Macrothink Institute™

Journal of Studies in Education
ISSN 2162-6952
2016, Vol. 6, No. 2

Assessing the Development of Scientific Literacy among Undergraduates College of Education

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Received: Feb. 3, 2016 Accepted: May 26, 2016 Published: May 26, 2016

doi:10.5296/jse.v6i2.9405 URL: http://dx.doi.org/10.5296/jse.v6i2.9405

Abstract

The purpose of this study was to assess the development of scientific literacy among scientific departments at Najran University College of education, as well as the effects of demographic variables on it. The Sample of the study consisted of (20%) of the study population which included all students at scientific department (Physics, chemistry, Math's) of the college of education chosen randomly. To achieve these objectives (yes/ no) test, multiple choice as well as one open ended question was employed. After being analyzed, results showed the students scientific literacy develops through their university study years particularly during the late years, however what is gained through time did not exceed (10%), meanwhile the general level of scientific literacy was accepted and within employment scientific literacy according to Bybee scale among most of the students.

Results found no specific variable affecting scientific literacy among students except number of scientific courses studied by students; however its effect was weak. Finally, the study recommended the necessity of reconsidering teachers preparing program at college of education, as well as the addition of scientific literacy course in their study, in addition to improving academic courses at scientific departments, while connecting them to society issues.

Keywords: Scientific literacy, college of education students, Bybee scale, Najran University.

1. Introduction

Scientific literacy is one of the basic concepts characterizing sciences and always mentioned in scientific education and in science methods and teaching literature (Zaytoon, 2010), as well as an ongoing and of scientific education, which sought to achieve for all students of this age (The National Research council (NRC), 1996), in order to realize societal awareness needed to deal with charges and trends, in a flexible way, oleander by this age and to enhance economic growth and leadership, as well as improving both social and environmental well – being (Zaytoon, 2010), so , scientific literacy forms the driving power of change and reform in scientific education and science teaching methods.

So, scientific literacy is a wide construct that includes scientific ideas and concepts with and across scientific various majors, as well as scientific practices, It was detained in research literature as the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (National Academy of Science (NAS), 1996). While PISA in the frame of science assessments (2015) defines it as the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen (OECD PISA, 2013).

Achieving scientific literacy for all students is one of the main objectives for teaching science, and a continues aim of scientific education in our age (NRC, 1996), that goes with students for their lives. So Many countries around the world adapted this direction in the form of rushing towards equipping their subjects with scientific literacy as the most powerful element of our world advancement. In the United States, for instance, the National research council (NRC) and American Association for the advancement of science (AAAS) published new standards and scales about scientific literacy concert, assessment and teaching methods (NRC, 1996; AAAs, 1993). These organization in association (AAAS) with National science teacher Association (NSTA) a common statement on February (1996) emphasizing the importance of scientific literacy stating that the priority in scientific literacy became a salient slogan adopted by many educational systems all over the world (Holbrook and Rannikmae, 2009).

At the same dime, several international programs took care in measuring the achievement of scientific literacy among various society classes, i.e. teachers and learners, as a basic objective in learning, among which The program for international student Assessment (PISA) affiliated with the organization for economic cooperation and development (PISA, OECD, 2005) which focuses, mainly on retrieving knowledge from form instructional content. And trends in mathematics and science studies (TIMSS) program (NCEs, 2011) which tends to focus on practical knowledge as practiced at work, that is perceiving scientific questions, specifying related evidences, critical assessment of conclusions and communicating scientific ideas (Fensham & Harlen, 1999; Harlen, 2001; OECD/ PISA, 2005).

Bybee (1997) and the Biological Science Curriculum Studies BSCS (1993) suggested a comprehensive theoretical scale that is more suitable for the assessment of scientific literacy during science studies at school, since its hierarchy can be easily transferred to instructional purposes. This scale was used as one of the theoretical frameworks for the current study. The scale suggests the following levels of scientific literacy:

- Scientific illiteracy (SI): Students who cannot relate to, or respond to a reasonable question about science. They do not have the vocabulary, concepts, contexts, or cognitive capacity to identify the question as scientific.

- Nominal scientific literacy (NSL): Students recognize a concept as related to science, but the level of understanding clearly indicates misconceptions.

- Functional scientific literacy (FSL): Students can describe a concept correctly, but have a limited understanding of it.

- Conceptual scientific literacy (CSL): Students develop some understanding of the major conceptual schemes of a discipline and relate those schemes to their general understanding of science. Procedural abilities and understanding of the processes of scientific inquiry and technological design are also included in this level of literacy.

- Multidimensional scientific literacy (MDSL): This perspective of scientific literacy incorporates an understanding of science that extends beyond the concepts of scientific disciplines and procedures of scientific investigation. It includes philosophical, historical, and social dimensions of science and technology. Here students develop some understanding and appreciation of science and technology regarding its relationship to their daily lives. More specifically, they begin to make connections within scientific disciplines, and between science, technology, and the larger issues challenging society. (Shwartz, Ben-zvi, & Hofstein, 2006; Holbrook and Rannikmae, 2009).

2. Literature Review

Most previous studies showed fewer level of scientific literacy among individuals, most prominent of which Miller (1970) study that measured scientific literacy level in the united states of America and showed that only 7% of the Americans can be as scientifically literates, as well as his study in (1980), which showed the low level of technical enlightenment of compulsory teaching students and American's Youth (25Years olds) and for these of 65 Years or older (Miller, 1983).

As well as the study conducted by Arizona University at Tucson for a period of 20 Years and showed no improvement in university scientific literacy (Impey, Buxner, Antonellis, Johnson & King, 2011). And Bin-zvi & Hofstein (2006) study that assessed chemical literacy development among senior high school students, using Bybee scientific literacy taxonomy, and found that students improved their nominal and functional scientific literacy.

In addition to the Arab Studies and Saudi Arabia precisely; which indicates a low level of scientific literacy at the teachers and students' teachers in colleges of education (Zoubi, 2008; Shahrani, 2000; salama, 1996). These studies come Unlike Chen (2005) which indicated that first-year students in the teachers colleges in Taiwan have a convincing level of scientific literacy.

Several other studies addressed factors influencing scientific literacy, including Miller (2007) study that found that number of scientific study courses taken by a student, during his study, had a strong influence on scientific literacy level, as well as other variables such as GPA level,

and using electronic resources; however Impey et al. (2011) study found no specific factor affecting scientific literacy, while Al – Khataibeh and Ambo (2002) study has confirmed this result.

The mixed results of previous studies dousing an university, forced us reconsidering teachers preparing Programs in our universities, so as to make able to produce scientifically literate and critical teachers capable of solving science related problems (Bybee, 1995).

3. Research problem

Several research studies showed that prevailing scientific literacy do not work on preparing scientific literate persons (Al – Zoubi, 2008), therefore several scientific education programs, to achieve scientific literacy among students, were developed, including 2061 project introduced by AAAS, projects for National scientific Education standards proposed by National Research council a branch of NESE, movement for science courses Reform in the light of the interaction between science, Technology and society (STS) and Scope sequence coordination (SSC) Project in the united states of America (Ali, 2013).

However, several international studies found that scientific literacy level among teachers, students, and individuals was low in third world countries, (Jenkins, 1994; Prime, 1998; BouJaoude, 1998; Zaytoon, 2010). As teaching and Learning process depends mainly on teachers for the development of scientific literacy, Therefore, the need for preparing teachers capable of accomplishing the spread of scientific literacy and enhancing its levels among students, rose up.

In Light of repeated calls for transmitting scientific literacy among students and the importance of this literacy, and given the paucity of research studies dressing students teachers category, to find the level of their scientific literacy in the Arab society in general and in Saudi Arabia in particular. So this Study aimed to assess the development of scientific literacy among scientific departments students at education colleges during their university study that prepare them for the profession life as pre – service teachers, as well as specifying their scientific literacy levels and their ability to understand and analyze daily life phenomena's observations and situations, as well as factors influencing it. So, the present study sought answering the following research questions.

- Does scientific literacy level among scientific department's students, at college of educations, develop during their study years?
- What is the level of scientific literacy among students of scientific departments at Education College according to Bybee scale?
- What is the effect of demographic variables on the level of scientific literacy among university students?

4. Significance of the study

Significance of the present study stems from the importance of the subject it addressed, which is the assessment of scientific literacy development among scientific departments'

students at Education College. So it is hoped that its results provide, researchers in this subject with valuable information on the level of scientific literacy in developing countries, compared with developed countries- where scientific literacy is one of the most important educational aims- which needs continuous study in light of continuous development and change around that world. And it might constitutes a feedback to those specialists concerned in syllabi development at universities regarding the effectiveness of university Courses in developing scientific literacy to achieve advancement of scientific literacy among students in light of continuous development of scientific education. Finally this research might contribute in directing those responsible of teachers Preservice preparing programs, views, regarding the level of their student's scientific literacy at the end of their preparation period, which might help in the development of current programs and designing programs that go hand by hand with globalization and technological age.

5. Research limitations

- The study was conducted on a single university in the kingdom.
- The study was conducted during 2015 / 2016 academic year.

6. Research concepts

6.1 Scientific literacy

Knowing and understanding scientific concepts and processes needed for personal decision making and participating in civil, cultural and economic productivity affairs (NRC, 1996).

6.2 Bybee scale

A comprehensive theoretical scale which assesses scientific literacy during learners' scientific study in the educational institution that considers ease of knowledge transferee in a hierarchical sequence to educational purposes, as well as classifying scientific literacy of the individual into levels (Bybee, 1997).

7. Methodology and procedures

7.1 Population and Sample

The study population consisted of scientific department students (physics, chemistry and Mathematics) at Najran University (freshmen – final years) totaling for 1106 students, while research sample consisted of (20%) of them, totaling for 216 randomly selected students.

7.2 Methodology and instruments

The study employed descriptive survey method based on studying the phenomenon sits is for a large sample size, to shedding light on scientific Literacy among university students in Saudi Arabia, for this objective, a questionnaire of two parts, one for collecting the following demographic data (Estimated GPA, Respondent age, Children at home, science courses completed, Educational level, Major, interest in science, Technology, or environmental issues, Use of traditional/ electronic informal science-learning resources), The other is cognitive test of yes / No type, multiple choice and one open ended question that focus on a set of scientific

literacy standards, vise a vise, basic scientific structure concepts, understanding science processes and its inquiry nature, and Level of science and technology influence on both individuals and society. However some of its items interfered, with NSF questionnaire indications, which was administered by Miller for many years, and which were consistent with scientific knowledge studied by students at Saudi universalities, where Miller's scale enjoyed with the advantages that most of submitted issues were the focus of 2016 project and revolved around core concepts of the universe formation, and he distributed that questionnaire on paper to the students in their classes and was collected at the same time.

Data were interred into the computer, but coded manually by the researcher, after assuring its content validity by submitting it to a panel of referees from educational experts in science and mathematics and their teaching methods from Najran University as well as Measurement and evaluation experts. Its reliability was assured by administering it on pilot sample of (50) students from the study population but not from the study sample, internal consistency coefficient (α - Cronbach) were computed and were (78).

7.3 Statistical Analysis

Researcher entered data to the computer for a period of four months (one study semester) during 2016, uncompleted and residual data which were excluded from the analysis were 10% of the total questionnaires. Cognitive test in its both parts (Objective and open ended) was scored. After that descriptive analysis of each of the knowledge questions started, variable by variables, summing total scores for each question and total test score for each student, computing Means, standard deviations, One-Way ANOVA, and Sheffee post hot test, to determine scientific literacy level in general and the extent of its development during university study years as well as, correlation and regression coefficients to find demographic variables effect on scientific literacy level from the other hand.

8. Results and Discussion

8.1 Results related to the first research question

Does scientific literacy level among scientific department's students at Education College, develop during their study Years? Means and standard deviation of students' scores for each year, on the test. Table 1. shows results summary.

Table 1. Means and Standard deviations on the cognitive test for each academic year

Academic year	N	Mean	St. Deviation	Percentage	Level
1st year	50	9.06	1.953	60%	Weak
2nd year	68	8.90	1.933	59%	Weak
3rd year	54	8.44	2.416	56%	Weak
4th year	46	9.85	2.076	66%	Acceptable
Total	218	9.02	2.137	60%	Weak

*** Performance acceptable in the study = 65*

The above table shows that mean of correct answers among freshmen students was 1st-year students of 9.06 (60%), for 2nd year was 8.9 (59%), for the 3rd year was 8,44 (56%), And for the 4th year students was 9.85 (66%). which indicates differences between students due to their academic year. To find out if these differences were significant, One-Way ANOVA was performed, and results are displayed in table 2.

Table 2. ANOVA results for scientific literacy difference by academic year

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	50.518	3	16.839	3.832	0.011
Within Groups	940.368	214	4.394		
Total	990.885	217			

** The level of statistical significance (α= 0.05)*

Table 2. shows that the observed difference in scientific literacy level according to study year was statistically significant, suggesting the development of scientific literacy and improvement during university study years. To find which study years were most effective sheffee post hoc test was employed, and table 3. illustrates this.

Table 3. sheffee post hoc test of scientific literacy mean scores by academic year.

Academic year	Mean	1st year	2nd year	3rd year	4th year
1st year	9.06				
2nd year	8.90	0.16			
3rd year	8.44	0.62	0.45		
4th year	9.85	0.79	0.95	1.40*	

** The level of statistical significance (α= 0.05)*

Table (3) shows statistically significant differences between third and fourth students mean scores, favoring fourth year students. Which indicates the improvement of scientific literacy level among fourth year students as compared with other years, and its development through university study year, which means that scientific knowledge taken by students during university study years at scientific departments, increases their scientific knowledge about natural concepts and phenomena and its importance in their daily life and society as well as their ability to make decisions. This might be due to increased specialized academic knowledge among students as well as controlling some psychological factors as anxiety, fear, and increased practical practice in Laboratories. This result is consistent with Chen (2005) and Buxner (2011) studies and non-consistent with Miller (2007) study, which showed low level of scientific literacy among university students.

8.2 Results related to the second research question

What is the level of scientific literacy among students of scientific departments at Education College according to Bybee scale? In answering this question, students responses were classified on the basis of correct answers for seven or more of the (14) of the cognitive questions, and the answer on the fourth but not on the fifth question because these two questions are interrelated in that they both describe the concept and understanding it, as well as, the answer on science operations (processes) (Multiple-choice) and the open – ended question regarding scientific Methodology (correct, incorrect, illogic or None), as shown in Figure (1).

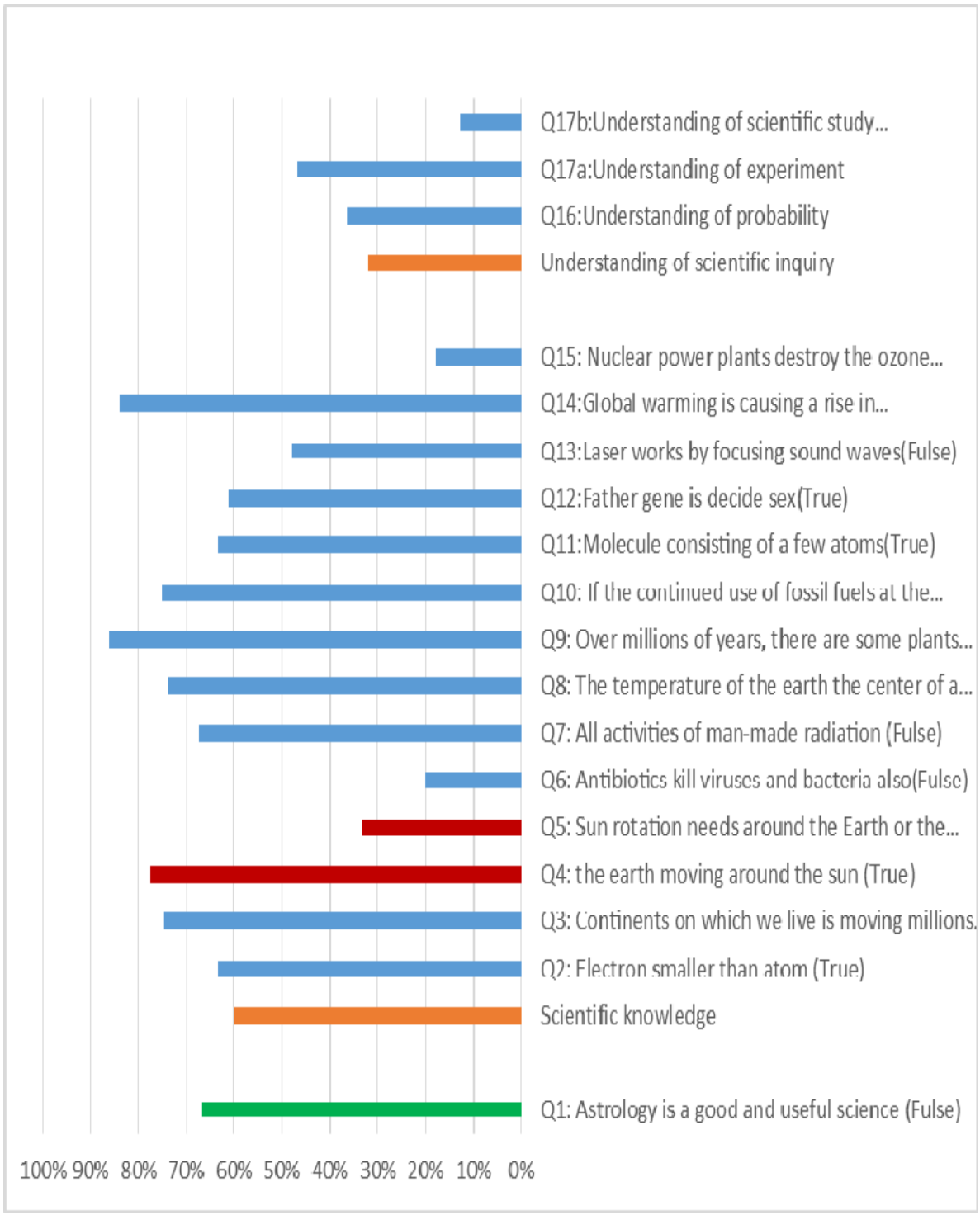

Figure 1. Correct answers and proportions of the students and foundations Category.

Then percentages of correct answers were computed according to this classification to establish theoretical scale to find the dimension or the level on which university students stand for scientific literacy according to Bybee taxonomy, results are displayed in table 4.

Table 4. Levels of scientific literacy according to Bybee scale and their percentages among students

Scientific Literacy Level	Percentage
Scientific illiteracy (SI)	5%
Nominal scientific literacy (NSL)	28%
Functional scientific literacy (FSL)	44%
Conceptual scientific literacy (CSL)	18%
Multidimensional scientific literacy (MDSL)	5%

Table (4) shows that pseudo-science university student's proportion who admitted that "astrology is a useful and beneficiary science" and their level of scientific knowledge below the middle (5%), Bybee has called this group of individuals "Scientific Illiteracy". And students who have a "Nominal Scientific Literacy" proportion (28%), this group realized concepts and their relationship with science, so their scientific knowledge was high however they committed clear concept mistakes (misconception) such as not realizing astrology concept and it is relationship with science. But the percentage of " Functional Scientific Literacy" students was (44%), and this category was able to describe the concept of globe's annual circle correctly, while having limited understanding about it, such as specifying time period of this cycle. Students with "Procedural Scientific Literacy" consisted (18%), and these were able to understand science processes and inquiry through their knowledge of a birth of inherited disease child from four probabilities and through their ability to distinguish the correct experimental design to test the effectiveness of a hypertension cure medicine, as well as their possession of scientific methodology their rationale for choosing comparison based experimental design between groups. And finally the percentage of respondents with "Multi – Dimensional Scientific Literacy was (5%), these respondents were able to understand science's and technology's social, historical, and philosophical dimensions, connecting them with issues challenging society and taking decision regarding them, such as usage of coal fuel, adaption and nuclear energy.

From this, we can conclude that the majority of respondents possessed related functional scientific literacy according to Bybee scale. Students perceive scientific concepts and can distinguish and describe them, however their limited understanding of them, in addition to their poor understanding of science processes and scientific inquiry, as well as lack of interest in science and society issues. This might result from students non interested in deepening scientific knowledge during university study, while focusing on academic achievement more their understanding and explanations accompanied by university teaching that is not interested in relating scientific knowledge with life and society. This result is in line with shoartz, Ben-Zui & Holstein (2006) study.

8.3 Results related to third research question

What is the effect of demographic variables on university students' scientific literacy? Pears on correlation coefficient were used in answering this question, and table 5. displays the results.

Table 5. Pearson correlation coefficient between scientific literacy and Demographics.

Variables	Pearson Correlation	
	Scientific literacy (SL)	Sig.
Educational attainment (estimated GPA)	.055	.417
Respondent age	-.001	.986
Children at home	-.061	.367
science courses completed	.417	.038*
Educational level	.087	.202
Major	.058	.392
Interest in science, technology, medical, or environmental issues	.121	.074
Use of traditional/ electronic informal science-learning resources	.026	.704

* Significant at the level of significance (α = 0.05). N = 218

Table 5. shows that Pearson correlation coefficient significant value was with scientific courses completed, where it was (0.038), suggesting a correlational relationship between scientific courses completed and scientific literacy and this was a weak positive correlational relationship, meaning that scientific literacy increases by the increase of the number of scientific courses taken by the student during his university study. This variable measures the number of scientific courses a student studies during his current university year, and was classified into 4 Levels: (No courses; 1-3 courses; 4-10 courses, More than 10 courses). However other demographic variables have no relationship with scientific literacy. This result is consistent with Miller (2007), Impey et al. (2011). And Al- khatybeh and Ambo (2002) studies.

9. Conclusion

This study aimed at assessing the development at scientific literacy among scientific departments students at college of education in Najran university during their university study years, as well as finding out the level of their scientific literacy and factory's influencing it. The following conclusions were reached:

- Accepted level of students' scientific literacy.
- Low rate at students' scientific literacy during their university study years, where it appeared in the fourth year only.
- Students' gain of scientific literacy over time does not exceed (10%).
- Most students stand on related functional scientific literacy, with few percentage that improved from this level to procedural and multi-dimensional one.
- The students believe that astrology is useful and beneficial powerful and relatively high reached 67%, and nothing to do with the level of knowledge.
- Scientific courses completed by the student in the improvement of the level of scientific literacy affects but poorly.
- In general, there is no specific variable affects the scientific literacy.

10. Recommendations and suggestions

- Improving university courses curriculum in scientific departments at Education College as to focus on functional knowledge side concerning individuals, society, life issues and problem solving.
- Reconsidering teachers preparing program to provide them with appropriate scientific literacy.
- Using suitable teaching strategic that enhances scientific inquiring, experimenting and ability in decision making.
- Adding scientific literacy courses to graduate students.
- Conducting similar studies with larger and more representative samples.

Acknowledgement

The research is financed by the Deanship of the Scientific Research at Najran University No. NU/SHED/14/031.

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