the availability of school resources, the quality of the learning, and the teaching curricula. This background is important because it allows participating countries to measure their progress in mathematics and science education and helps them to make necessary educational reforms based on an objective and comprehensive assessment. Furthermore, a comparison is made among participating countries regarding the cognitive and scientific skills that students have learned in Grades 4 and (Mullis et al., 2009) .

Various studies have focused on the requirements for applying TIMSS to assess the level of student performance and then reforming science education (Abd Al-Salam et al., 2007; Al-Khatib, 2017; Al-Ruwaili & Al-Enezi, 2018; Al-Zoubi et al., 2018; Atalmis et al., 2016; Averett et al., 2018; Khattabah, 2018; Martin et al., 2011; Stephens et al., 2016).

Programme for International Student Assessment (PISA)

PISA is a cooperative effort among participating members from OECD countries, in addition to a number of other participating countries. PISA testing covers four knowledge areas: mathematics, reading, science, and problem-solving skills (Education Supreme Council, 2012). The importance of this program is that it provides a method for assessing knowledge, skills, and trends by measuring students' ability to use knowledge in everyday life situations (Breakspear, 2012). PISA also aims to compare the levels of students around the world and reveal their shortcomings, allowing academically weaker countries to benefit from the experiences of academically superior countries. These assessments integrate science ,mathematics, and reading assessments with information on students' social and economic background, learning styles, and learning environments. Thus, PISA tests results reveal the variables that affect the growth of knowledge, skills, and trends at both home and school, and show how these variables interact together (OCED, 2014).

A number of studies have examined the PISA program, how to develop science curricula in the light of its requirements, and how to evaluate the level of students' performance in it (Abdel Fattah, 2016; Al-Tayyib, 2003; Le Hebel et al., 2017; Mubarak & Sawalmeh, 2010; Nassef, 2018; OECD, 2016; Osborne & Millar, 2017; Roehl, 2015;Topçu et al., 2015) .

Modern Trends to Prepare the Science Teacher

Science Teachers' Preparation Standards

Science teacher preparation programs have developed clearly and distinctly since the 1980s, when competency-based teacher preparation first began. In the beginning of the new millennium, the Standards Movement emerged as a new direction for teacher preparation reform in all disciplines. Although several organizations developed these standards, the most prominent institution was the National Council for Accreditation of Teacher Education, which became responsible for accrediting teacher preparation programs in the United States (NCATE, 2008). Furthermore, the National Board for Professional Teaching Standards (NBPTS) established a group of standards that include the knowledge and skills that teachers must fulfill in order to obtain a license to practice the teaching profession (NBPTS, 2003). According to the NBPTS' Teacher Standards, a teacher must be able to take care of her or his students and their education, be familiar with the content of the subject she or he is teaching and know how to teach it, be responsible for monitoring students' learning, constantly think of her or his performance,learn from her or his experiences, and work as a member of the school community .

In light of this, the NSTA established the Standards of Teacher Preparation in the United States (NSTA, 2003). These standards include the knowledge, capabilities, and skills that a science teacher must possess; they are indicators to assess a science teacher's performance and provide an important approach to the professional level of science teacher preparation programs. The NSTA standards include:

- Content. This refers to the science teacher's ability to understand scientific knowledge and practices and be able to relate and interpret concepts, ideas, and applications in daily life.
- Nature of Science. This refers to the science teacher's ability to teach the history and philosophy of science and its processes, to help students distinguish between what is science and is not science, and to help students understand science as a universal human endeavor.
- Inquiry. This refers to the science teacher's ability to help students study science through scientific inquiry skills.
- Issues. This refers to the science teacher's ability to help students make decisions related to social science and technology issues.
- Skills of Teaching. This refers to the science teacher's skills in teaching science, which may include a variety of teaching strategies.
- Curriculum. This refers to the science teacher's ability to plan for the implementation of an effective science curriculum that is consistent with the objectives of the National Standards of Science Education.
- Science in Community. This refers to the science teacher's ability to link the field of science to local and regional communities, and to use individual and institutional community resources in the teaching process.
- Assessment. This refers to the science teacher's ability to design effective assessment methods and tools to determine student achievement including personal, mental, and social aspects.
- Safety and Welfare. This refers to the science teacher's ability to create and equip safe learning environments that support student success.
- Professional Growth. This refers to the science teacher's ability to continuously and professionally develop him or her in order to meet the needs of learners, the school, the community, and the teaching profession.

Various studies have focused on preparing science teachers and evaluating their level of performance in light of the different performance quality standards and national and international standards (Donnelly & Sadler, 2009; Hagevik et al., 2010; Issa & Mohsen, 2010; Veal & Allan, 2012; Al-Ahmad, 2013; Luft et al., 2015; Samila, 2017) .

Recommendations

Based on this review, the following important recommendations are made: scientific research plans should be adopted in the field of curricula and science teaching methods according to contemporary trends. For instance, annual studies should be prepared by scientific committees that are specialized in the field of science education that is inclusive of recent relevant research developments. Qualitative conferences should be conducted on trends in science education based on trends in contemporary science research.Qualitative research in science education that focuses on interdisciplinary studies among the various contemporary components monitored herein should be enriched and curriculum developers in the fields of education and scientific research should establish a consistent research vision based on contemporary trends in practical education research in a way that guarantees comprehensive development.

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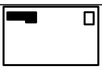

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