

Promoting Scientific Literacy by Using ICT in Science Teaching

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Abstract

This study aims to identify the way upon which ICT can be employed in science teaching to develop scientific literacy level.

The study has conclude to design a triple learning model (PEA) based on ICT and constructive learning strategy in teaching science through a context which cares for building positive trends of searching for knowledge and increasing scientific literacy level of the students at schools and universities. The PEA model depends on the use of ICT in the teaching of science through the following three requirements:

1. Using ICT in a way that is consistent with the tendencies of the students and their attitudes.
2. Constructing educational content based on the constructivist theory of learning.
3. Providing social learning environment.

Thus, the study recommends the bodies in charge of the educational process to necessarily adopt the project of rebuilding scientific literacy through supplying classrooms and laboratories with ICT supplies as well as training teachers and faculty members in universities on science teaching skills by using ICT based on the Constructivist Theory.

Keywords: constructivist theory, ICT, science teaching strategies, scientific literacy

1. Introduction

The level of scientific literacy of individuals significantly affects development in the society (Laugksch, 2000), (Adubifa, 2003) and the growing of scientific literacy leads to economic growth and social stability at political and social levels, (Bidokht & Assareh, 2011).

There is a close relationship between the scientific literacy and cultural renaissance. This relationship may be attributed to the idea that the standard of development of modern societies is based on how much citizens perceive science and technology (Milne, 2007; Al Shibani, 2000). Furthermore, economic boom, development of society, and ability of competition in the era of globalization are based on scientific excellence. This positive change cannot be achieved unless such groups are able to adapt themselves to requirements of scientific movement (Wagner & Kozma, 2005).

Providing all components of society such as basic kinds of knowledge, whether scientific or technological ones even in a simplified manner, to the commons especially the young generation; has become a key objective in the knowledge society (Adubifa, 2003). Accordingly, it is not enough that a society seeks to prepare elite to undertake thinking and creativity on behalf of other groups, rather, the point is that members of "knowledge society" should be provided with fundamentals of science and that knowledge be available for all people (ALECSO, 2008).

Thus, the society will become, little by little, familiar with the achievements of science and technology and that each member turns to be an active factor having basics of systematic scientific thinking where his/her cognitive abilities get developed, consequently; his/her judgments and behaviors will be logical and constructive (Durant, Evans & Thomas 1989).

The most important tool of our present time upon which we can depend for purpose of heading toward a reasonable level of scientific literacy is ICT (Arntzen, Krug, & Wen, 2008; Mirskaya, 2007). Such technology is not mere tools; rather, it provides information and adjusts our communications forms and even the ways of our thinking and creativity.

How could we ensure access of all people to these information and intellectual resources and at the same time overcome social, cultural, and linguistic obstacles? How could we encourage process of placing contents on the internet where they are more varied and able to be a significant source for all people? What are the pedagogical opportunities provided by these new means of telecommunications? (Science in Information Society, 2005).

Regarding the academic area that is considered the gate of entering to distinct scientific literacy, the modern technology has redefined and reevaluated scientific literacy concepts and learning activities and entrusted teachers with new roles (Ovensi & Alibabic, 2010). This has been achieved through the ability of modern technology to recycle and transmit texts, images, information, and knowledge across the world in a short time, which in turn, increases opportunities of learning and familiarizes people with all modern and sophisticated issues. Accordingly, providing opportunities for continuing learning and knowledge based on social and economical motivations, namely, cultural and scientific communication among people plus knowledge-based-economy requires qualified workforce that is able to develop its abilities, obtain more training, and be familiar with all recent developments related to its specializations in particular and various areas of science in general (Thoe, Abdul Rani, & Fook, 2005).

Considering scientific literacy as a demographic characteristic of the society, most of studies in this field(Luu & Freeman, 2010) show connection of this characteristic with ICT awareness of citizens and the nature of tasks they carry out using this technology.

These facts have pushed us to ask about various forms of ICT can be employed/implemented for purpose of reinforcing levels of scientific literacy which has become a basic demand within knowledge society, yet what made it difficult to answer such question is the relation of this objective with other aspects other than the technical aspect as desires and trends of individuals.

This study examines the following question:

How could we employ the ICT to reform scientific awareness and build a pioneering project of scientific literacy?

2. Scientific Literacy

The citizen's culture is the factor that determines his/her concerns, practices, behaviors, and priorities, and clarifies his/her intellectual grounds, scientific pillars, and self-motivations (Al Shibani, 2000). Thus, providing the citizen with scientific literacy is a necessity for development and growth. As a resultant, the scientific awareness becomes a main element of the public awareness, accordingly, success of scientific and research activities and technical development will become a collective trend in community.

In this context, the so-called "knowledge society" has become the most popular aspect designated upon the human society today, where the citizen who is able to adapt himself to live effectively in this society is the one who has the scientific literacy that enables him to use knowledge creatively to solve his everyday problems, to take the correct decisions and to develop of his living standards (Watters & Ginns, 2000).

Being familiar with basic facts about outcomes of science, the scientific literacy is considered an integral part of the general culture and an important aspect in developing the youth's abilities for purpose of taking in science and technology concepts to be a routine daily behavior in life (Salameh, 2005; Harlen, 2006).

The U.S National Center for Education Statistics defines "scientific literacy" as perceiving and understanding scientific concepts and processes which the citizen needs to make decisions and participate in civil and cultural affairs and economic production rates (NAS, 1996).

The scientifically educated citizen is a person armed with skills such as (NAS, 1996; Prenzel, 2006):

- Understanding basic scientific facts and their meanings.
- Inquiring, searching, and answering the questions arising from curiosity about everyday experience.
- Describing, explaining, and predicting natural phenomena.
- Consciously reading articles in newspapers about sciences and involving in social discussions about validity of conclusions.
- Identifying scientific issues beyond the national and local decisions and carrying out explicit actions about them.
- Evaluating quality of scientific information based on its sources and the ways they are produced.
- Establishing and assessing the arguments that are based on evidences and applying the conclusions appropriately.

The world has realized the importance of scientific and technological culture since early stages and it has carried out many considerable projects in order to develop effective scientific literacy among citizens. The most well-known projects are:

1) 2061 Project

This project, supported by the American Association for the Advancement of Sciences (AAAS), aims to upgrade standard of scientific literacy among the Americans and build a new American citizen. The project was built mechanism which believes the education can prepare the students to understand the way the world operates and help them to think independently and critically as well as enable them to enjoy life with responsibility as productive persons.

This project concentrates on the scientific vision toward the world, investigation methods, nature of scientific projects and mathematical process, relation between science and technology (AAAS, 1989).

2) Japan Science and Technology Agency Project

Here, this project aims to increase efficiency of scientific and technical awareness among commons especially the children and youth. It also includes holding scientific festivals, building video and multimedia libraries for sciences, and establishing scientific museums. Moreover, it aims to support studies of science and technology and create future leaders in terms of science and technology through (JST, 2012):

- Discovering and encouraging talented persons.
- Studying and applying advanced teaching programs.
- Developing and enhancing cooperative learning among schools and other institutions of society.
- Increasing activities and programs of rehabilitating teachers.

3) (Chemistry is All Around Us) Project

This project has been carried out in some European countries since 2011. It targeted developing successful strategies to enhance continuing learning and awareness of many scientific issues through utilizing ITC. Furthermore, this project helps develop educational methods and tools that assist students effectively in this regard for purpose of acquiring the skills necessary for scientific knowledge in the future. The persons in charge of the project believe that all its objectives can be achieved when increasing research collaboration between Faculty of Education and faculties of science, so the project focused on the providing teachers with training program during service and holding scientific exhibitions and conferences for students and parents. (Chemistry is All Around Us, 2001).

3. ICT Tools

Information and communication technology (ICT) has affected all areas of social, economic, and industrial life (Ovensi & Alibabic, 2010), where the growth in all these areas has produced remarkable improvements concerning knowledge which in turn has made keeping up with and being familiar with all these kinds of knowledge produced by this movement a very difficult problem. Moreover, ICT is considered a key pillar to establish knowledge society since it is the main tool to spread out knowledge plus its role in developing, supporting, facilitating, and accelerating scientific and cultural research as wide as possible (Arab Knowledge Report, 2009).

Employment of ICT is almost the common factor among all programs and projects that scientifically try to build the educated society, where this technology provides sophisticated potentials, mechanisms, and programs to be used effectively to increase joining individuals in a continuing learning process.

In science teaching, ICT tools can be employed in order to improve learner's ability of understanding, using, and evaluating communication (Hoadley & Bill, 1996; Volna. Et al, 2011) Where the student resorted to accessing information sources, carrying out processes of analysis and evaluation. ICT Provides opportunities for interaction with knowledge in various patterns and forms such as:

3.1 On-Line Discussion

ICT provides virtual learning environment (computer-based simulated classroom). The most important advantage of this technique is that it allows interactive scientific discussion and communication with others efficiently (Sorin, 2004; Sutherland, Marcus & Jessup, 2005). It also shows its role in creating opportunities to develop thinking and presenting ideas to be criticized (Otero et al, 2005), developing problem-solving skills (Ferry et al.2005), and encouraging continuing self-learning (McDonald & White, 2005).

The most important advantages of the virtual environment on the internet are democracy and freedom of expression where all persons may discuss issues without any control or supervision (Bradford-Smith, Smith & Boone, 2000; Swan, 2001; Scott & Ryan, 2008; Kumar & Vragov, 2009). Furthermore, it allows students to easily communicate with their peers of students, teachers, scientists, researchers, industrialists, leaders, scientific centers, companies and clubs, etc (Tinio, 2003; Osborne & Dillion, 2010).

Computer-mediated Communication in teaching strategies and curricula planning may offer real and multiple learning opportunities through discussions that allow:

- A. Granting students sufficient time for answer and dialogue.
- B. Freedom of dialogue not subject to standards of the classroom.
- C. Sharing ideas.
- D. Later examination of ideas.

In order to get advantage from scientific discussion through (Social Networking Technologies), the users need various social and emotional skills in addition to the skills they use when meeting each other face to face (Jones & Issroff, 2005).

(Osborne & Dillon, 2010) has examined a set of studies to find out that the young people who have been taught according to synchronous and asynchronous online discussion have become interested in acquiring knowledge through the scientific groups that are interested in urgent scientific issues across the world.

3.2 Digital Curriculum

One of the most magnificent obstacles of development of education is the way upon which the curricula are carried out in schools and universities and not seeking to develop it (Shawer, Gilmore, & Banks-Joseph, 2008; Shawer, 2010). Today, ICT provides an opportunity to develop curricula and their ways of implementation through E-curriculum or the so-called Digital curriculum which is a form of E-Teaching forms. Communication is considered a digital one when it is carried out via the internet or through another digital mean like CDs. E-curricula represent the set of educational and scientific experiences provided to the learner through the enormous potentials provided by ICT, where the digital curriculum is considered a new form of communication between professionals and learners (Abbey, 2010; Kirkwood, 2011).

The digital curriculum employs several e-learning pattern through links with educational sites containing simulation programs of scientific concepts and phenomena that cannot be displayed or observed inside the classroom such as celestial bodies, earthquakes, and volcanoes (Ismail, 2010). Moreover, digital curricula have relations with (Tutorial Programs), Drill and Practice, Virtual interactive Lab which provides tools for labs of chemistry, biology, and physics to perform chemical reactions, physics experiments, in addition to using microscope to observe microscopic slices (Miller, 2011).

In science teaching the web based remote control laboratory is a system that enables students to control real experiment from a remote location using internet and an ordinary web browser. This pattern of technology earns the Student benefits to explore many experiments not available in traditional labs, in addition to opportunities for communication and scientific knowledge (Cooper, Donnelly & Ferreira, 2002)

The digital curriculum helps to achieve education objectives which mostly cannot be achieved in the traditional curricula as expected for many reasons, In addition, digital curriculum can easily build positive values and attitudes in the students toward scientific issues and phenomena. Thus, (Mckenzie, 2000) believes that the digital curriculum supports information culture of learners and helps to prepare them to technology-directed-world, if it is designed and developed properly.

3.3 Multi-Form of ICT in Education

ICT provides multi-tools such as include probes, spreadsheets, databases, internet search engines, word processors, simulations, presentation/multimedia tools, concept mapping tools and graphics tools (Alberta Learning, 2010) that can be employed through learning strategies for purpose of preparing learning opportunities in various ways.

4. ICT Strategies in Science Teaching

Since the anticipated objective of science teaching is preparing the young generation to have the sense and feeling about the ways upon which the world moves so that they can think independently and critically and be responsible as productive individuals in a world shaped with a culture based on science and technology (Kang, 2008). We notice that this objective can be achieved by building the culture that creates positive behavior and practice especially scientific literacy (Mirskaya, 2007).

Thus, teaching science strategies plays a key role for establishing scientific literacy that distinguishes the citizen who is able to adapt himself to society of technology and knowledge (Rutherford & Ahlgren, 1990) (NRC, 1996). This can be carried out through teaching strategies that give the students active role in social communication environment (Milne, 2007) (Linn, 1995) and self directed tasks develop strong motivations in them for purpose of continuing learning (Chee, et.al. 2011; Bidokht & Assareh, 2011). To achieve this objective, a teacher who is able to build real learning opportunities and manage positive educational environment should be prepared. In addition, science curricula should be planned to work in the same context for purpose of matching learning activities with student's interests and encouraging their abilities to think freely and in advanced levels to be enthusiastic for continuing learning and having the scientific literacy (Marks & Eilks, 2009).

The modern studies shows that the methodology of using ICT in teaching has strong impacts on scientific literacy level of the students (Luu & Freeman, 2011). Undoubtedly, using effective educational strategies encourages creativity and innovation and builds trends of inquiry and investigation to build distinct scientific literacy for the students (Marks & Eilks, 2009), unlike the common traditional teaching pattern which does not exceed the methods that just concentrate on retention of information by the students where teaching processes lack strategies and techniques that establish for distinct scientific literacy.

Concerning the pedagogical area, ICT provides a big opportunity to apply theories of learning that give the students a central role (Learner-Centered Pedagogy) when performing learning situations, equip them with strong motivations for continuing learning, and motivate them to search and investigate and eventually to gain a wide scientific literacy.

The high flexibility of ICT and diversity of its usages in teaching make it eligible to be the top priority in teaching process since it allows instructors to produce knowledge and share with others, it also provides opportunities of quick search and information retrieval in a well-organized method (Anderson, 2010).

Constructivism Theory concentrates on the student to perform real learning tasks that require using higher thinking skills with an exploratory context and through team work (Linn, 2000). (Computer Supported Collaborative Learning) performed in the context of knowledge integration environment greatly enhanced continuing learning and knowledge production.

Thus, Constructivism Theory pressures on designers of means and tools of ICT to shift from concentrating on traditional roles of transmitting knowledge and information to employing such means and tools to design constructive learning environment (Karagiorgi & Symeou 2005; Solomonidou 2006)

ICT simulates authentic science learning through its tools that increase communication of the real world, reflective thinking, and problem-solving. Thus, the studies assert that the learning environment that employs ICT achieves Non-Linear Learning and increases learner's role which in turn facilitates the task of designing of constructive learning environment (tekos & Solomonidou, 2009).

Accordingly, it is shown that employment of constructional teaching strategies during learning by using ICT is considered a key supporter that helps students acquire scientific culture with advanced levels.

5. Positive Attitudes toward Scientific Knowledge

Enabling students to use ICT tools help them to build positive attitudes towards scientific and environmental issues, animal protection, health, and prevention of epidemic diseases, besides, discussion are important to acquire critical thinking skills and upgrade a scale of positive values and trends toward learning and knowledge and ethics of science (Harris, Buchanana & Walker, 2002). Concern for learning, acquiring knowledge, and continuous career development have a close relation with trends, interests, and motivations of the individual (Thoe, Rahihan, Abdul Rani & Fook, 2005).

The great desire of the young to use modern technology and its services in all areas especially in the social one (Lenhart et al. 2008; Levin & Arafeh 2002; Pew Internet & American Life report 2002), shows the effect of ICT upon their trends and emotions. Thus, access to the internet has become the most important concern of this generation since it represents their wide world through providing them with freedom of expression, dialogue, and knowledge of others' ideas and culture (Mehanna, 1995; Dinger & Sashinkayas, 2011).

The multiplicity and diversity forms of knowledge displayed by ICT (text, simulation, movies, games, discussion) increase the desire of students to learn attain and retain knowledge where this is consistent with their wishes and interests.

6. Method

The study was initiated at the first semester in the academic year 2011-2012 at Al-Hussein Bin Talal University in Jordan. The researcher tested the scientific literacy about the concepts of space and astronomy for the control group consisting of (123) students in science college, who have studied the course of Astronomy and Space Physics by the traditional way. The test has been prepared to measure the level of scientific literacy about the space and astronomy concepts, and had all the statistical treatments, where the reliability coefficient was (0.87)

At the beginning of the second semester, experimental group were selected in the science college consisting of (121) students, and it was to ensure parity for the two groups. The colleagues who taught the course to the experimental group were trained and informed about the objectives and methodology of the study and familiarized them with ICT tools. Also, they were briefed on the most important programs and technologies related to teaching course Astronomy and Space Physics including:

- 1- E-mails
- 2- Facebook & Twitter
- 3- On- line conference
- 4- Learning Site:
 - YouTube-Cosmo Learning
 - <http://www.space.com/>
 - <http://www.universetoday.com/>
 - <http://www.astronomynow.com/>
 - <http://astronomy101.jpl.nasa.gov/>

The colleagues also had been trained on how to teach through employment of ICT using planning an educational tasks and worksheets by exploratory context .at the end of the semester, students took the same test.

7. Result

The table 1 shows the results of the two groups at scientific literacy:

Table 1. Averages and standard deviations of the level of scientific literacy among the two groups (experimental and control)

Group	N	Mean	Std. Deviation
Control	123	11.8943	5.12438
Experimental	121	21.3967	6.08479

In order to identify the statistical significance of the differences among means. T-test was used as shown in the table 2. It was found that the impact of teaching using ICT was positive at the level of scientific literacy

Table 2. T-Test

	t	df	Sig. (2-tailed)
Equal variances assumed	-13.203	242	0.000
Equal variances not assumed	-13.184	233.880	0.000

The colleagues who have ran the teaching process using ICT, confirmed the employing ICT in physics teaching was effective for acquisition of scientific concepts and growth of scientific knowledge among students. Here are some of their comments.

Teacher A:

The students' motivation to learn was high when teaching through ICT tools compared to the usual way, as one of the most important pros have appeared keen students on self and continuous learning.

Teacher B:

The implementation of the learning tasks in the teamwork communication pedagogy through electronic networking sites was a major cause in the interest of students to learn more.

Teacher C:

Employing ICT tools in teaching physics line with the interests of this generation of students and make them employ these techniques to acquire things that develop their thinking.

The study results confirmed the strong relation between usage of ICT by the individuals and their scientific literacy (Wu & Glaser, 2004). However, as it turns out the nature of this relation depends on the way of using ICT in learning and the level of skill to use it as well as the nature of learning tasks entrusted to the students (Luu & Freeman, 2011).

8. Discussion

Developing scientific literacy and establishing a scientific awareness requires a new relation between the learner and knowledge sources in order to identify the most useful things for learning, the most effective ways to acquire such things, the best sources, and the best way the modern technology can help in this regard (McNair, 2000).

ICT is considered a key role for continuing learning, since it ensures a quick access to every new knowledge around the world regardless of spatial and temporal limits (McNair, 2000). Accordingly, ICT provides an increasing range of tools to treat digital data and access to a wide and varied set of contents that support the information age (McFarlane & Sakellariou, 2002) which makes this technology an important tool for people and societies in order to develop their scientific and cultural abilities and be able to keep up with developed countries.

However, in order to get the most advantages from this technology to develop the culture of citizens and increase their abilities to produce scientific knowledge, education institutions should comply with the correct methodology of using ICT in learning processes through constructive learning strategies within social contexts to perform real tasks (Arntzen, Krug & Wen, 2008; Luu & Freeman, 2011).

ICT provides many tools and patterns that can be utilized through constructive learning strategies in teaching science, where the student can perform several tasks and activities and be responsible for his learning process. These tools can achieve constructive social learning environment like (Chat/Online Conference) as well as getting advantage from the increasing usage of this technology by the students especially social networking sites (Facebook, Twitter, Fliker, Youtube, Skype) (Ito et al, 2008) besides the constant use of mobiles, I-Phone, and I-Pad, consequently, to overcome the key obstacles facing ambitions of the people responsible for education and upgrade scientific literacy level of the citizens (Figure.1), namely, forming the real motivations and establishing positive trends in the students to gain more scientific knowledge. (Vanderlinde. et al, 2010)

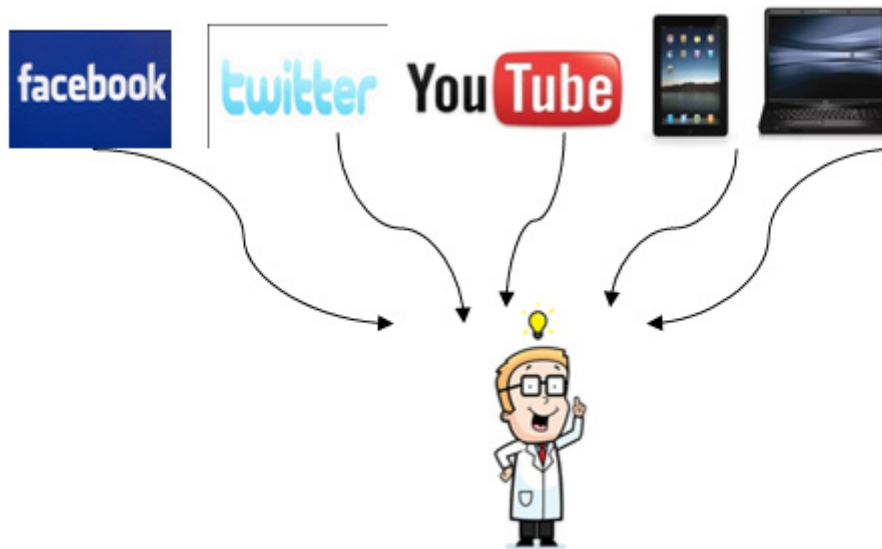


Figure 1. Scientifically educated citizen

The relation of ICT with students' motivations and trends has central role in developing scientific literacy and encouraging the continuing learning, as this technology has a deep impact on learning process and content and building positive trends toward learning when performing learner-centered approach and preparing opportunities of collaborative and interactive learning (Leu et al. 2004; Dinevski & Kokol, 2004).

To conclude, we come up with a model (Figure 2) that helps teachers in the various stages to give their students an advanced level of scientific knowledge.

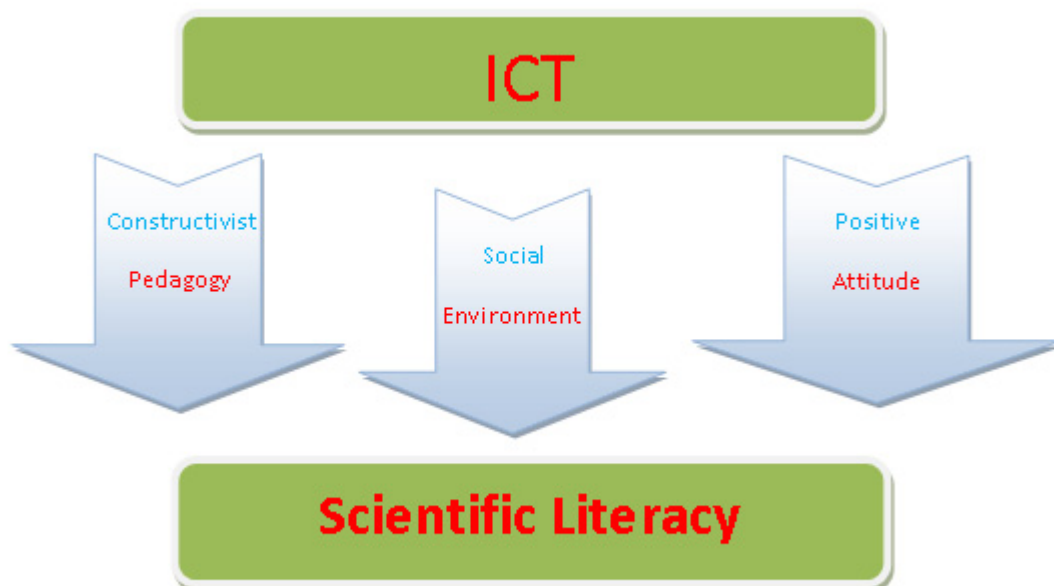


Figure 2. PEA model

The PEA model depends on the use of ICT in the teaching of science based on the following three requirements:

1. Using ICT in a way consistent with the tendencies of the Students and their attitudes.
2. Constructing educational content based on the constructivist theory of learning.
3. Providing a social learning environment.

Having shown the model, must promoting a scientific literacy through rebuilding and planning various curricula especially science curricula according to the strategy of using ICT in teaching sciences that is based on Constructivist Theory (Staples et al., 2005). The model is expected to include training to prepare the teachers and faculty members in universities to apply such educational strategy. To sum up, the implementation of a leading scientific literacy requires designing the appropriate learning environment through providing supplies, programs, networks, and the classrooms equipped with new technologies that enable communication with the world easily and quickly.

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