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A Comparative Study of Context-based Curriculum of Experimental Sciences in Junior Secondary School in Iran and Selected Countries

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ABSTRACT

The purpose of the current research is to compare Context-based Curriculum of Sciences in Junior Secondary Schools of Iran and selected countries. The countries of the England , Netherlands, and United States of America were chosen based on their pioneers in the field of science education and according to the strategy of "different social systems, different educational outputs". Also, the four-stage Bereday's model was used to analyze and compare the data. In order to increase the validity and reliability of the data, the original documents and self-assessment were used respectively. The findings of research indicated that the most important similarities between four selected countries are strengthening scientific literacy, acquiring process skills and understanding science concepts. The most important difference between the selected countries is use of different contexts and approaches in implementing the curriculum. Also, the comparison between Iran and the selected countries reveal that the similarities are more in the intended curriculum and differences in the implemented curriculum. In fact, in Iran's educational system, the appropriate framework and necessary arrangements for the implementation of the curriculum have not been prepared. Weakness in implementation has been effected Iran's acquired curriculum. Another finding of the research highlighted that there is no consistency between the three planned, implemented and acquired curricula in Iran. It is suggested to the curriculum planners of Iran to pay more attention to the role of teacher in designing the curriculum, role of the student in the learning process, and also the evaluation process of the curriculum.

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1. Introduction

Training of experimental sciences has always been considered as one of the important subjects in educational systems (Mehr Mohammadi, 2000). The all-round developments that have taken place since three decades ago in the selection of new approaches for designing and producing curricula - especially the curricula of experimental sciences - have entrusted the realization of part of the new missions and responsibilities of the education system to this basic subject. Because of this, some experts in the field of science education have considered changes in science, math and technology curricula to be the core of sustainable development of societies in the 21st century (Ahmadi, 2009). In recent years, many countries have adopted a context-based approach to design experimental science curricula at all levels of education (Ilhan et al, 2016). The context-based approach is one of the innovative approaches that have been used as the basis of curricula in many countries such as the Netherlands, USA, Germany, England, Canada & Australia (Tural, 2013). Context-based teaching of science is an approach in which the context that is meaningful to the learner is used as a starting point for learning scientific concepts (De Putter-Smits, 2012). This approach connects experimental science lessons with students' daily lives (Cabbar & Senel, 2020) and eliminates the gap between difficult abstract scientific concepts and the world in which students live (Swirski et al, 2018). This type of curriculum is developed based on the problem solving approach (Badrian, 2009).

Research revealed that context-based education increases the motivation of learners (Cigdemoglu,2020; Ilhan et al, 2016), upgrading metacognitive skills (Dori et al, 2018), increasing students' interest in practical programs (King & Henderson, 2018), positive attitude to science (Perkins, 2011; Tekbiyik, 2010; Tural, 2013) and academic achievement (Esra & Tosun, 2011; LaGerstrom et al, 2021; Park & Lee, 2004; Wiyarsi et al, 2020). Walan et al. (2016) have studied the challenges of teachers in using a context -based approach to science education. These challenges were mainly related to how to find the context, lack of time, populated classes, and individual differences between pupils. Many countries have used the experiences of successful countries to design science curriculum. For example, Japanese researchers have examined the context-based science education programs in the United Kingdom and the United States. The Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) in accordance with the country's cultural structure, also planned widespread goals for science education using context -based approach. Among these goals are the following:

- Breeding scientific and technological citizens who are able to solve new issues and problems of daily life,

- Expand citizenship awareness in a civil society,
- Expanding a widespread understanding of the new approach that leads to the understanding of the conditions and right judgment based on values (Nagasu & Kumano, 1996).

Since 2011, in Iran a new curriculum has been developed for science education which one of its dimensions was the use of the context-based educational design (Textbooks Authoring & Planning Office, 2015). However, the performance of Iranian students in international tests has been poor. For example, in the Trend International Mathematics and Science Study (TIMSS), Iranian pupils had poor performance in science test of Grade 8 (National Center for TIMSS & PERLS Studies, 2016). A comparative study of science education in Iran and United Kingdom reveals that new teaching methods - especially exploration and participatory methods and patterns - are used in the UK schools, while Iranian teachers still use traditional approach (Brahuimoghadam & Kahrazehi, 2020). Kabiri et al. (2017) highlighted that although in Iran's science education programs some competencies - such as acquiring knowledge & understanding of the basic concepts of science, science literacy, research design and positive attitudes to science - are considered, but the use of science, knowledge of applying scientific tools and performing mathematical operations (in theoretical and practical areas); integration of knowledge, scientific explanation of natural phenomena, and criticism of others (in competencies related to high -level concepts); use of models (in the competencies of working with models and diagrams); evaluating evidence and scientific reasoning (in scientific exploration competencies) and supporting exploration along with the dominance of doubt on science (in attitudinal competencies) have been ignored.

Comparing the performance of the top and weak countries in the TIMSS indicated that in the second group the traditional teaching method is more commonly used, which makes learners unable to learn the subjects of science in an active way (Karimi & Kabiri, 2013). Traditional methods are often teacher -centered, and students are only passively preserved taught content, and therefore avoid entering deeper layers of the learning process. Jafari et al. (2009) also in a comparative study of the science education curriculum in Iran and several countries have come to the conclusion that the similarity between these countries has been more in the goals & content and upstream documents and differences in teaching and evaluation methods. Ahmadi (2006) also indicated that there is no harmony in Iran between intended programs (aspirations, goals, content, etc.), implemented programs (a set of teaching -learning activities) and acquired skills (learning and behavioral change) and therefore due to the weakness of the implementation, part of the science education program's goals is not fulfilled. Despite the changes made in the experimental science textbooks of Iran schools and use of a context-based approach, the results of the TIMSS test show that the performance of Iranian pupils is still not favorable. Research literature also shows that the context-central program of Iran's science education has not been compared with leading countries so far. Therefore, the purpose of study was to compare Iran and leading countries to utilize science education experiences with a context -oriented approach. In order to fulfill the purpose of research, the following questions are raised:

- What is the status of context-based curriculum in Iran and selected countries?
- What are the similarities and differences of context-based curriculum between Iran and selected countries?

2. Research Method

In terms of nature, purpose and method, this is a qualitative, applied, and comparative research using George Bereday's regional approach. The research population includes all countries that use the context-based approach in science education of higher secondary school. The research sample includes the Netherlands, the United States of America, the United Kingdom and Iran, which have been selected through the strategy of "different social systems, different educational outputs". Context-based curriculum of United States and United Kingdom are the most famous in the world (2015, Mai). In the international level and over the past 20 years, the context -based programs of these two countries have been the main focus of science education studies. These programs have also been recognized by prominent international researchers in context -based education as a starting point for designing science education programs and courses (King, 2012). Other research shows that these countries are a leader in context -based programs (De Putter -SMits et al, 2020; Kortland, 2010; Tural, 2013). Since at selected countries the context -based curriculum was initially limited to the junior high schools (Grades 8& 9) (Kortland, 2005), the present study also compared this program for same level of education. In addition, the focus of context-based curriculum in leading countries is more focused on chemistry and physics. In context-based curriculum, these two subjects are taught separately. In Iran, these two topics are included in a single book namely "Experimental Science". Data were collected from upstream and national documents, research reports and articles published in the period of 1990-2020 and through searching external databases such as Science Direct, ProQuest, Springer, Sage, Google and Iranian databases such as SID, Magiran, Civilica, and IranDak. To increase the credibility and reliability of the data, the original documents and researcher self-evaluation were used.

3. Findings

According to the data analysis and regional approach, first the results of the two stages of description and interpretation are presented together. In the next step, the findings of juxtaposition and comparison will be presented.

Description and interpretation

What is the status of context-based curricula in Iran and selected countries?

A- Intended Curricula

Netherlands

One of the most famous context-based courses is the Physics Curriculum Development Project (PLON) in the Netherlands. The PLON project is a five-year course for pupils aged 12 to 17 started in the 1970s (Bennett et al, 2007). The idea behind a context-based curriculum is to embed science knowledge in a collection of practical situations – such as traffic safety, weather forecasting and energy supply – showing, first of all, that science relates to everyday life and enables us to understand practical applications and socio-scientific issues, and, secondly, that science content has a personal and/or social relevance in enabling thoughtful decision making about everyday life behavior (Kortland,2010). The nature of science, social issues related to science, and technological processes and products form the content of this program (Kortland, 2005). In the context-based approach, several educational frameworks have been described and used. Figure 1 shows the format of a Physics Curriculum Development Project (PLON).

A unit starts off with an orientation, introducing a basic question taken from the society students live in. The second part of a unit addresses basic information and skills: the physics relevant for answering the basic question. This part is followed by a number of options in which groups of students independently do some further work on aspects encountered in the unit's previous part and report their findings to other groups in class. Then the basic question turns up again in the last part of the unit, in which the physics concepts and skills are broadened and/or deepened by applying them to situations in which the basic question is prominent: does the physics taught help in finding answers, help in being able to cope with a technological device, a consumer decision, a socio-scientific issue? This turning back to the basic question – to society – is essential because it reflects the relevance of our physics teaching (Kortland, 2010).

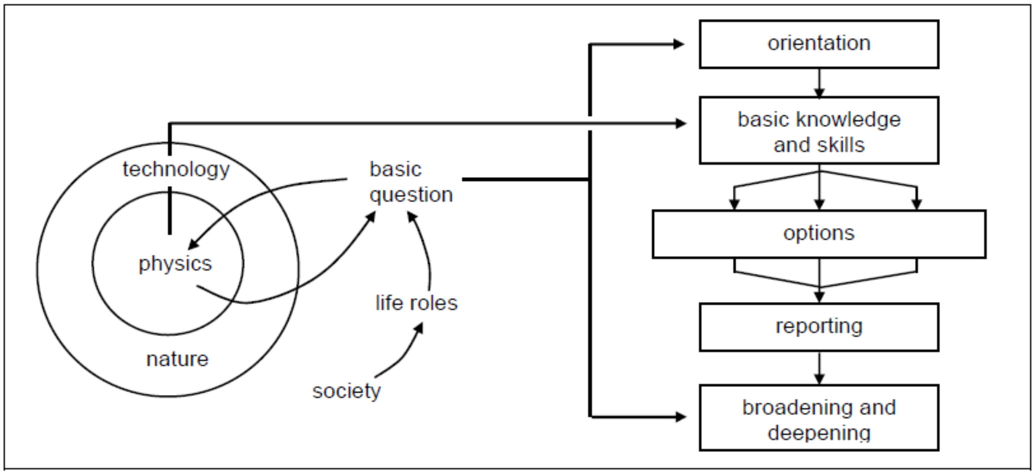

Figure 1. The format of a PLON unit (Kortland, 2010)

England

The context-based approach is called the Salter's approach because the development of chemistry teaching materials by Salter's Institute for Industrial Chemistry, which included context-based learning, was successful. The Salter's story also started during the past two decades and is still ongoing, being used by a group of science educators who met at York to discuss ways of making science attractive to learners at school. The educators at that meeting decided to develop five context-based chemistry units for junior-secondary schools and it was named Salter's courses (Khumalo, 2009). In Salters' project, the "need to know" is presented in three components: Story lines, chemistry ideas, and folder of activity. Each unit is driven by a story. In this way learners are referred to portfolio activities and chemistry ideas - which form the infrastructure of the pupils' conceptual map of chemistry knowledge through a “drip-feed’ approach” (spiral curriculum) (Bennett & Lubben, 2006). Two basic criteria are used to design Salters programs: selected ideas and concepts. The contexts in which learning takes place should enhance learners' understanding of how chemistry:

- It helps their or others’ lives around the world,
- Helps them to have a better understanding of the natural environment (Bennett & Lubben, 2006).

The nature of science, and technological processes and products form the content of this program (Kortland, 2005). At present, there is a full range of Salters courses covering biology, chemistry and physics, designed for high school students (ages 11-18).

USA

The Chemistry in Community (ChemCom) course, which was designed by the American Chemical Society in the early 1980s, is organized based on the Science-Technology-Society (STS) approach. The main goal of this program is to strengthen the scientific literacy of pupils aged 12 to 17 years (Bennett et al, 2007). High school traditional chemistry courses do not address the relationship between science, technology and society. Also, since the traditional courses were formed based on the preservation of real knowledge and laboratory books, there was a need for course of chemistry that would change the learners' perspective on this subject and in which there would be more motivation to learn and recognize the value of science in daily life (Sutman & Bruce, 1992 as cited in Panek, 2012). Bennett et al. (2007) found that the term "context-based" is more commonly used in Europe, while researchers in North America prefer the term "STS". According to Lee (2010), the science, technology and society (STS) approach is a perfect example of context-based science education. This approach focuses on current issues and helps students gain a deeper understanding of science concepts and allows them to apply their skills in the classroom and in everyday life.

Chemistry in the context, which has a strategy similar to chemistry in society presents a framework in terms of the spider-web metaphor; the information and activities that introduce each chapter, student decision-making activities, questions, and tasks; laboratory work; assessments, etc. This pattern of elements constitutes the backbone of teaching and learning (Schwartz, 2006).

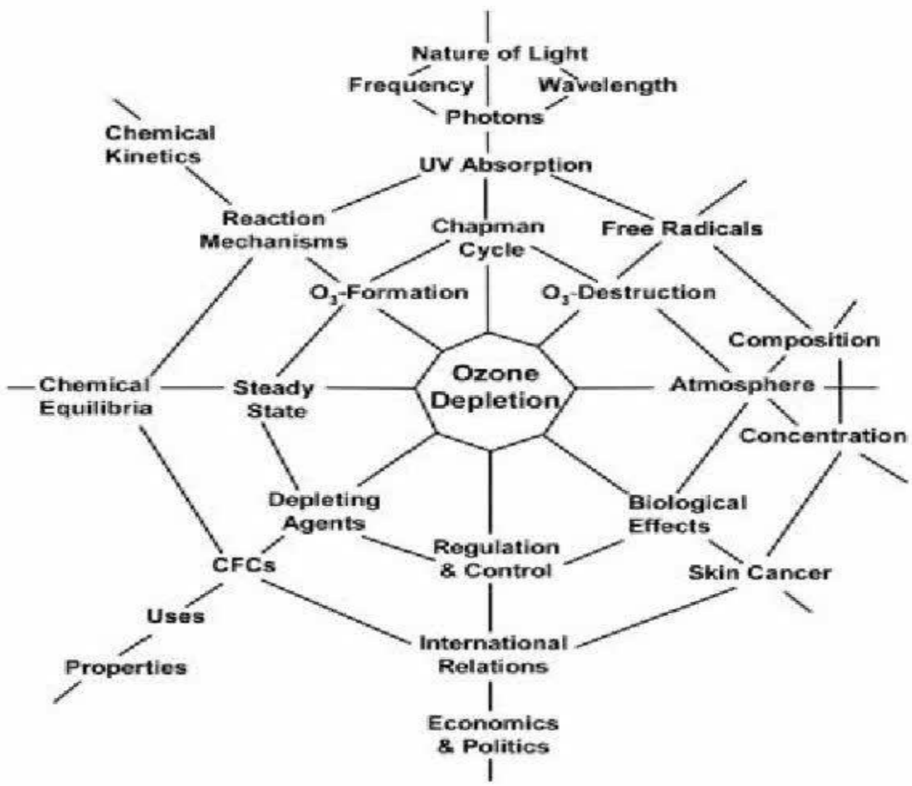

Figure 2 - A spider's web metaphor for learning chemistry: Interconnectedness of concepts related to "ozone depletion" (Schwartz, 2006)

Iran

Training of experimental science in Iran starts from the first grade of primary education. Also, from the Grade 1 to 9, a separate book called "Experimental Science" is authored and published by the Ministry of Education. In addition, the lessons of chemistry, physics and biology - which are branches of science education - are included and taught in the same book (Textbooks Authoring & Planning Office, 2020). In the experimental science books of the junior secondary school (Grade 7-9), there are also activities and examples related to students' lives, although the dominant approach in most chapters of this book is subject-oriented. Since in Iran's educational system, the curriculum is designed without students' participation, naturally the exploratory activities of the learners are not considered and programs are mainly content-based and result-based rather than student-oriented and process-oriented (Esareh, 2019). Since 2013, a new curriculum was prepared by the Ministry of Education for the teaching of experimental sciences. One of new curriculum dimensions is selection of a context-based approach in educational design. In the book "Teacher's Guide" for the experimental science curriculum of the junior secondary school, according to the characteristics of context-based teaching, activities are suggested, although a framework for the design of context-oriented units is not provided. For example, students' possession of technological scientific literacy - in the personal and social dimension - is one of the important functions of experimental science education (Textbooks Authoring & Planning Office, 2013).

B- Implemented Curricula

Netherlands

In the Ministry of Education, Culture & Science of the Netherlands, innovation committees have been formed for science subjects. In line with this, context-based educational materials are currently being designed in teams of science teachers led by science pedagogical professionals and under the authority of the four science innovation committees. This not only ensures that the new materials will fit classroom needs, but also engages the teachers in the innovative design process, and is likely to contribute to these teachers context-based competency (De Putter-Smits, 2012). In this program, students explore the relationship between science and society and choose their favorite topics to study and learn physics using a variety of methods - with special attention to group work and group discussions (Eijkelhof et al, 1996). Also, in these courses, daily life activities - such as making decisions about water quality and scientific and social issues - have been used (Kortland, 2010).

England

Starting in 1983, Salters' course - designed by a group of science teachers - began for 13-year-old students (Bennett & Lubben, 2006). Research on the role of chemistry in social events and daily life, internet search, class discussion, role playing and games are among the various activities that are implemented in this course (Barber, 2000). Salters' program uses active learning approaches—such as discussions, lectures, simulations, and decision-making activities—to introduce learners to scientific concepts and ideas. Also, a wide range of skills such as problem solving, practical activities and research-based activities are implemented to support students' learning. In individual research, pupils are encouraged to ask questions about science-related phenomena and then plan a practical activity to answer questions (Bennett & Holman, 2002).

USA

The Chemistry Education Program in USA is a comprehensive annual program designed around 7 parts during which students are introduced to social issues related to chemistry and science. This program presents chemistry based on need-to-know principles, and analyzes and relates chemical principles to social issues (Panek, 2012). For example, in examining water resources, students enter social and environmental debates (Bennett & Holman, 2002). The course of the context - based contains decision-making activities to apply chemistry to solve problems. Materials include pupils-centered, activity-based, issue-oriented activities to practice individual problem-solving and co-operative learning (Lubben et al, 2005).

Iran

As mentioned before, in Iran, the experimental science curriculum is designed by the Ministry of Education, and teachers and students have no role in its preparation and design. Nevertheless, in the junior secondary school, a specialized teacher is used to teach experimental science books. The content of the experimental science book should be presented to students based on three sessions per week (each session is 50 minutes) (Textbooks Authoring & Planning Office, 2020). Although the context-based approach is adopted in the upstream documents for the curriculum of experimental sciences, but teachers do not have enough information about the context-based approach and its effects, and they usually use traditional methods (Asadpour, 2014). Madanipour (2014) also indicated that the necessary arrangements have not been made for the implementation of experimental science curriculum with a context-based approach, and this approach is not implemented in practice.

C- Acquired curricula

The evaluation of the PLON project shows that its biggest achievement is making students interested in physics and discovering the connection between this science and society (Eijkelhof et al, 1996). Also, the findings of Wierstra and Wubbels (1994) highlighted that this project has increased positive attitude of students towards science. The Salters project evaluation revealed that students were very satisfied with the context-based course and became interested in studying chemistry (Barber, 2000) and their motivation to continue their education increased (Bennett & Lubben, 2006). Evaluation of the ChemCom project shows that students enrolled in this course better understand the relationship between chemistry and their lives and enjoy this science more (Panek, 2012). Also, pupils who completed the ChemCom course perform significantly better in assessing chemistry content and ability to use it compared to students who complete a traditional science education course (Bennett et al, 2005). In Iran, no research has been done about the acquired curriculum, but the results of the TIMSS showed that students of Grade 8 had the weakest performance in the science test - combining knowledge of science and information related to daily life and single contexts (National Center for TIMSS & PIRLS Studies, 2015).

Juxtaposition and Comparison

What are the similarities and differences between Iran and selected countries in context-based curricula?

In this section, according to findings of the previous steps, the context-based curricula of the four countries were placed together and compared, and similar and different items were extracted (Table 1). The results obtained from comparison of intended curricula reveal that the most important similarities in the four selected countries are the selection of goals such as strengthening scientific literacy, acquiring process skills in the curriculum, acquiring knowledge and understanding science concepts, and creating interest and a positive attitude towards science. The most important similarities among the Netherlands, England and USA are the existence of a guiding framework for the design of a context-based unit and use of a specific context as a starting point for learning scientific concepts. The similarity between USA and the Netherlands is use of personal and social spheres as a starting point for learning. The most important similarity between Iran , the Netherlands and England is attention to nature of science in the science curriculum. The most important differences between Iran and the countries of the Netherlands, England, and USA are lack of using a specific context as a starting point for learning scientific concepts and lack of a guiding framework for design of a context-based unit in Iran. In new context-based teaching approaches, the contexts are provided to students before introducing the content (De Jong, 2008). Also, after introducing scientific concepts, learners are exposed to other contexts. In these approaches, the introduced contexts act as a reason for teaching scientific concepts and a motivation to learn new concepts. Thus, in the leading countries, new approaches are used in the context-based curriculum as a starting point for learning. The findings related to comparison of implemented curricula indicated that the most important similarity between educational systems of the Netherlands, England and USA is cooperation of teachers in the design and implementation of the context-based unit and collaboration of teachers with their colleagues. Also, the most important difference between USA education system and the Netherlands and England is use of science-technology-society approach in implementing the curriculum of this country.

Table 1. Similarities and differences of selected countries in context-based curriculum

Curriculum	Components	Netherlands	England	USA	Iran
Intended	Strengthening scientific literacy	PLON	Salters	Chem Com	Context-based
	Acquiring process skills	*	*	*	*
	Acquiring knowledge and understanding science concepts	*	*	*	*
	Creating interest and positive attitude towards science	*	*	*	*
	Existence of context-based design guide framework	*	*	*	*
	Starting point of learning with a specific context	*	*	*	-
	Using personal and social sphere as source of context	*	*	*	-
	Attention to nature of science	*	-	*	-
Implemented	Teachers' collaboration in design of context-based unit	*	*	-	*
	Collaboration of teachers in implementation of curriculum	*	*	*	-
	Sharing efforts of teachers with colleagues	*	*	*	-
	Utilizing a wide range of skills and activities	*	*	*	-
	Using science, technology & society approach	-	*	-	-
	Using storytelling approach	-	-	*	-
Acquired	Understanding relationship between science and life	-	*	-	-
	Increasing interest in science lessons	*	*	*	-
	Increasing motivation to learn science	*	*	*	-

The most important differences between educational system of England with the Netherlands and USA are the use of a wide range of skills and activities and storytelling approach related to chemistry in the English curriculum. The most important differences between Iran's education system and the Netherlands, England and USA are the teachers' collaboration in designing and implementing the context-based unit and their collaboration with colleagues in these three countries. In leading countries, science teachers themselves are active in the design of context-based curriculum. The reason for this is that teachers are more inclined to accept change when they are a part of it. An innovation cannot be successful unless it is supported by different teachers.

The results of comparing the obtained curricula indicate that the most important similarities between the Netherlands, England and USA are the increase of students' interest in science lessons and understanding relationship between science and life. The implementation of the context-based approach in these countries has created the interest of the learners in experimental sciences and understanding relationship between science and their lives. The most important difference between Iran and the Netherlands, England and USA educational systems is the low performance of Iranian students in understanding the relationship between science and everyday life.

4. Conclusion

The current research was conducted with the aim of comparative study of the context-based curriculum of experimental sciences in Iran and selected countries (England, Netherlands, and USA) and in order to benefit from the experiences of leading and active countries. In this approach, the contexts that are meaningful for the student are used as the starting point of science learning.

Considering that the implementation of the context-based approach depends on the context, which is derived from philosophical, social, cultural and historical foundations, then this approach is more dependent on the specific environmental situation than other approaches. The findings of research showed that the focus of context-based curricula in leading countries is more on chemistry and physics. Therefore, in the subject-oriented curricula of the junior secondary schools, chemistry, physics and biology lessons are taught separately. In Iran, these subjects are taught in a single book namely "Experimental Sciences". The findings also highlighted that the most important similarities among the four selected countries are selection of goals such as strengthening scientific literacy, acquiring process skills and acquiring knowledge and understanding science concepts in the intended curriculum. The most important differences between the four countries are the use of different contexts and approaches in implementing the curriculum. The most important differences between the educational system of Iran with the Netherlands, England and USA are as follow: Lack of using a specific context as the starting point of learning, lack of a guiding framework for design of a context-based unit, lack of an active role of teachers in design of the curriculum, and lack of necessary arrangements for implementation of context-based program. The comparison between Iran and selected countries shows that the similarities are more in documents or intended curriculum, while the differences are more visible in the implemented curriculum. This finding is consistent with the research of Jafari et al. (2009). It can be said that context-based has been considered only in the upstream documents of the educational system, and in the production of the curriculum, no value has been paid to the new approaches.

Other findings show that there is no consistency between the three planned, implemented and acquired programs in Iran. This finding is consistent with Ahmadi's (2006) research. He emphasized that the existence of distance and inconsistency between the three mentioned programs is the fundamental weakness of Iran's educational system in the context-based curriculum. In the studied countries, teachers with the participation of students provide suitable grounds for lesson design and implementation, while in Iran, no framework has been provided for the implementation of the context-based curriculum. Also, teachers are not familiar with the implementation of this approach and the necessary arrangements for its implementation have not been provided. In fact, the attempt to change the way of education unintentionally faces various obstacles, which is mostly due to the lack of a guiding framework. This issue is an important challenge facing the implementation of the context-based program because teachers do not see it as a new and real reform. As the different results of TIMSS indicated the performance of Iranian students in science tests is not appropriate and their score is lower than the world average. For the successful implementation of the science curriculum with a context-based approach, it is necessary to provide appropriate arrangements such as in-service training for teachers and real participation of teachers and students in designing appropriate contexts. According to the findings, it is suggested to the curriculum planners of Iran:

- Preparation and compilation of the guideline framework for design of the context-based unit,
- Grounding the active participation of teachers in the design of context-based curriculum,
- Attention to process of curriculum planning and production,
- Preparation of necessary arrangements for implementation of context-based approach,
- Attention to the student's role in learning process and implemented curriculum,
- Evaluation of implemented curriculum to solve the challenges of context-based curriculum.

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