Chain Reaction Develops Jordanian Student Inquiry Skills as Perceived by Participating Teachers

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Abstract

The study aims to explore the perceptions of participating science teachers at Jordanian schools regarding the impact of chain reaction project on their students acquisition of inquiry skills gained from their engagement at the project compared with those who didn't take part in it. The population consisted of all participating science teacher (male and female) who were adopted the Chain Reaction Project material based on inquiry science education at Jordanian schools, with a total Numbers of (30) teachers (15 females and 15 males) during a three-year period of the project. The sample consisted of 25 science teachers (10 males, 15 females).

A five scale Likert type of questionnaire was developed by the researchers for the purpose of the study. It consisted of 24 items which tackle the perceptions of participating science teacher about the impact of the project on their students' inquiry skills. The validity and reliability of the questionnaire were insured.

The study results showed that the teachers rate the degree of inquiry skills for the participating students was higher than those who did not participate at the project. The analysis of the data showed that there who significant differences on the students acquisition of inquiry skills as perceived by science teachers in favor of those who participated at the inquiry Based Science Education (IBSE) and on the teachers genders in favor of female for the non participating students only.

Key Words: science inquiry skills, chain reaction project, inquiry learning, Jordanian schools

Introduction and theoretical framework

Teaching of science gives students the an opportunity to be equipped with scientific knowledge, skills and information which needed for the daily life. But it has been noticed the students interest in both science and math decrease which affect the students enrolment in scientific related jobs . However, there is evidence that the way in which science is taught is a key issue in the students understanding of science and drives their attitudes and interests in science (Gibson. & Chase, 2002). This promote science educators to develop the teaching and learning methods to meet the new generation needs. Inquiry Based Science Education (IBSE) is one of these methods which is supposed to develop students inquiry skills.

There are many theories behind the inquiry based curriculum and teaching techniques such as, "constructivism", "Blooms taxonomy of learning", "multiple intelligences", "whole-language" and "accelerated learning". In simple terms it is a learning process or strategy rather than any specific set of lessons. The IBSE aims to enhance learning based on (1) increased student involvement, (2) multiple ways of knowing and (3) sequential phases of cognition (Hall and McCurdy, 1990). By using student derived investigations knowledge is more relevant and meaningful. This leads to active construction of meaningful knowledge, rather than passive acquisition of facts transmitted from a lecturer. Next, by engaging students' multiple intelligences more types of students are successful contributors and students are engaged on more than one level. In addition, this process mirrors the stages of Blooms learning phases, which leads to more complete cognition by building on previously learned knowledge.

Lastly, the student to student collaboration reinforces assimilation of knowledge, while the teacher to student collaboration builds trust for future discovery. Also known as project based curriculum, it typically adheres to the following guidelines (Hubbard, 2001):

- Start with an open-ended question or demonstration (as opposed to beginning a lesson with definitions and explanations).
- Gather responses and subsequent questions from students with little comment or direction.
- Require students to collaborate on designing experiments or methods of inquiry.
- Student teams conduct experiments or gather data.
- If time allows, re-evaluate question based on new data and re-experiment or collect new data based on revised question.
- Students present findings as an oral presentation, a poster presentation or an evaluative write-up.

So, inquiry learning involves developing questions, making observations, doing research to find out what information is already recorded, developing methods for experiments, developing instruments for data collection, collecting, analyzing, and interpreting data, outlining possible explanations and creating predictions for future study (Bell, Urhahne, Schanze and Ploetzner, 2010). IBSE concentrates on " how we know, while traditional science education focuses on what we know" aspect of science, (Harlow, 2010).

IBSE is well documented, with studies highlighting the popularity and effectiveness of classroom science that encourages 'hands on' activity and discovery. These studies also recognize that classroom science should be relevant to the day to day life of students and have a real and tangible context. The inquiry based approach to science teaching is supposed to be inductive rather than deductive, which requires students to identify and pose questions, design and carry out investigations and experiments, and communicate their findings with others (Murphy & Beggs, 2003; Osborne *et al*., 2003; Jenkins & Nelson, 2005; Osborne *et al.*, 2008) IBSE allows students to experience science in a way that is grounded in reality and within a context that they can understand and are able to relate to, which is more effective in establishing and maintaining interest. The are an effects of discovery learning on students' success and inquiry learning skills (Balım, 2006)

IBSE linked to the way in which professional scientists and researchers carry out their work, and aim to develop motivation and interest in science. In addition, problem solving and inquiry based approaches have proven successful across mixed abilities as they encourage a range of skills development and not just learning theoretical concepts. The approach has also been reported as encouraging participation of students from different Backgrounds (Dokme and Aydinli, 2009) .
In order to maximise the benefits of an inquiry based approach, an active method of teaching and learning should be encouraged for this to happen. Moreover, science teachers need to be provided with appropriate training and support in inquiry based teaching approaches, to develop an inquiry skills (IS). Martin (2010) pointed out that there is relation between teacher preparedness and inquiry- based instructional practices to students' science achievement.

Inquiry skills are important for the continuity of the learning process, where learners can build a deep understanding of the scientific concept or phenomenon, expand their knowledge in them and provide scientific justifications and explanations with (Dokme& Aydinli, 2009). By practicing IS, students encourage to ask questions to explore the scientific phenomena and expand and deep their understanding of it and practicing scientific research by collecting data and analysing them to come to answers supported by evidence.

Chain reaction project:

It is a sustainable approach to inquiry based science education project aims to use a proven and established resource and approach - Pupil Research Briefs (PRBs) - which were created and utilised in the successful Pupil Researcher Initiative (PRI) project) - to implement problem solving and inquiry based learning across 12 partner countries. The aim is to introduce materials and approaches at the European level, while allowing each country to adapt the materials as appropriate. Initial training in problem solving and IBSE was given to teacher training specialists from each country along with the PRBs. The PRBs adapted in each country to fit with the cultural and curricular needs of pupils, and introduced to five schools every year of the project within each country. Each partner country developed a set of resources suitable to their own situation, context and needs, but based around the proven principles of problem solving and inquiry based learning in science and based on materials that have already been tried and tested as part of the original project.

Over the three year project each partner directly trained 30 science teachers from fifteen schools (five schools per year; 10 teachers per year). These teachers will then be required to disseminate their training to colleagues through peer-to-peer knowledge sharing. It is anticipated that this indirect training will reach 1200 teachers over the 3 year life of the project (based on an average of 8 teachers per school receiving this training). Trainers will use existing networks of teachers to establish groups of teachers. A major part of the proposed project is the establishment of a European teacher's network, in order to offer teachers a collaborative forum through which to develop the pedagogy further, share ideas, link theory to practice through engagement with educational researchers and disseminate knowledge. Studies have found that the lack of such a network to support teachers new to this methodology may lead to difficulties with effective implementation, as teachers can lack confidence and appropriate knowledge (Eick & Reed 2002, Harlow 2009). The project aims to achieve the following objectives:

- Adapt and disseminate a set of themed inquiry based science Pupil Research Briefs (PRBs) which have been adapted to meet each partner's cultural and curricular needs, to be used for briefing teachers and in the classroom
- Promote the use of IBSE in secondary schools across the 12 partners via a programme of teacher development which will engage young people in science through student-led inquiry based research
- Help bridge the existing gap between science teachers and the science education community
- Promote a European teacher network
- Dissemination of resources Earth and Universe Pupil Research Briefs (EUPRBs)and effective practice
- Effective evaluation and reporting
- To hold 36 national and three international celebration events for teachers and students.

The project Implementation :

First, the Technical Boards (TB) received an introduction to IBSE, student led creativity in science and the EUPRBs at the kick off meeting held in, Sheffield Hallam University (partner number 1) at the beginning of the project period .Then On a national level within each separate member state The school management will be introduced to the value of IBSE and the EUPRBs by the national level Technical Board

So then IBSE, EUPRB and creativity is Briefed to the teachers by the Technical Board (TB) in several teachers meetings .(Each year there is 4-5 EURPBs) Then they delivered the Using of critical thinking, reasoning and problem solving skills, to students in the 14-16 age groups that work together to research scientific scenarios. Their work is summarized in presentations that is shared at a national student Conference event each year. These annual national Conferences take place in each partner country and called "Express yourself conferences " to celebrate science and the work completed by the students.

The student presentations encourage students to detail the inquiry processes they engaged in and share findings whilst being creative and imaginative through their presentations.

The national events also engages practicing scientists (early year science professionals or PhD students) who acts as role models for the students and share their work to inform and encourage young people to consider a career in science related fields.

Role Models are recruited from local industry and research institutions and Universities to share there scientific experience with the students . National conferences are followed by an international conference each year where a number of students from each national conference are selected to attend. The Chain Reaction

Project is cyclical so each year the project will recruit new teachers from different schools, ensuring a large number of teachers and students are able to participate. The project provides a strong and sustainable IBSE framework both for teacher educators and for teachers, along with resources tailored to each partner's individual cultural and curricular needs. Teachers are able to build their knowledge and skills, learning independently as well as being part of a wider teacher network.

Over the three-year project each partner directly brief 30 science teachers from fifteen schools (10 teachers from five schools per year). These teachers will then be required to disseminate this to colleagues through peer-to-peer knowledge sharing. It is anticipated that this dissemination will reach 1,440 teachers over the three-year life of the project (based on an average of eight teachers per school receiving this briefing). Chain Reaction will reach a minimum of 10,800 students over the period of the project.

The statement of the problem

It has been observed that educators draw criticism in large to the methods of teaching in general and teaching science specially. As mentioned above, A number of expert reports and academic papers, have highlighted the need for a change in pedagogy in relation to the teaching of science. Alongside this recognition has been acknowledgement of the effectiveness of problem solving and inquiry based learning in science education (OECD, 2006). Additionally, studies have highlighted pupils' views that classroom science should involve approaches which encourage 'hands on' activity and discovery through inquiry, rather than a curriculum that follows a rigid prescriptive format (Osborne & Collins 2000, Sjoberg 2004, Bevins *et al.,* 2008; Osborne & Collins 2000, Bevins *et al.,* 2006). This approach differs from the "traditional" methods of science teaching in that it is inductive rather than deductive, and is student centred, requiring pupils to identify and pose questions, design and carry out investigations and experiments and communicate their findings (Keys & Bryan 2001, Eick & Reed 2002, Windschitl 2003, Linn *et al.,* 2004).

By using problem solving and inquiry based learning, the need to understand abstract ideas and concepts while memorizing information in a deductive framework is eliminated. Instead, this approach allows children to experience science in a way that is grounded in reality and within a context that they can understand and are able to relate to, which is more effective in establishing and maintaining interest.

Chain reaction project is European Union sustainable approach to inquiry based science education aims to use a proven and established resource and approach through twelve partner countries over a three-year period starts from June 2013 and ends in June 2016. Jordan participated at this project alongside with eleven countries form EU, under the umbrella of Jordan Society for Scientific Research (JSSR). The researchers are the Jordanian Project team, who organized, direct and trained science teachers to implement the project. They conduct this study to find out if the students who take part at the project have gained inquiry skills compared with their collages who do not participated at the chain reaction project as perceived by participating teachers.

The study question

The study aims to answer the following questions:

1. What is the rating level of inquiry skills acquisition by student for participating and non- participating as perceived by science teachers?
2. Are there any statistical differences between the teachers perceptions of inquiry skills gained by their students between those who participated at the Chain reaction project and those who do not participated at the project?
3. Are there any statistical differences between the teachers perceptions of inquiry skills gained by their students between those who participated at the Chain reaction project and those who have not participated at the project attributed to teachers' gender (male, female).

Significance of the study:

Chain reaction project partners need to conduct several studies that highlight on progress, issues or problems that may have arisen, and how objectives and milestones are being met. These reports will support the ongoing development of clear understanding of project implementation and impact. Since inquiry skills are very important to be developed by students during their study life and the concentrated in all aspect of inquiry based science teaching, The researchers conduct this study to find out if the students who take part at the project have gained inquiry skills compared with their collages who do not participate at the chain reaction project as perceived by participating teachers. To the best of the researchers knowledge, it is the first study that investigated the effect of chain reaction project on the acquisition of inquiry skill by student.

The results of the study may also encourage other science teachers to use inquiry based science teaching in Jordan to build their students' inquiry skills. It may also encourage the decision-makers at the Ministry of Education, educational stakeholders and curriculum developers to develop and imply inquiry skills in the teaching and learning materials. It may also open the platform for further research in other aspect of the project such as students' achievement, interests and attitudes towards sciences.

Limitations:

The study results are limited to the to the perceptions participating science teacher who are adopted the chain reaction project material based on inquiry science education at Jordanian schools; during a three-year period of the project; starting from June 2013 and ending in June 2016.

The definitions:

- Inquiry: It is the way that students learn when they are left alone by asking questions, observe and collect information, classifying, measuring and experimenting and transferring their thoughts to each other in the light of their mental level their interests.
- Inquiry skills: They are mental process carried out by the learner through which to organize his information and previous experience gained in order to reach new knowledge through offering an appropriate environment to be engaged in an investigation to build their skills that the chain reaction project seeks to be gained by participating teachers.
- Participating teachers: The teachers who were selected by the Jordanian project team to present and organize the teaching and learning activities using Pupil Research Briefs (PRBs). These PRBs were created and utilized in the successful Pupil Researcher Initiative (PRI) project; which were translated to Arabic Language by the Jordanian TB.
- Chain reaction project: A sustainable approach to inquiry based science education aims to use a proven and established resource and approach through twelve partner countries over a three-year period starts from June 2013 and Ends in June 2016 supported and funded by the European Union. All those countries from Europe except Jordan.

Procedures and methodology

This is a descriptive study based on survey the perceptions of participating science teacher who were adopted the chain reaction project material based on inquiry science education at Jordanian schools; during a three-year period of the project; starts from June 2013 and ends in June 2016.

Population and Sampling: The study population consisted of all participating science teacher (male and female) who were adopted the Chain Reaction Project material based on inquiry science education at Jordanian schools, with a total Numbers of (30) teachers (15 females and 15 males) during a three-year period of the project; starts from June 2013 and ends in June 2016. The sample of the study consisted of 25 science teachers (10 males, 15 females) who were responded on the questionnaire sent to them. Five teachers do not response on the study tool despite the demand of them more than once.

Instrumentation: A five scale (options) Likert type of questionnaire was developed by the researchers to tackles the perceptions of participating science teacher who were adopted the chain reaction project material based on inquiry science education at Jordanian schools and asking the about the impact of the project on the acquisition of inquiry skills they gained from their engagement at the project. The questionnaire consisted of two parts: bibliographical information includes teachers' name, school, and gender. While the other part includes 24 items of the teachers' perception.. Each item of the questionnaire followed by five options with values ranked from 5 to 1, as fellow (Always given 5, usually, 4; sometimes, 3; rarely, 2 and never, 1).

The validity of the questionnaire was insured by giving it to a jury of experts in the field of science education to check its appropriateness to the purpose of the study. Their remarks and notes were taken into consideration. The final draft attached below (Appendix 1) The reliability of the questionnaire was counted by utilizing suitable statistics, Coronbach's Alpha, equal (0.95) which was consider statically reliable.

Results and discussion

First question: what is the rating level of inquiry skills acquisition by student for participating and non-participating as perceived by science teachers?

To answer this question; a descriptive statistic was used. A mean score and standard deviation are calculated according to the total degree of the study scale. Table 1 summaries that.

Table 1: mean scores and standard deviation of the teacher's perceptions according degree of the study scale

Variable	Gender	mean	Std
participating	male	4.35	0.37
	female	4.68	0.49
	total	4.55	0.47
Non participating	male	2.64	0.62
	female	3.29	0.49
	total	3.03	0.63

It is clear from table 1 that the science teachers rate the degree of inquiry skills for the participating students to be very high with grand total mean (4.55) and standard deviation of (0.47). While the teachers pointed out that the rating degree of non participating student of having inquiry skills to on moderate level, with grand total mean score (3.03) and standard deviation of (0.63).

This results highlight the importance of the briefs and activities of chain reaction project and their impact on students' posing of inquiry skills. Inquiry based learning gives students a chance to experience science in real settings within a context that they can understand and are able to relate to, which is more effective in establishing and maintaining interest (Dokme and Aydinli, 2009) . This result is on the line of other studies which showed an effects of discovery learning on students' success and inquiry learning skills (Balım, 2006). The teachers themselves have an opportunity to be trained on how to practice inquiry based teaching on their classroom sittings.

The second question; Are there any statistical differences between the teachers perceptions of inquiry skills gained by their students between those who participated at the Chain reaction project and those who do not participated at the project.

To answer this question an independent sample t-test was employed to find the Comparison of teacher's perceptions of students' inquiry skills between those who take part on chain reaction project and those who do not (table 2)

Table 2. Comparison of teacher's perceptions of students' inquiry skills between those who take part on chain reaction project and those who do not.

Variable	Group of students	No of teachers	correlation	Mean score	St. D.	Df	t	sig*
participation	participated	25	0.55	4.55	0.47	24	1.74	0.000
	Not participated		Sig (0.005)	3.03	0.63			

Table 2 showed that there are significant differences between the teachers' perceptions of inquiry skills gained by their students between those who participated at the Chain reaction project and those who do not participated at the project in favour of those who participated at the project. This may be attributed to the fact that student studied by IBSE have an opportunity to gain inquiry skills by practicing scientific observation, collecting data, analysing data and come to conclusion (Harlow, 2010). This is different from those students who do not have this opportunity and studied by conventional way of teaching.

Moreover, as mentioned above, engaging students on the Chain Reaction project rooted in problem solving and inquiry based learning principles, aiming to actively involve students in their science work, and enable them to experience the excitement and challenges of experimental and investigative science, which developed their inquiry skills.

The third question: Are there any statistical differences between the teachers perceptions of inquiry skills gained by their students between those who participated at the Chain reaction project and those who do not participated at the project attributed to teachers' gender (male, female). Table 3 summarized the differences between the teachers perceptions t.test analysis regarding inquiry skills due to teachers' gender (male, female).

Table: 3 Independent samples t.test regarding the perception of the teachers by gender

Variable	Gender	No	Mean	st	t	df	Sig*
Participating students	Male	10	4.35	0.37	1.803	23	0.84
	Female	15	4.68	0.49			
Non - Participating students	Male	10	2.64	0.62	2.929		0.008*
	Female	15	3.29	0.49			

Sig*

From table, 3. We can see that there are no statistical differences between the male and female teachers' perceptions regarding the participating students' level of inquiry skills. This result can be justified logically because all students have the chance to practice inquiry skills by adopting the same EURPBs. And have received the same support from the Jordanian project team (technical board). They also have the chance to present their work at the express yourself national conference where they can see the work of other students works and activities from other schools that came from all parts of Jordan.

Meanwhile, it can be noticed from the above table that there are differences between the male and female teachers' perceptions regarding the non-participating students' level of inquiry skills (Significant level = 0.008) in favor of female teachers.This may be attributed to the fact that the non-participating student learn science in conventional ways of teaching and learning. Sometimes female science teachers take into consideration science practical work which indeed develops inquiry skills, while other science teacher do not pay such attention to science practical work which will not develop inquiry skills efficiently. This may depend on the teachers' commitment to the job, available recourses at schools, class-size and the teaching philosophy of the teachers.

Recommendations

On the light of the study results, it is recommended that:

- Science teachers need to be trained on developing inquiry skills by implementing related science practical activities that can develop inquiry skills.
- Adopt inquiry based science education activities and teaching materials and EURPBs to the science classroom teaching and learning process.
- Give the chance for science teachers who participated at chain reaction project to transfer their experience on inquiry based science education to their collages at same schools and the nearby schools.
- The stakeholders of the Ministry of Education are asked to facilitate and encourage science teachers and educators to cooperate totally with any person or authority that offer science teaching project such as Chain Reaction.

 # Acknowledgement: the researchers extended their acknowledgements to the European Commission, seventh framework programme, Grant agreement no: 321278 for supporting the Chain Reaction Project, and the Society For Scientific Research, for facilitating and monitoring the project.

** Jordan Society For Scientific Research, Jordan***.**

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Appendix. 1.

Questionnaire for science teachers participating in the Chain Reaction project

Dear Teachers participating on the Chain Reaction Project.

This is a Study done by The Board of the Chain Reaction project Jordan; to see how much the project benefit and influenced the students who participated in the project from the point of view of the teachers compared to that for students who did not participate in the project in terms of developing inquiry skills. Therefore, we hope that you fill in the attached questionnaire by putting (X) in the appropriate cell accurately and hand it over to the management of the project as soon as possible, knowing that all data will be treated to the highest degree of secrecy will only be used for the purposes of scientific research.

Teacher Name :

School Name :

Gender : Female / Male

Important Note : There will be two parts for each point: one for the students who participate in the project, the other for Students who didn't participate in the project .

no		Participating of students	Always	Almost always	Some times	Rarely	Never
1	Shows clear changes in the materials and objects.	Participant					
		Not Participant					
2	Uses Scientific instruments for the purposes of scientific observation.	Participant					
		Not Participant					
3	Classifies objects, material and collected samples	Participant					
		Not Participant					
4	Suggest framework of reference for the classification of objects, material and samples.	Participant					
		Not Participant					
5	Use the familiar objects as units to find a standard numeric value	Participant					
		Not Participant					
6	Makes different graphics in certain sizes.	Participant					
		Not Participant					
7	Uses simple Statistics in the inspections and calibrations.	Participant					
		Not Participant					
8	Uses scientific tools and devices (for the purposes of scientific measurement).	Participant					
		Not Participant					
9	Describes things and accidents in a scientific precision.	Participant					
		Not Participant					
10	Able to put Scientific data in a tables	Participant					
		Not Participant					
11	Represent Scientific data graphically.	Participant					
		Not Participant					
12	Recorded scientific Information accurately	Participant					
		Not Participant					
13	Draw scientific maps, forms and images.	Participant					
		Not Participant					
14	Express scientific ideas clearly.	Participant					
		Not Participant					
15	Formulates hypotheses to explain the relationship between two variables.	Participant					
		Not Participant					
16	Wondering how natural phenomena occur.	Participant					
		Not Participant					
17	explains Recorded scientific data on basis of available evidence	Participant					
		Not Participant					
18	Expected occurrence of scientific phenomena through the information available	Participant					
		Not Participant					
19	Planning to carry out scientific activity or scientific experience.	Participant					
		Not Participant					
20	Designed scientific activity (or scientific experiment) on the controlled variables.	Participant					
		Not Participant					
21	Able to make judgments about the scientific activities and laboratory experiments.	Participant					
		Not Participant					
22	Implements (applied) scientific activity or scientific experiment successfully.	Participant					
		Not Participant					
23	Engaged in questions relating to science	Participant					
		Not Participant					
24	Connects interpretations with scientific knowledge that s/he has.	Participant					
		Not Participant					