Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.8, No.3, 2017

The Effect of Fermi Questions in the Development of Science Processes Skills in Physics among Jordanian Ninth Graders

Haytham Mousa Barahmeh
Abu Dhabi Education Council

Adwan Mohammad Bani−Hamad
Abu Dhabi Education Council

Dr. Nabeel Mousa Barahmeh
Yarmouk University

Abstract
This study aimed at exploring the effect of Fermi question on the development of science process skills in the physics subject at ninth Grade students.The sample of the study consisted of (2) classes for males and (2) classes for females, which were randomly divided into (2) groups: An experimental group of (41) students divided into a class of (21) males and a class of (20) females. This group was taught through the Fermi question. - A control group of (44) students divided into a class of (23) males and a class of (21) females. This group was taught through the traditional method. –science process skills test was prepared by the researchers according to the purpose of the study. The test was administered before and after the treatment. The results of the study showed that there were statistically significant differences (α=0.05) in science process skills test (In favor of experimental group), and that there were statistically significant differences (α=0.05) due to gender in favor of females.
Keywords: Fermi Question, Science process skills, Physics

Introduction

World, since late 20th century and early 21ist century, witnessed substantial development in various as pacts including the educational process, as a result of knowledge explosion, the need for educational process components to change in it's used tools and methods of instruction, particularly in science which is one of the basic subjects developing students thinking processes.

All teaching methods for science courses instruction, are based on questioning at all levels and types, where this method is one of the most used method in the learning teaching process, given the importance assigned to questions in stimulating student mental abilities and installing that in their brains, as well as probing them. However, no teaching method, but has questioning (Al – Sayfi, 2009; Al – Qutmi, 2004). Furthermore, and to the best of knowledge, main rationales for using questions in teaching and learning process is overcoming (defeating) educational problems with in classrooms, such as bareness, inattention, poor classroom interaction in the service of educational objectives achievement (Al. Fatlawi, 2004: p247; sexton & Gerlouich, 2001).

Fermi questions are based on asking specific questions, in an attempt to get quick logical answers, so Fermi questions do not give students all needed information, but he has to search and make hypothesis, and therefore it gives him the freedom of thinking and search (Romak, 2000) moreover, Fermi questions require group work, communication, and use of estimating as it emphasizes of the way of problem solving, more than the answer.

Fermi question is estimating problem, designed to teach approximations, and importance of specifying one's assumption in a clear way, however these problems holding the name of the physics scientist Enrico Fermi, will imply making guesses rationalized on quantities that appear impossible to calculate in light of limited available information, as well as its emphasis on the way rather than on answer, however it requires more than knowledge, where Fermi was known for his ability to conduct good approximated calculations without real information on with little information (Arab Army forum, 2012).

Maryland university suggested that students using Fermi question, as a learning strategy, should be familiar, and knowledge of basic measurement skills, using addition, subtraction, multiplication and division processes, as well as full knowledge of fractions, decimal, percentages and the need of completing six steps or each question of Fermi, when using this kind of questions, as flows (Stewart, 2013).

- Asking a question and explaining interpretations and wondering.
- Making initial approximations for the question answers not containing calculations.
- Making guesses, based on scientific educational methods, containing a series of reasons and computations based on daily experiences and estimates.
- Identifying variables and constructing arithmetic equations needed to solve Fermi question.

- Excuting scientific experiments, making surveys, conducting measurements and finding information for improving estimate and finding minimum reasonable, and maximum reasonable value along with the most probable value to Fermi question.
- Summarizing all results, potential error sources useful learned facts and potential directions for conducting future investigations.

Example
What is the volume of air you breathe in one day?
Answer:

1. I have to fill one ball one sized 2 liters 10 times of breath.
2. An individual. 10 time / min, so I breath about 2 liters per min, meaning that I breathe (120) liters of air per min.
3. Then I breathe about (2880) liters of air per day (120x24)

So, a teacher who uses Fermi questions in teaching, must consider some things including moving between students, listens to their discussions, watching their works in answering Fermi questions, gives them the needed directions if they need additional support, stopping them after each step of the solution steps, and shares them in their works (Stewart, 2013; Abrams, 2011). Thus, one of the science teacher main duties in the classroom is encouraging thought and investigating spirit in students and the effective way to do that through asking questions in the classroom (kanopka, 2015).

Furthermore, Fermi questions help in developing problem solving skills noticeably among students, as well as they develop and improve estimating skills, however, through student's success and reaching results, they feel self – confidence, regardless of their answer being accepted or not. Move over, what is good in Fermi questions in the methodology followed in reaching a correct answer for these questions, as solution steps are more important than the answer self, and there is no correct answer for these question, in real life, however the range of answers is the most important (Kanapka, 2015; Arleback, 2009).

Additionally, Fermi questions enjoy a lot of fun, which encourages students in finding answers more easily, as well encouraging creativity, communication, cooperation, enhancing self-confidence, acquiring estimating skills, ability to clear determination of imitative assumptions, working with various measurement tools, creating and using laws and formulas for problems processing, and using internet search engines to find information (king, 2014).

Given the gradual transfer of science processes concept to science processes concept to science subjects for the purpose of taking care of students practicing of skills included with these processes, and developing their capabilities is generating knowledge using the skills imbedded in these processes (Zaytoon, 2003) and as a result science becomes inclusive of integration between subjects and method.

Myers and Dyer (2006). Pointed out that science teaching must focus on providing learners with science processes skills, as they are the basis for investigating process, scientific exploration, solving problems faced in their daily life, moreover they are necessary for understanding universal phenomena ground them, as well as they help learners using their knowledge to reach new knowledge's and developing various thinking skills through observing phenomena, collecting data and information on them, organizing and analyzing them to reach logical explanations for these phenomena (Martin, Sexton & Gerlovich, 1997).

Carin and Evans (1980), emphasized that science has three main elements including science outcomes, science methods and processes and its directions, which means that science is not only an information set, but also is a research method and direction in thinking, which requires directing attention, when teaching science by methods or processes through which scientific knowledge is achieved, and this is what national council for the advancement of science in its reports that training in the scientific method ought to be one of the major objectives of science teaching (Addarabee, 1995, p 54).

Most educators pointed out that science processes include eight skills: observation, measurement, classification, using time and space relationships, communication, inferring; predicting, and numbers using (Haidar, 1993, Zayton, 1991; Hamadah, 1993; Abdelfattah, 1999) Moreover, American Association for the Advancement of science (American Association for the Advancement of science, AAAs, 1973) suggested training of learners, during science teaching, on observing, asking questions, and planning (khataibeh, 2005, p 32), which basic for real and long lasting education, as well as the quality of study subject plays a role in identifying the quality of science process skills and their development, and finally science processes gain their importance from practical activities presented in the classroom (Ataallah, 2001).

Given the importance assigned to science subjects in general and physics, in particular, Jordan ministry of education seek to give students science processes through training them on the developing science instruction curricula, in general, and physics, in particular, where the development of science processes and diving them to students in a functional form, became among the most important objectives of science curricula development, as it puts activities that consider the training of students on science processes, in the developed curricula, to help students think logically, and departing from the importance of the role, which science curricula and books should

play in developing science processes skills in students, however, due to paucity of previous studies, as to researchers best knowledge – that addressed Fermi questions and their role in advancing science processes in physics, the current study came to identify the effect of using Fermi questions in the development of physics science processes skills among ninth graders in Jordan.

Significant previous studies:

Researcher could not find any studies that employed Fermi questions as a teaching strategy, so researchers choose studies that addressed questions in general among which, younis (2007) study which aimed at identifying the effect of using probing questions in biology teaching in the development of science processes among fourth female graders, the study was conducted on a sample of (65) female student, assigned to an experimental (32) and control (33) groups. Results showed statistically significant differences between experimental and control groups where experimental out performed controls, as well as differences in the development of science processes skills in favor of experimental taught by probing questions.

Assuaidi (2010), conducted a study aiming at identifying the level to which ninth graders mastered basic science process in science, the study was conducted on a sample of (100) male and female ninth graders, randomly selected from two, one boys and another female (girls) schools in Yemen Results showed no statistically significant differences the mastery level of basic science processes, among students, due to students gender, as well as low mastery level at these basic processes among studied students.

Abdelwahed and Shnief (2014) conducted a study aiming at identifying the effect of using probing questions in developing fourth scientific grade students towards renewable energy. The study was conducted on a sample of (73) fourth grade female students, the students were randomly assigned either in experimental (38) or control group (35) students where the former was taught using probing questions strategy and the later with the traditional teaching method; data were collected by a researchers developed scale measuring attitudes toward renewable energy issues. Results skill statistically significant differences, between groups, on the attitudes towards renewable energy issues scale after the treatment, where experimental out performed controls.

Hasan and Zamel (2012) conducted a study aiming at finding out the effect of using preparation questions on study achievement, among second middle grade, in chemistry. The study was conducted on a sample of (94) students divided to three equivalent group: controls, experiential one and experimental group 2 Results showed the superiority of experimental groups over the controls.

Adedoyin (2010) conducted a study aiming at investigating students understanding and perception of teacher's classroom questions and their effect on their Mathematical achievement. The study was conducted on a sample of (471) secondary school students, of whom (277) boys and (194) girls in Botswana. Results showed no positive statistically significant effect on students learning outcome neither performance nor achievements, due to teacher's classroom questions.

Reviewing the previous studies revealed a paucity of these addressing Fermi questions as a teaching strategy, however some of these studies addressed probing questions including (younis, 2007; Abdelwahed and shneif2014, and Hasan and Azzamel 2012) which addressed preparatory questions, and Adedoyin (2010) study that addressed classroom questions previous studies differed also in the study instrument used to collect data, where some used tests like (younis, 2007; Hasan and Azzamel, 2012, and Assweidi, 2010) studies, while others used attitudes scale as(Abdelwahed and Shneif 2014) study, still others used questionnaire as Adedoding (2010) study.

This study is consistent with previous studies in that it addressed science processes skills (younis, 2007; Assweidi, 2010), and inconsistent with others in that it uses Fermi questions as instructional strategy, and the subject it addressed, and the nature of the test prepared by the researchers.

Research objectives

This study aimed at identifying the effect of using Fermi questions in developing science proses skills in physics among Jordanian ninth graders, which is – at the best of researcher's knowledge – the first at the Arab world level, which addressed Fermi questions as a teaching strategy.

Significance of the study

The present study significance stems out of the importance of the role that Fermi questions might play in physics teaching and learning as well as in finding answers and solutions, to problem, in an easy and joyful manner, moreover, what added to the current study significance that it came, as an empirical application consistent with general framework and learning general and specific outcomes of physics education in Jordan that calls for the need for using new methods and Strategies that help students developing thinking skills, facilitating understanding, perception and problem solving (Jordan Ministry of Education, 2005). However, the study significance can be specified as follows:

Theoretical significance

1. It is the first at the Arab world level as to researcher's knowledge in addressing Fermi questions in teaching and learning physics for ninth graders.
2. It presents model to be followed by science teacher, in general, in how to use Fermi questions in teaching.

Empirical significance

1. Physics teacher's educators might benefit from the present study results by focusing on training pre-service teachers on using Fermi questions in their teaching.
2. The increase of physics supervisor's interest in implying new methods and strategies in the classroom during their supervisory visits.

Research problem and questions

The problem of this study can be specified by its attempt to answer the following main questions what is the effect of using Fermi questions in the development of science processes skills in physics among Jordanian ninth graders? Of which the following questions can be derived:

1. Are there statistically significant differences at ($\alpha = 0.05$) level in the development of science processes skills in physics, among ninth graders, due to the method of teaching?
2. Are there statistically significant differences at ($\alpha = 0.05$) level in the development of science processes skill in physics among ninth graders, due to their gender?

Terminology of Study

- **Fermi questions**: Are questions related to the chosen and developed units, made with very specific information, and require students to make operation (processes) like asking multiple questions, reasonable assumptions, numerical estimations, and conducting computations to reach the answer.
- **Science processes**: defined by assayed (2002: p. 100) as mental processes used in early education stages, which facilitate there acquisition and learning and included eight processes: observation, classification, measurement, communication, reasoning, predicting, using time and space relationships and using numbers. However, researchers defined them as mental processes that help students understanding scientific material in a simplified manner and represent the basis for learning other more complicated skills and included the following processes (Measurement, prediction and using numbers) in the current study.
- **Traditional method**: definition of this construct varied widely, Barahmeh and Barahmeh (2013, p. 8) for example, defined it as a set of procedures, through which, educational material is presented as its sequence in the school textbook with no addition or deduction, which Al-Yazeedy (2006: p.22) defined it as the set of activities and exercises that are preplanned and that incorporates presentation and discussion, and through which instrument and teaching materials along with the textbook are used, with the teacher being efficiency source during the educational process. However, researchers defined it as the teaching methods in which the teacher depends on traditional techniques in presenting educational material as it is in the book, without depending on other sources, and where students are passive recipients of information only.
- **Physics subject**: is the assigned physics textbook for ninth graders for school year 2015-2016.
- **Ninth grade**: one of the upper basic stage in the Jordanian educational ladder.

Limitations

Results of the current study can be limited by the following:

- Human limit: ninth graders in Jordan.
- Time limit: 2015- 2016 school year.
- Space limit: public school at Al-korah district, Jordan.
- Limiting the educational material on the nature of science unity of study from ninth grade's physics textbook for the school year 2015- 2016.

Procedures

In conducting this study, researcher followed the following procedures:

- Choosing the study unit.
- Preparing the science processes skills test and stabling its validity and reliability.
- Specifying study population and drawing its sample.

Study population

The study population consisted of all ninth graders at Al-korah Directorate of Education for the school Year 2015- 2016.

Study sample

The study sample included four schools (2 for boys and two for girls) that included ninth grades, for the school year 2015- 2016, where these schools were intentionally chosen due to the full readiness of their administrations to cooperate with researchers and the physics teacher in these schools, desire for cooperation and application of this study. The sample contained (85) students divided in four sections, two for boys and two for girls, where boys sections included (44) and girls sections included (41) students sample distribution according to type of the group number of students, sections and gender.

Table (1) Sample distribution by group, number of students sections and gender

Group	Gender	Number of students	Number of sections
Experimental	Males	21	1
	Females	20	1
	Total	41	2
Control	Males	23	1
	Females	21	1
	Total	44	2
Total	Males	44	2
	Females	41	2
	Total	85	4

- Visit the schools sample to explain the study purpose to school principal and physics teacher.
- Administering pre science processes skills test on both experimental and control groups to assure groups equivalence, and two-way ANOVA (2×2) procedures was conducted to identify statistical significance of difference, and table (2) displayed the results.

Table (2) Results of two-way ANOVA for difference on pre science processes skills test, between groups

Source of variance	Sum squares	DF	Mean Squares	F	Sig
Group	2.453	1	2.453	0.653	0.421
Gender	0.048	1	0.048	0.013	0.911
Group X Gender	0.317	1	0.317	0.084	0.772
Error	315.740	84	3.759		
Total	318.500	87			

Table (2) shows no statistically significant differences at (α= 0.05) level due to group (method) and gender where F value was (0.084) and p= 0.772, indicating the equivalence between groups.

- Teaching experimental group using Fermi questions strategy, while controls were taught using the traditional method, where two teachers applied Fermi questions with experimental groups, while two other teachers taught the other control groups the same teaching unit using the traditional method, teaching for both experimental and controls to 6 lessons 45 minutes each.
- Administering post science processes skills test after the unit teaching immediately

Study variables:

- **Independent variables:**
  - Teaching method (Fermi questions vs traditional method).
  - Gender male, female.
- Dependent variable science processes skills in physics.
- **Statistical treatment.**

  Means, standard deviation and 2-way ANOVA were used in the current study.

Instrumentation

First: Fermi question – based educational material and is prepared as followed:

1. Educational material selection the educational material was unit one (nature of science) from ninth basic grade physics book for the 2015- 2016 school year, this unit contains six lesson: physics science and areas, scientific measurement, mathematics the language of physics, universal system of units, applications on using measurement tools, calculating intensity for metal and oil.
2. The study unit was constructed based on Fermi question, after that, it was presented to a panel of referees, three of whom specialized in science teaching methods, and other three specialized in physics, and their comments were taken into consideration and needed adaptations were made, so the teaching

unit became in its final form.

Second: science processes skills exam (test)

Researchers constructed this test to measure the effect of using Fermi questions in the development of science processes skills in physics among ninth graders, the test included (21) multiple choice question divided as follows:

- 7 questions measuring measurement skill, 7 questions measuring prediction skill, and 7 measuring numbers using, however correct answer takes one point while zero point are given to incorrect one, so the sum score of the test is (21) points.

To establish test validity, it was presented to a panel of professors and referees, 4 of whom specialized in science teaching methods, two specialists in measurement and evaluation, and 3 science education supervisors, and three science teachers, teaching physics for ninth grade, and were asked to give their opinions regarding questions phrasing and suitability for this grade level and that it measures science processes skills for which it was designed. Their suggestions, however concentrated around rephrasing some questions and replacing some answers with others. All their suggestion were taken into consideration.

Test reliability

To assure test reliability, it was administered on a pilot sample of (20) students from outside the study sample, and K R (20) formula was applied, correlation coefficient was (0.81) and is deemed appropriate for the purposes of the current study. So, the test now is ready to administer in its final version.

Results

In answering the research question, means, and standard deviations of experimental and control groups scores on science process skills test were computed and table (3) displays them, however for identifying significance of differences between means, 2-way ANOVA was used and results are displayed in table (4).

Table (3)Means and standard deviations of the study sample performance on science processes test in physics by group and gender.

Skill	Gender	Fermi(exp.)			Traditional (control)			Total		
		M	SD	N	M	SD	N	M	SD	N
Measurement post – test	Male	6.00	1.142	24	5.05	1.431	21	5.56	1.358	45
	Female	6.57	0.978	21	5.68	1.555	22	6.12	1.366	43
	Total	6.27	1.095	45	5.37	1.512	43	5.83	1.383	88
Using Numbers Post	Male	5.50	1.351	24	3.57	1.326	21	4.60	1.643	45
	Female	5.90	1.179	21	4.55	1.654	22	5.21	1.582	43
	Total	5.69	1.276	45	4.07	1.564	43	4.90	1.633	88
Prediction Post	Male	5.33	1.810	24	3.52	1.209	21	4.49	1.792	45
	Female	5.90	0.988	21	4.32	1.673	22	5.09	1.571	43
	Total	5.60	1.483	45	3.93	1.502	43	4.78	1.705	88
Both groups	Male	16.83	2.792	24	12.14	2.220	21	14.64	3.452	45
	Female	18.38	1.627	21	14.55	3.405	22	16.42	3.289	43
	Total	17.56	2.427	45	13.37	3.102	43	15.51	3.471	88

Table (4) Two-way ANOVA for means differences significance by method, gender and their interaction

Teaching method	Sum Squares	Df	Mean Squares	F	Sig
Group	398.621	1	398.621	58.303	.000
Gender	85.568	1	85.568	12.515	.001
Method x Gender	4.009	1	4.009	.586	.446
Error	574.312	84	6.837		
Total	1047.989	87			

First: Results related to the first question answers are there statistically significant differences at (α=0.05) level in ninth graders achievement, in physics, due to teaching method?

Table (4) shows apparent differences in student's achievement scores on physics science processes skill test where experimental group mean score was (17.56) and sd = (2.427); However, table (5) showed that these significant differences at (α=0.05) level were in favor of experimental, meaning that these differences are due to teaching method.

Second: Results related to the second research question stating "are there statistically significant differences at (α=0.05) level in student's achievement scores on physics science processes skill test due to their gender?

Table (4) showed apparent difference in student's achievement scores, due to student gender, where males means score was (16.83) with SD= (2.792), while that for females was (18.38) with SD = (1.672).

However, when testing these differences statistically, it was found that they were in favor of girls, meaning the existence of significant differences due to student gender.

Discussion:

Discussion of results related to the first questions results related to this question showed superiority of experimental group, tough using Fermi questions over the control group taught by the traditional method in test scores achievement, where statistically significant differences at (α=0.05) level between groups, and these differences were in favor of experimental group, and these results can be attributed to several factors including:

- Students don't feel boring, and increased interactions between students through group work.
- Students though were directed toward higher thinking levels, where teacher had to use various strategies in teaching, such as Fermi question, which was efficiently employed in this strategy.
- Giving students opportunity in thinking freedom, and emphasis on the way of solution rather than the end result.
- Fermi questions help creating multi solutions for the given problem.
- Novelty of this method in teaching and ability to apply outside classroom, where students feel free.
- Fermi question contributed to provide students with higher order thinking skills and the ability to use them. This result is consistent with result of each of younis (2007), abdelwahed and Shneif (2014) and Hasan and Azzamel (2012) studies which showed superiority of experimental group taught by probing questions – preparation- over the control in achievement. However, this result was inconsistent with Adedoyin (2010) study, which showed that teacher class room questions have not a positive effect on student's Test.

- **Second**: Discussion of results related to the second research question.

Results of this question showed statistically significant differences, at (α=0.05) level, due to student gender and in favor of female students, this result (finding) can be attributed to several factors.

- Female are more disciplined than males, through good listening to and follow instructions, more accurately as well as attention, homework completion, and better organization than boys.
- Females are more accurate in goals achievement work organization, in addition to female spending more time in studying, and doing school duties, rather than males who spent most of their time in sports playing, which was supported by Gnaulati (2014) study.
- Females are more inclined to understand while learning to prove their self steem and actualization, more than males do (Zolfagharifard, 2014).

Recommendations and Suggestions:

Recommendations:

In light of the above results, researchers recommend the following.

- Inviting Jordan ministry of education, curricula section in particular, to employ Fermi questions in science textbooks.
- Training science teachers in general, and physics in particular on how to use Fermi questions and employ them in the teaching learning process.

Suggestions:

- Conducting more studies on the effect of using Fermi questions in science education in other grades and stages.
- Conducting other studies with different dependent variable.

References

- Abdel Aziz, Said. (2009). Teaching thinking and Skills. Dar Athaquafah Publishers, 1st, 2nd ed. Jordan, Amman.
- Al-fatlawi, Soheilah. (2004). Teaching individuation in preparing and qualifying teacher: A Model in Educational Measurement and evaluation, Dar Ashoroug Publishers. Amman.
- Abdel wahed, Ala'a, and Shneif, Mazen. (2014). The effect of using probing questions the development of fourth scientific student's attitudes towards renew able energy issues, Al-koufa study center Journal, vol. 32 (1).
- Abdel Fattah, Huda (1999). An Analytical Study of Scientific Activities and Questions encluded in the Second Prepatory grade Science textbook in light of Science Processes, Egyptian Society for Practical education, Third Scientific Meeting on Science Curricula for the 2 1st. Century, future vision, volume (1), Ainshams University, Egypt.
- Abrams, Lloyd. (2011). Fermi Questions a Guide for Teachers, Students, and Event Supervisors, Fermi Questions Guide https://www.soinc.org/sites/default/files/FermiQuestionsHandout.doc
- Addarabei, Samiha. (1995). Development of the ability to apply science processes among basic stage

students in a sample of Jordanian students, unpublished master's thesis, Jordan University, Jordan.
- Adedoyin. Omobla (2010) An infestation of the effects of teachers, Classroom Question on the Achievements of students in school. European Journal of Educational Studies 2(3).
- Alyazidy Alia. (2006). The Effectiveness of a Program to Computerized Teaching to Teach Arabic Language to fourth basic graders in the sultanate of Oman in the development of some creative thinking skills unpublished master's thesis, Al Yarmouk University, Irbid, Jordan.
- American Association for the Advancement of Science, (1973), Guide for Instruction: Science Process Approach. New York.
- Arabic Military Forum. (2012). Types of nuclear pombs, on www. Arabic – Military. Com.
- Ärlebäck, Jonas Bergman (2009) on the use of Realistic Fermi problems for introducing mathematical modeling in school TMME, vol6, no.3, p .331
- Assaify, Atef. (2009). The teacher and Modern Learning Strategies, Dar Arresalah, Amman, Jordan.
- Assueidi, Berlenti. (2010). The degree to Which ninth graders master basic science processes in science education, Damascus University Journal, vol. 26, pp. 209- 234.
- Assayed, Ahmad Jaber. (2000). Using distanced thinking questions in history teaching to Show their Effect on Achievement and development of Creative thinking among first secondary graders, Studies in Curricula and Teaching, Egyptian Society for Curricula and teaching methods, No. 67, pp. 5- 25.
- Assayed, Mohammed. (2002). Scientific education and Science teaching, Dar Alfiker Al-Arabiya, Cairo.
- Attaallah, Misheel. (2001). Science teaching methods, Dar Al-Maseerah Publishers, 1st ed. Amman Jordan.
- Ayasreh, Mustafa. (2003). The effect of using computerized educational software in ninth graders achievement in Islamic education, unpublished Master thesis, Yarmouk University, Irbid, Jordan.
- Barahmeh, Nabeel and Barahmeh, Haytham. (2013). The Effect of Computer Assisted Learning in the Achievement of First Basic Graders in Social Studies Education in Jourdan, Al-Najah University Research Journal, Vol. 27 (8).
- Carin, S.A & Evans, J.M (1980), Sciencing Central Michigan UN 2ed
-Gnaulati , Enrico. (2014). Why Girls Tend to Get Better Grades Than Boys Do
- Haidar, Abdellatif. (1993). Science teaching in light of Contemporary Educational Trends, 1st ed. Taez, Al-hadi house publishers.
- Hasan, Falah and Zamel, Adel. (2012). The Effect of Using preparation questions and Feedback strategies in the achievement of Second Middle grade students in chemistry, Al-Ostathe Journal, No. 201.
- Kanopka, Klint(2015)Solving Big Problems: Using Estimation to Develop Scientific Number Sense, Yale National Initiative, Yale University, to strengthen teaching in public school http://teachers.yale.edu/curriculum/viewer/initiative
- Khataibeh, Abdullah. (2005). Teaching science for all. Amman. Dar Almasera publishers.
- King, Alessandra. (2014). Fermi Questions – A STEM Activity for Middle School, Journal of the Association of Independent Maryland & DC Schools.V2.
- King, Alessandra (2015). Making Sense with Fermi Problems
- www.nctm.org/Publications/Mathematics-Teaching-in-Middle-School
- Martin, R. &Sexton. & Gerlovich, J.(1997).Teaching Science for All Children. Boston: Allyn and Bacon
- Martin, R., Sexton, C. & Gerlouich, J (2001) Teaching science for all children (3rdedition) Massachusetts, USA: Allyn and Bacon
- Morrison, Philip (1963) Letters to the Editor, Am. J. Phys., August 1963, v31n8 p626-627
- Myers, B. & Dyer, J. (2006). Effects of Investigative Laboratory Instruction On Content Knowledge and Science Process Skill Achievement Across Learning Styles. Journal of Agricultural Education .47 (4), - 5263
- Peter, Andrea (2009) Teaching and Understanding Mathematical Modelling through Fermi-Problems
- Al-Quitamy, Yousef. (2004). Class room Management Dar Al-fiker, Amman.
- Romack, Barbara (2000) Fermi Problems - From Pianos to m&m'http://ed.fnal.gov/trc_new/sciencelines_online/fall99/activity_insert.html
- Said, Habib. (1999). The Effect of Using Odds Strategy on the Development of Scientific Thinking and some Science Processes among 5th Graders the Science material Egyptian Society of practical education the third Scientific meeting, Science Curricula for the 2st Century, future vision, volume 1, Ain Shams University.
- Salameh, Hasan Ali. (2005). Hybrid Teaching and Natural Development of electronic Learning, a paper Presented at south valley university, Faculty of Education, Sohaj.

- Shamsan, Abdel Kareem. (1999). The Extent to which Science Teachers at Secondary Schools in Taez and Aden cities, master Science Processes, Unpublished Master's thesis, Faculty of Education, Aden University, Yemen.
- Stewart, Lori (2013). Fermi Questions Activity http://www.education.com/activity/article/Fermi_middle
- Tan, Z. (2007). Questions in Chinese University EL Classrooms: What lies beyond it? RELC, 38 (1), 87-103.
- University of Maryland (2002) A Collection of Estimation Problems. http://www.physics.umd.edu/perg/fermi/fermi.htm
- Younis, Wafa. (2007). The Effect of Using the questioning by probing questions in biology on the development of science processes skills among general fourth grade girl's students, Journal of Science and Education, Val (14), No. (2).
- Zaytoon, Ayesh. (1991). Science nature and Applications in Practical Education, Faculty of Education, Jordan University, Dar Ammar.
- Zaytoon, Ayesh. (1999). Science teaching methods, Ashoroug house, Amman, Jordan.
- Zaytoon, Kamal (2003). Instruction: Models and Skills. Alam Alkotoob, Cairo.
- Zolfagharifard, Ellie. (2014). Boys perform worse than girls in EVERY school subject - and they have for at least 100 years, claims study
- http://www.dailymail.co.uk/sciencetech/article-2616906/Boys-perform-worse-girls-EVERY-school-subject-100-years-claims-study.html