CHAPTER 1

INTRODUCTION

1.0 Introduction

It has been said that all the key features of education are in science (Paul, Willsen, & Binker, 1993). Physics is one of the fundamental natural sciences. It involves the study of global laws, and scientific experiments and the relationships between a broad range of physics phenomena. Learning physics can result in the acquisition of theoretical and procedural knowledge relevant to students' daily lives (Authority, 2007). Science, as a whole is a creative and critical subject which provides many opportunities to motivate students' thinking skills. In relation to this, one of the main central questions for the science teacher is, 'how can science be taught to help students become skilled in creative and critical thinking?' (Lawson, 1989).

Students become more active when using their thinking skills for exploring phenomena. The challenge in teaching science is to provide students with experiences and the opportunity for cooperation in order to reflect and move their thinking from the intuitive to the scientific (Jones & Wyse, 2004). Enhancing mental abilities in physics is not merely useful in enhancing creative and critical thinking of students, but also to improve students' perceptions, attitudes and promote better physics learning (Cheng, 2004). The teacher has an axial role in the success of any teaching and learning approach, especially as a teacher makes a decision on improving thinking skills through encouraging students to think in deeper ways, to discuss, to brainstorm, to make decisions (Aizikovitsh-Udi & Amit, 2011).

However, there are a number of reasons why many teachers are not confident in terms of teaching thinking skills and are unable to engage their students in these skills in their science lessons. One reason is that students themselves put a strong emphasis on the learning of science content, instead of the enhancement of thinking skills. Education textbooks never tell teachers how to enhance thinking skills because of institutional pressures, including the need to cover significant amount of material. The need to prepare students to score well on standardized tests usually does not focus upon thinking abilities. The teaching of physics (or science) continues to be taught using methods that do not enhance creative and critical thinking skills (Sawyer, 2011). Learning to think skillfully is an effective method to achieve several objectives, but it is also an objective in itself, in fact it should be the main objective of education (Lizarraga, Baquedano, & Rufo, 2010).

Several reasons justify the importance for enhancing our future students' creativity and critical thinking in general science education and in particular for physics education. The reasoning is as follows:

i. Cognitive theories support learners as active creators of their knowledge, through positive interaction and participation in the learning process;

ii. Creative and critical thinking supports active cognitive processing, which leads to better learning. It equips students to take their thinking beyond the information given, systematically to handle flexibly with problems and situations, to take a crucial decision on the information and arguments, as well as to communicate effectively (McGuinness, 1999);

iii. Creative and critical thinking plays an important role in social change (Morris, 2008);

iv. Creative and critical thinking leads to a deeper understanding of content knowledge of the learner (Narode, 1987);

v. Creative and critical thinking leads to learner independence in thinking, freedom from dependence and pivoting around the self (Forrester, 2008);

vi. Creative and critical thinking encourages the spirit of inquiry and pushes them to inquire research;

vii. Creative and critical thinking makes school a meaningful experience for students and promotes learner to apply and practice;

viii. Creative and critical thinking raises the achievement level of the learner (Cotton, 1991);

ix. Creative and critical thinking increases the learner's confidence and raises the level of self-esteem; and

x. It enables students to distinguish between fact and opinion, ask good questions, make detailed notes, reveal assumptions and determine the conditions, and make affirmations based on commonsense and solid evidence (Narode, 1987).

Teaching should move from a knowledge–based education to brain –based education that enables the minds to create a better future (Fisher, 2002). Paul and Elder (2008) asserted that both imaginative and critical thinking must be integrated during learning. Paul (1992) explained that knowledge is coterminous with thinking, especially creative and critical thinking.

Cotton (1991) recommended that students' creative and critical thinking skills could be improved through efficient instruction and practice. However, typical school instruction does not promote the enhancement of higher-order thinking skills and is only

mainly characterized with factual knowledge. This type of learning is simply rote learning and the result is that the students memorize the material without understanding the logic of it. It is the responsibility of science educators to help students to think in creative and critical ways about what science is, and whether the impact is for the greater good (Gunn, et al., 2008). One way of reinforcing learning and thinking is to use interactive engagement methods such as brainstorming, mind mapping, and problem-based learning which are far more effective than traditional methods in the teaching of physics (Hake, 1998; Holubová, 2010).

One of most efficient technique for students to improve their thinking skills is the brainstorming technique. It plays an important role in the education of students because this technique encourages students to think aloud and learn from each other (Patrick, 1993). Moreover, it helps students to focus on the subject and contribute to a free flow of ideas. The brainstorming technique stimulates left and right sides of the brain during the learning process to respond to educational stimuli and produces ideas to cope with the situation and restore equilibrium (Fanona, 2012).

Fisher (2002) defined that the right brain represents creative thinking and the left brain represents critical thinking. From the above discussion, the researcher of the present study has summarized the brainstorming technique in Figure 1.1. During a brainstorming session, each side of the brain simultaneously feeds off and strengthens the other in a manner which provides students' limitless potential to solve problems and make decisions.

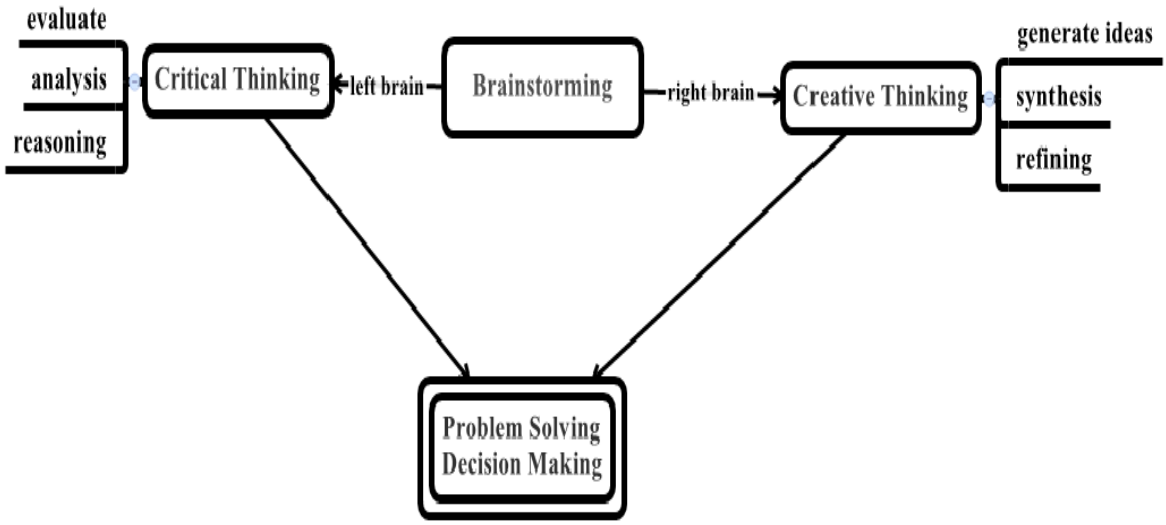

Figure 1.1 Brainstorming technique for solving problems and decision making

There is research evidence that emphasizes that the brainstorming is a powerful teaching technique for enhancing creative and critical thinking skills. Davis (1986) asserted that brainstorming has a great importance in the teaching process and enhancement of creative thinking, critical thinking and problem-solving skills among students for the following reasons:

i. It helps students to learn because there are no rules to restrict the production of ideas and there is no criticism or evaluation of any kind;
ii. It models thinking processes in the students;
iii. It is fun and exciting for every individual to participate in a discussion group or collective problem-solving and this gives a flow of opinions or a combination of exotic ideas;
iv. It is a therapeutic process as each individual participating in the debate has the freedom of speech to express ideas or solutions to a problem, and
v. It is a training process to stimulate the imagination and flexibility training in creative thinking.

Osborn (1953) suggested that central to a successful brainstorming session is a commitment to certain rules. These rules are:

i. Idea quantity is the goal. Quantity is not desired for its own sake, but because a large number of ideas seem more likely than a small number to yield a good solution;

ii. Criticism must be ruled out. No person is to evaluate any idea until all ideas have been put forward; participants must understand that this rule precludes both verbal and nonverbal criticism no eye rolling; face making, or other signals;

iii. Freewheeling is welcomed. In brainstorming, ways out of the normal notions are seen as stepping stones to creative ideas. Suggestions that appear to be farfetched can open a new point of view that may lead to a workable idea;

iv. Many good ideas can be found by building on or combining previous ideas and such elaborations are to be encouraged; sometimes extra effort is required to convey the notion of shared ideas to students accustomed to competition and individual ownership (Osborn, 1953).

The ultimate aim of these four rules is to liberate students from being negative and remove the fear of participating in brainstorming sessions. This could probably help the students to integrate and cooperate with other members of the group and push them to more freely express their ideas which most probably in turn help to unleash thinking.

In addition to these basic four rules, Osborn offered a number of recommendations for managing groups and preparing for a productive brainstorming session (Goldenberg & Wiley, 2011). He recommended that the leader of the session should be able to ask stimulating questions, pose challenges and assign investigation

tasks, develop plans for guiding the generating of ideas, and manage the planning and scheduling of follow up the session (Isaksen, 1998).

In this present study, the researcher investigated the use of the brainstorming technique for enhancing creative and critical thinking among students because brainstorming involves motivation, cognitive processes and cooperative learning, which are three strong components of learning (Paulus & Paulus, 1997; Wang, Rose & Chang, 2011). Moreover, mutual stimulation among students in a group which occurs during the steps of brainstorming is the focus of recent research (Brown & Paulus, 2002; Rusbult, 1997; Stroebe, Nijstad, & Rietzschel, 2010). The brainstorming technique is designed to expand the cognitive toolkit for learners by thinking about a question from different perspectives, as well as exploring the perspectives of their classmates. Students can enhance thinking skills to help them access and generate a broader range of ideas. Using brainstorming as a teaching method in the classroom not only will help students to work together towards a common goal, but also encourage students to help each other expand their minds and create an enthusiastic atmosphere (Maheshwai, Singh, & Agarwal, 2003). Brainstorming provides a relatively straightforward way to measure creativity and assess various underlying processes related to thinking in individuals and groups (Paulus, Kohn, & Arditti, 2011).

The present study undertook to investigate the use of the brainstorming technique because there are many features that make brainstorming a useful technique in teaching and learning physics (Cheng, 2011; Wang, et al., 2011) as illustrated by the researcher of the present study in Figure 1..

Figure 1.2 Features of the brainstorming technique

Figure 1.2 shows the rationale behind the brainstorming technique used in this study in attempting to enhance creative and critical thinking skills for selected secondary Iraqi physics students. The brainstorming technique is designed to help students when faced with a problem (in this study a physics problem) to think about the question from different perspectives, as well as exploring the perspectives of their classmates. By doing so, students could be motivated to enhance the skills to help them access and enhance a broader range of ideas for solving the physics problem. The brainstorming technique provides students with a range of cognitive strategies for effectively generating and evaluating ideas. Additionally, employing cooperative learning strategies in the classroom is a creative and motivating way to help students learn. Brainstorming is an ideal activity to activate students' prior knowledge of a subject, while engaging them physically in the learning process. Brainstorming provides a free and open environment that encourages everyone to participate. Idiosyncratic ideas are welcomed and built upon, and all participants are encouraged to contribute fully, helping them

develop a rich array of creative solutions. Brainstorming brings team members' diverse experiences into play. It increases the richness of ideas explored, which means that the students can often find better solutions to the problems that they face (Bradly, 2011).

1.1 Background of Study

The word brainstorm consists of two words, brain and storm. To brainstorm means to use the brain to storm (or think of) problems (Conklin, 2007). Alex Osborn in (1953) introduced and developed brainstorming through the book "Applied Imagination" to help teams generate solutions to everyday problems. Since the publication of Osborn's book, there has been a significant amount of research on group brainstorming. The brainstorming technique has been conducted all over the world (Starko, 2009). However, many of the researchers seem to have ignored the impact of the brainstorming technique in education in enhancing creative and critical thinking skills (Patrick, 1993; Wood, 1970).

Isaksen (1998) reviewed fifty empirical studies and found that most of the research on brainstorming focused more on comparing individuals or nominal groups and brainstorming group productivity, and ignored the original stated purpose and design of the technique. In contrast, Rietzschel, Nijstad, and Stroebe (2007) asserted that high productivity in brainstorming is not sufficient to lead to better solutions.

It is surprising that only a few researchers have used brainstorming for fostering only creativity in physics despite the fact that brainstorming is an effective technique for enhancing both creative and critical thinking in physics (Cheng, 2004, 2011). Wang et al. (2011) showed that the brainstorming technique is beneficial for students' learning in science education. The learning through brainstorming comes from the cognitive,

inferential process of idea generation, building on prior knowledge as well as from the collaborative process of students' building on one another's ideas. These components of cognitive process and collaborative process make brainstorming a powerful technique for students' learning and teachers' teaching. Additionally, Wood (1970) also showed that the brainstorming technique of problem solving has much merit, as it makes learning an active process. The learner will have fun and soon will become very skilled and perceptive in the science. In addition, Conklin (2007) stated that traditional teaching methods are not effective and more teachers should use interactive methods such as the brainstorming technique which can enable students to construct knowledge and improve mental abilities. Enhanced performance in group brainstorming has been found to be due to cognitive stimulation and cooperative learning (Paulus & Yang, 2000). Starko (2009) suggested that brainstorming is a helpful technique in generating new and appropriate variables for a possible science experiences. Harbi (2002) identified that the brainstorming technique does not just enhance thinking skills for students during science lessons but also has a significant effect on enhancing achievement for students.

DeHaan (2009) demonstrated that brainstorming provides an opportunity for teachers to pose a problem and to ask the students to suggest as many solutions as possible in a brief period, thus enhancing ideational fluency. Here, students can be encouraged explicitly to build on the ideas of others and to think flexibly. Moreover, Mohammed (2010) asserted that the brainstorming technique provides an opportunity for a learner to impose assumptions, observe, experiment, measure, and infer.

In more recent studies, (Mased &Yamin, 2012; Mohammed, 2010) it has been stated that critical-thinking ability is stimulated in brainstorming, through the process of problem solving, particularly in the evaluation and selection of ideas when group brainstorming discussion critically considers one best possible solution for the problem.

In addition, brainstorming has been found to improve creative thinking skills, critical thinking skills, problem-solving skills, and achievement among learners, as well as improving improves attitude of learners towards science learning (Cheng, 2011; Fanona, 2012).

Nevertheless, in spite of much positive research, Holubová (2010) found that teachers are afraid to apply the brainstorming technique in the classroom because they do not have experience on how to teach using brainstorming and believed that the brainstorming technique needs a long time to conduct and therefore they will be unable to finish the physics syllabus.

1.2 The Education System in Iraq

In Iraq, education is provided by the government through a centrally organized school system. Basic education in the Iraqi education system is twelve years. The education system is divided into three learning levels which includes the primary stage (or elementary, grades one to six) which is compulsory and encompasses six-years in duration and enrolls students from the ages of six through eleven years. The second level is the intermediate stage (or lower secondary, grades seven to nine) which encompasses three year duration, follows a common curriculum, and culminates in the Third Form Baccalaureate or Certificate of Intermediate Studies. This level enrolls students from the ages of twelve through fourteen years. The third level is the preparatory stage (or upper secondary, grades ten to twelve) which encompasses three years following the intermediate stage. This level enrolls students from the ages of fifteen through seventeen years. In the general academic schools, the preparatory stage requires students to choose a specialization, one of three tracks. Students choose

scientific, literary or vocational secondary schools, where the students with the lowest marks go to vocational schools. Students choose scientific or literary studies leading to the Sixth Form Baccalaureate. Vocational secondary education is divided into agricultural, industrial, veterinary or commercial studies. Courses would lead to a Vocational Baccalaureate. Finally, tertiary education is open to students who satisfactorily complete secondary education and it lasts from three to six years in duration.

The Iraqi curriculum is mainly based on Western patterns but also includes religious teaching. The language of instruction is Arabic. The maximum obtainable mark is 100; the minimum passing mark is 50. The school year consists of two semesters which starts in October and ends in June. The teaching of physics begins at the first grade of the intermediate stage to the six grade of the preparatory stage for students who choose scientific studies. Prior to that, physics is taught as part of science as a general subject (UNESCO, 2003).

In Iraq, the teaching methods for scientific subjects (physics, biology, chemistry) carry on being dependent on traditional methods (lecture) with no emphasis on enhancing mental skills or problem solving. Teachers in Iraqi schools depend only on the textbook as a tool for teaching and learning. On the other hand, most Iraqi schools are devoid of a laboratory, which gives an opportunity for students to practice and enhance mental skills. As a result, the Iraqi teacher explains the physics experience theoretically.

Education is free in Iraq and the government has identified education as one of its main priorities and is committed to promoting quality education and learning as a lifelong experience from the pre-primary level through to the end of the secondary level. However, According to UNESCO's (2003) situation analysis of education in Iraq,

the educational system in Iraq has rapidly deteriorated during the last two decades due to several wars, acute insecurity and economic sanctions. Furthermore, education in Iraq faces challenges such as the poor state of primary education which undermines cognitive development, causing irreversible losses in opportunities for learning and leads to a high drop-off in enrolment rates going into the intermediate and secondary education (IAU, 2010; Alwani, 1999).

1.3 The Statement of Problem

The world today is much more technologically complex, and economically competitive and classroom instruction is increasingly failing to educate our students to participate in this new kind of society (Sawyer, 2011). Asian countries are now in need of effective methods to infuse mental skills into regular science lessons (Cheng, 2011). Students need to learn integrated and useable knowledge rather than the sets of fragmented facts emphasized by instruction. Furthermore, students need to be able to take responsibility for life-long learning. Teaching in most Arab states continues to be didactic, teacher directed, and not conducive to fostering critical thinking, creativity, and problem-solving skills. Assessment of student learning relies on memorization of definitions, facts, and concepts rather than the ability to think critically, as noted in national and international tests. The education system in Iraq need to free the teacher in teaching remembering and indoctrination processes and enhance the application of higher-order thinking (analysis, synthesis and evaluation). It is time to start teaching physics in the Arab countries through a wider horizon lens and through processes which mobilize students' educational capabilities, and cause them to think about abstract patterns and levels (Faour & Muasher, 2011).

Unfortunately, the quality of teaching science in Iraq is very poor (Dagher & BouJaoude, 2011). Learning and teaching physics in Iraqi schools is still characterized by chalk-talk methods. The current physics teaching suffers from a lack of state of the art teaching methodologies and remains obsolete. According to the UNESCO (2011) report secondary education in Iraq has the worst enrolment rates in the region and of the students who sat for their graduating exams, less than 38 percent received a passing grade. Much of the curricula and teaching methods are outdated, and the capacity to develop appropriate curricula is still lacking (Dagher & BouJaoude, 2011). Schools today are designed around common sense assumptions that are opposed to creative learning. School education should aim at enhancing mental abilities, many of which are related to creative and critical thinking enhancement. The abilities include, creating, imagining, innovating, thinking flexibly, questioning, posing problems, use of all senses to make a decision, taking responsible risks, interpreting, thinking interdependently, and remaining open to continuous learning (Cheng, 2011).

In general, teaching materials are now in very short supply in most secondary schools in Iraq, as well as being outdated and inadequate, falling far short of meeting the needs for modern teaching and quality education (UNESCO, 2011). Iraqi teachers need to be exposed to the nature of active learning and practice in active teaching. Text books have not been adequately improved upon or updated to keep up with advances in science and educational research. The teaching methods used in the teaching of physics are memory based and does not train students to think actively or to enhance creative and critical abilities. This system encourages blind memorization and discourages creative and critical thinking, which produces students who are poorly equipped to succeed in the modern world and workplace (Kadir, 2011). The main problem is that

teachers have no experience with interactive methods and are unwilling to apply this method.

In addition Dagher and BouJaoude, (2011), Kadir, (2011) and the UNESCO report, (2011) have asserted that the poor quality of teaching science (including physics) in Iraq, have resulted in students' being weak in skills of creative and critical thinking. The researcher herself through her experience of teaching physics in an Iraqi Saba school has seen the difficulties and problems of teaching physics, these problems include lack of teacher training, shortage of teachers, poor teacher preparation, unsuitable instructional methods, lack and low quality of science laboratories, libraries, equipment, an outdated curriculum, and the wide-spread phenomenon of private tutoring, which takes students away from the public system.

In short, physics teaching in Iraq focuses on the theoretical aspects at the expense of practical aspects, and gives importance to memorisation without enhancement of thinking skills and problem solving. Lessons lack the inquiry approach and manifest multiple weaknesses in that desired goals for physics education are not attained. Therefore, the researcher of the present study considered verifying the impact of the brainstorming technique in the enhancement of creative and critical thinking skills among selected secondary Iraqi students.

In order to improve creative and critical thinking skills among secondary physics students in Iraqi schools, interactive teaching methods such as the brainstorming technique need to be used to try and provoke the minds of students and motivate them towards the proper methods of thinking. However, based on literature review, there appears to be a gap in the literature on physics teaching and learning related to the utilization of the brainstorming technique for enhancing both creative and critical thinking. Moreover, physics teachers believe that brainstorming technique is an

unsuitable technique for physics teaching, although much of the literature has asserted that brainstorming is an effective technique for teaching and learning science, especially with secondary students, to try and enhance abstract reasoning skills (Cheng, 2004, 2011; DeHaan, 2009; Fanona, 2012; Harbi, 2002; Mased & Yamin, 2012; Mohammed, 2010; Rusbult, 1997; Starko, 2009; Wang, Li, Rosé, Huang, & Chang, 2006; Wang, et al., 2011; Wood, 1970).

Therefore, in this study, the researcher prepared and utilised the brainstorming technique to try and scaffold secondary Iraqi physics students in enhancing creative and critical thinking skills in physics for students in the Iraqi Saba School. It is hoped that the research can contribute to the knowledge base that brainstorming is a technique in enhancing creative and critical thinking skills among students in the teaching and learning of physics.

1.4 Objectives of Study

Analysis of previous studies for secondary Iraqi students in science (physics) education has shown that there is a lack in creative and critical thinking skills in physics. To promote these mental skills among students, there is a need to use interactive teaching methods to teach. Hence, this present study had utilised the brainstorming technique for selected secondary students in the Iraqi Saba School, to try and infuse creative and critical thinking skills in learning physics. Therefore, the objectives of this study were as follows:

1. To determine if there is a significant difference for creative thinking skills, critical thinking skills and physics achievement among selected secondary Iraqi

physics students between the control and experimental groups before the intervention of using the brainstorming technique in teaching physics.

2. To prepare and utilize brainstorming techniques for the teaching and learning of physics among selected secondary Iraqi students.
3. To determine if there is a significant difference for creative thinking skills, among selected secondary Iraqi physics students between the control and experimental groups after the intervention of using the brainstorming technique in teaching physics.
4. To determine if there is a significant difference for critical thinking skills among selected secondary Iraqi physics students between the control and experimental groups after the intervention of using the brainstorming technique in teaching physics.
5. To describe the enhancement of creative and critical thinking skills in using the brainstorming technique among selected secondary Iraqi physics students.
6. To describe the selected secondary Iraqi physics students' perceptions about teaching and learning using the brainstorming technique.

1.5 Research Questions

This present study addressed six questions related to the problem as follows:

1. Is there a significant difference for creative thinking skills, critical thinking skills and physics achievement among selected secondary Iraqi physics students between the control and experimental groups before an intervention using the brainstorming technique?

2. Is there a significant difference for creative thinking skills among selected secondary Iraqi physics students between the control group who were taught using the traditional approach and the experimental group who were taught using the brainstorming technique?
3. Is there a significant difference for critical thinking skills among selected secondary Iraqi physics students between the control group who were taught using the traditional approach and the experimental group who were taught using the brainstorming technique?
4. How is the enhancement of creative and critical thinking skills among selected secondary Iraqi physics students who have experienced the brainstorming technique in the teaching and learning of physics?
5. What are physics students' perceptions about learning using the brainstorming technique?

1.6 Research Hypotheses

For the quantitative research questions 1 to 3 which are subjected to statistical testing, null hypotheses were generated and examined.

The first research question generated the following three null hypotheses:

$H_o(1)$: There is no statistically significant difference between the mean scores in the test of creative thinking of the students in the experimental and the control groups before intervention.

$H_o(2)$: There is no statistically significant difference between the mean scores in the test of critical thinking of the students in the experimental and the control groups before intervention.

$H_o(3)$: There is no statistically significant difference between the mean scores in the physics achievement test of the students in the experimental and the control groups before intervention.

The second research question generated the following null hypothesis:

$H_o(4)$: There is no statistically significant difference in the mean scores of the test of creative thinking between the experimental group students who were taught physics via the brainstorming technique and the control group students who taught physics via the traditional method.

$H_o(5)$: There is no statistically significant difference in the gains scores (difference between the pre and post test scores) of the test of creative thinking for the experimental group students who were taught physics via the brainstorming technique and the control group students who taught physics via the traditional method.

The third research question generated the following null hypothesis:

$H_o(6)$: There is no statistically significant difference in the mean scores of the test of critical thinking between the experimental group students who were taught physics via the brainstorming technique and the control group students who taught physics via the traditional method.

$H_o(7)$: There is no statistically significant difference in the gains scores (difference between the pre and post test scores) of the test of critical thinking for the experimental group students who were taught physics via the brainstorming technique and the control group students who taught physics via the traditional method

1.7 Rationale of the Study

In this era of globalization, knowledge alone is not enough for our students. More skills are needed to be acquired in order to prepare students for a better future. The role of

physics is central in many important developments in engineering, medicine, economics and other fields of science and technology (Authority, 2007). In addition, students ought to have the ability to apply the knowledge that they have learned to face the challenges of life beyond school. Basic skills are necessary but not sufficient to face this challenging world. The students must be able to solve multifaceted problems by thinking creatively and generating original ideas from multiple sources (Soh, Arsad, & Osman, 2010; Sulaiman, 2011). International organizations have increasingly emphasized the need for educating for creativity (Sawyer, 2011).

As a developing country, Iraq is in great need of improving science teaching in its schools at all levels of schooling. It needs a considerable number of technicians, specialists in the fields of science and scientists for economic and social development. Some progress has been achieved through the improvement of science, but greater efforts are still needed in this respect. The creative thinking activities in physics are not merely useful in fostering creativity of students, but also for promoting "better" physics learning (Alimen, 2009).

In Iraq, the teaching of physics as a subject begins at the first secondary level of the school system. The teaching of physics at all levels, concentrates very much on memorization of facts. Despite the importance of thinking skills for students for coping with life problems, very little or no attention is paid to the enhancement of the scientific method of thinking and the proper science attitude and appreciation. Facts are soon forgotten after passing the examinations, and the students don't grow much in terms of enhancement of the necessary skills and attitudes.

Physics should not be taught as a series of formulae to be memorized and applied just to pass examinations but must be taught as a dynamic branch of science, which should provide questions and explanations on how the world works (Alimen,

2009). Experiments are not very common in the teaching of science, and even when some experiments are demonstrated they are not presented in the proper sequence of the lesson and are mainly the ones mentioned in the book. The textbook is considered as the only source of information for many teachers.

Several researchers (Aizikovitsh-Udi & Amit, 2011; Dagher & BouJaoude, 2011; Holubová, 2010; Kind & Kind, 2007; Sawyer, 2011) have underpinned the inability of students to think creatively and critically to the teaching methods. Teachers in Iraqi schools depend on traditional methods, which do not do much to improve the mental abilities of learners. In contrast, teachers should teach students to be creative, to generate new physics ideas and to be critical enough to evaluate what is written in the textbook. The UNESCO report (2011) has emphasized that Iraqi students should enhance thinking skills (critical and creative thinking and problem solving) in order to become successful lifelong learners (UNESCO, 2011).

The physics teachers in the 21st century have to be a facilitator in the classroom. The learning is more effective, when students can construct their knowledge on their own. Creative teachers must recognize when encouragement is needed and confidence is threatened (Holubová, 2010). They must balance structured learning with opportunities for self-direction; and the management of groups with attention to individuals. They must judge the kinds of questions appropriate to different purposes and the kinds of solutions it is appropriate to expect (Aizikovitsh-Udi & Amit, 2011).

In the present study, a mixed method approach is used to examine the effectiveness of the brainstorming technique in enhancing the creative and critical thinking skills among physics students. In relation to this, the researcher has not found any such study that has been undertaken in the Arabian countries in general and in Iraq in particular. Both quantitative and quantitative data collection techniques were used to

investigate and explore the effectiveness of the brainstorming technique in enhancing creative and critical thinking among secondary Iraqi physics students. The goal of using a combination of qualitative and quantitative data collection techniques can ensure that the limitations of one type of data are balanced by the strengths of another.

Additionally, as stated in the earlier discussion, there exists a lack in the creative and critical thinking skills among Iraqi students in physics as reported in the UNESCO report, (2011). Therefore, this present study focused upon investigating this problem and proposes recommendations to enhance Iraqi students' creative and critical thinking skills via the brainstorming technique.

1.8 Significance of Study

Today, education involves teaching how to think, and in particular, how to be a critical and creative thinker. These thinking skills are important in every profession, and it allows us to deal with reality in a reasonable and independent manner (Aizikovitsh-Udi & Amit, 2011). Science is recognized as one of the important subjects for developing creativity (Cheng, 2011). Students should appreciate that science is an activity that involves creativity and imagination (Kind & Kind, 2007).

As reported earlier in the introduction of this chapter, creative and critical thinking skills are important and are commonly stated goals of education at all levels. Students who think creatively and critically are able to generate ideas and analyze complex situations (Barak & Dori, 2009; Sawyer, 2011). There is a need to reprocess the prescribed content material in order to integrate the teaching of thinking skills into traditional instruction.

There are many attempts to introduce science education reform into secondary and high schools in Iraq. However, even after reform efforts, widespread progress is still lacking for interactive teaching methods, which play a leading role for enhancing higher-order thinking skills among students in science. Although these skills are an important part of teaching and learning science, they are not emphasized enough in Iraqi classrooms. No doubt, the enhancement of thinking skills among students is prominent. However, in order for science education reform to succeed, teachers as ‘‘change agents" need to better understood, practice, and apply effectively to stimulate students to activate mental skills such as problem solving, critical and creative thinking (Dagher & BouJaoude, 2011; Mohammed, 2010; UNESCO, 2011).

Past studies have revealed that physics teachers think brainstorming as an unsuitable technique in the teaching and learning of physics. Teachers have been shown to believe that the brainstorming technique is beyond them and their student's ability. Moreover, during the brainstorming procedure, social loafing would occur when students tell their ideas aloud, and teachers may find it difficult to manage the classroom and time (Cheng, 2004; Holubová, 2010).

In the context of this study, the brainstorming procedures were prepared and utilized to improve creative and critical thinking among secondary Iraqi physics students in a selected school. Brainstorming procedures were prepared in this study with the specific goal of being a stimulus for students to investigate the problem at hand, evaluate the information and react to it as a critical and creative thinker, as these skills are the main objectives of science education (Barak & Dori, 2009). As stated earlier, there are a few studies which have reported on the use of the brainstorming technique in the teaching and learning of physics in the Iraqi context. However, as far as the researcher has searched there is no study investigating the use of the brainstorming

technique to try and enhance creative and critical thinking skills among students in the Iraqi context. Thus, it would be interesting to explore the effect of the brainstorming technique on enhancing of creative and critical thinking skills for students. Besides this, the findings of this study can contribute to the area of cognitive psychology in general and science cognition in particular for the teaching and learning of physics.

1.9 Definition of Terminologies

There are some definitions that need to be clarified to avoid any perplexity in this study.

Brainstorming Technique

Osborn's definition of brainstorming is "a conference technique by which a group attempts to find a solution for a specific problem by amassing all the ideas spontaneously by its members" (Osborn, 1953). In the context of this study, brainstorming is procedurally defined as:

A teaching technique which relies on a set of 6 steps in three stages leading to provoke and stimulate the minds of secondary Iraqi physics students to generate the largest possible number of ideas and evaluate these ideas in a certain period of time.

Traditional Method

The traditional method utilised by teachers in the Iraqi Saba School for teaching physics is defined as:

Teacher controls the educational process by providing ready information for the learner and display physics problems and solutions without giving an opportunity to the learner to inquire and explore.

Creative Thinking

There are many definitions of creativity. However, the most common definition of creativity is "as the process of producing something that is both original and worthwhile" (Sternberg, Grigorenko, & Singer, 2004).

Davis, (1986) classified creative thinking into the three abilities: - fluency, flexibility and originality. They are defined as below.

i. Fluency: thinking about numerous ideas.
ii. Flexibility: thinking of different groups or perspectives.
iii. Originality: thinking of exotic ideas.

In the context of the present study, creative thinking is procedurally defined as: The mental activity of the secondary Iraqi physics students when provoked by test items of the creative thinking test, which leads to the production of the largest possible number of different, diverse, new, and unusual ideas. This mental activity will be measured by the total scores students obtain from the creative thinking test. This creative thinking test will include fluency, flexibility, and originality, which are defined as follows:

Fluency

A secondary Iraqi physics student's ability to produce the largest possible number of ideas and alternatives that is characterized by quantity when responding to test items of the creative thinking test, and will be measured by the total score of the sum of these ideas.

Flexibility

A secondary Iraqi physics student's ability to produce the largest possible number of diverse ideas when responding to test items of the creative thinking test and will be measured by the total score of the sum all these ideas.

Originality

A secondary Iraqi physics student's ability to produce the largest possible number of original and new ideas when responding to test items of the creative thinking and will be measured by the total score of the sum all these ideas.

Critical Thinking

Willingham, (2008) defined critical thinking as: "seeing both sides of an issue, being open to new evidence that disconfirms your ideas, reasoning dispassionately, demanding that claims be backed by evidence, deducing and inferring conclusions from available facts, solving problems, and so forth" p. 8.

In the context of the present study, critical thinking is procedurally defined as: The mental activity of the secondary Iraqi physics students when provoked by test items of the critical thinking test, which will require the students to make inferences, recognize assumptions, interpret data, to enhance lines of argument and make sound judgments. This mental activity will be measured by the total scores students obtain from the critical thinking test involving the skills of inference, recognizing assumptions, making deductions, interpretations and evaluating arguments, which are defined as follows:

Inference

A secondary Iraqi physics student's ability to derive logical conclusions for a given statement and this mental skill will be measured by the total score a student obtains in test one of the critical thinking test.

Recognizing assumptions

A secondary Iraqi physics student's ability to judge and recognize proposed assumptions based on a given statement and this mental skill will be measured by the total score a student obtains in test two of the critical thinking test.

Deductions

A secondary Iraqi physics student's ability to deduce and conclude for a given statement and this mental skill will be measured by the total score a student obtains in test three of the critical thinking test.

Interpretations

A secondary Iraqi physics student's ability to judge the evidence and make decisions for a given statement and this mental skill will be measured by the total score a student obtains in test four of the critical thinking test.

Evaluating arguments

A secondary Iraqi physics student's ability to distinguish between weak and strong arguments for a given statement and this mental skill will be measured by the total score a student obtains in test five of the critical thinking test.

Achievement

Different scholars have defined the term academic achievement in different ways. However, the most common definition of achievement is the knowledge gained or skills developed in the materials usually identified through test scores or marks by teachers or by both (Good, 1959). In this present study, achievement is procedurally defined as: Total scores of secondary Iraqi students in the physics achievement test.

Secondary Iraqi Physics Students

The middle stage of intermediate level (lower secondary) in which the age of the student is 14 years old. These students take physics as one of their subjects in school. In this study, the phrases Iraqi second–grade intermediate students and secondary Iraqi physics students will be used interchangeably.

1.10 Limitations of the Study

There were some limitations in this study. First, participants who were engaged in this study are confined to secondary students of the second grade intermediate level in the Iraqi Saba School. Therefore, the findings may not be generalized to populations that do not share common characteristics.

Only four topics were selected from the physics text of the second grade intermediate level and these topics which were: light and reflection of light, refraction of light, thin lenses and color and electromagnetic spectrum. The main rationale for the selection of these physics topics was that these topics depend on experience and analysis of scientific thought; accuracy of observation; creative and critical thought; making conclusions; research skills and problem-solving (The Iraqi Ministry of Education, 2010). Thus, the findings may be only applicable to these topics. Further

investigation might need to be carried out in the future for other physics topics in order to explore student's thinking.

1.11 Chapter Summary

In this chapter, the researcher has articulated that there is a need to consider an alternative approach of teaching and learning in physics for Iraqi students. This includes the rationale of the study, significance of the study and definition of terms. The particular instruction strategy that has been suggested in this study is the brainstorming technique in an attempt to try and enhance students' creative and critical thinking. The next chapter presents a more detailed review of literature related to the brainstorming technique, creative thinking and critical thinking in science education.