

# **The Impact of Inquiry-based Learning on the Critical Thinking of high School Students**

تأثير التعلم القائم على الاستفسار على التفكير النقدي لطلاب المرحلة الثانوية

by

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## **Abstract:**

The aim of this research was to examine the effects on students' critical thinking skills using a guided inquiry model with critical thinking test through physics learning. The researcher used a quasi-experiment, with post-test only control group design.

The research subjects were 50 experimental group students and 40 control group students. The data were collected through critical thinking test with five description questions to see the student's critical thinking skills that have been implemented. Then, the data were analyzed using excel statistics and SPSS software.

Explanatory sequential mixed-methods approach was utilized in the current study in which the data are collected and analyzed quantitatively first, and then qualitative data were collected in order to fully explain the quantitative data results

The current study found that inquiry-based learning approach has a statistically significant positive impact on the high school students' critical thinking in where the independent T-test results were for  $t(90) = 7$  with a P value equals to  $0.000 < 0.05$ . Moreover, based on the observation through the experiment and students' responses during the interviews the results showed that students enjoy inquiry-based learning compared to Non-IBL approaches. The findings of the study revealed that implementing STEM-PBL has a great influence on the learning of the students, and that the students participated in the study expressed a positive attitude towards this approach. Students appreciate the benefits of understanding the subject and linking it with real-life problems as well as with the activities involved.

## الملخص:

كان الهدف من هذا البحث هو دراسة التأثيرات على مهارات التفكير النقدي لدى الطلاب باستخدام نموذج استفسار موجه مع اختبار التفكير النقدي من خلال تعلم الفيزياء. استخدم الباحث شبه تجربة ، مع تصميم مجموعة ضابطة بعد الاختبار فقط.

كانت موضوعات البحث 50 من طلاب المجموعة التجريبية و 40 من طلاب المجموعة الضابطة. تم جمع البيانات من خلال اختبار التفكير النقدي مع خمسة أسئلة وصفية لمعرفة مهارات التفكير النقدي لدى الطالب التي تم تنفيذها. ثم تم تحليل البيانات باستخدام إحصائيات Excel وبرنامج SPSS.

تم استخدام نهج الأساليب المختلطة التفسيرية المتسلسلة في الدراسة الحالية حيث تم جمع البيانات وتحليلها كمياً أولاً ، ثم تم جمع البيانات النوعية من أجل شرح نتائج البيانات الكمية بشكل كامل

وجدت الدراسة الحالية أن نهج التعلم القائم على الاستفسار له تأثير إيجابي ذي دلالة إحصائية على التفكير النقدي لطلاب المدارس الثانوية حيث كانت نتائج اختبار T المستقل لـ  $t(90) = 7$  بقيمة P تساوي  $0.000 < 0.05$ . علاوة على ذلك ، بناءً على الملاحظة من خلال التجربة واستجابات الطلاب أثناء المقابلات ، أظهرت النتائج أن الطلاب يستمتعون بالتعلم القائم على الاستفسار مقارنةً بالنهج غير المعتمدة على IBL. كشفت نتائج الدراسة أن تطبيق STEM-PBL له تأثير كبير على تعلم الطلاب ، وأن الطلاب المشاركين في الدراسة عبروا عن موقف إيجابي تجاه هذا النهج. يقدر الطلاب فوائد فهم الموضوع وربطه بمشكلات الحياة الواقعية بالإضافة إلى الأنشطة التي ينطوي عليها.

## Dedication

Every challenge needs self-effort as well as the support of people who are very close to our hearts, so it would be hard to reach for this achievement without their support.

I would proudly like to share my gratitude to my dear husband, son and parents, who always encouraged and inspired me to complete this research.

I would like to thank my supervisor, **Prof. Sufian A Forawi**, for his patience, inspiration and support.

Never giving up is the only way we can achieve what we expected as impossible!

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## **Table of Contents**

<b>Abstract .....</b>	<b>.....</b>
<b>Dedication .....</b>	<b>.....</b>
<b>Acknowledgement .....</b>	<b>.....</b>
<b>Table of Contents .....</b>	<b>.....</b>
<b>List of Tables .....</b>	<b>.....</b>
<b>List of Figures .....</b>	<b>.....</b>

<b>Chapter 1: Introduction .....</b>	<b>1</b>
1.1 Background of the Research .....	1
1.2 Statement of the Problem .....	2
1.3 Purpose and Question of the Study .....	2
1.4 Significance of the Study .....	4
1.5 The Structure of the Dissertation .....	5

<b>Chapter 2: Theoretical Framework and Literature Review .....</b>	<b>5</b>
2.1 Theoretical Framework .....	5
2.2 Literature Review .....	9

<b>Chapter 3: Methodology .....</b>	<b>12</b>
3.1 Research Design .....	12
3.2 Site .....	15
3.3 Study Procedure .....	17
3.4 Sampling and Participants .....	18
3.5 Instrumentation .....	20
3.6 Validity and Reliability of Study .....	21
3.7 Data Analysis .....	21
3.8 Ethical Considerations .....	23

<b>Chapter 4: Results and Data Analysis .....</b>	<b>24</b>
4.1 Quantitative Results .....	24
4.1.1 Equivalency and adequacy between experimental and control groups in the pretest. ....	27
4.1.2 Differences between pretest and posttest results of the experimental and control groups....	28
4.1.3 The differences between the control and experimental groups in the posttest scores. ....	30
4.1.4 Reliability of the study .....	32
4.2 Qualitative Results .....	33

<b>Chapter 5: Discussion, Conclusion, Recommendations and Limitations .....</b>	<b>39</b>
5.1 Discussion .....	39
5.2 Conclusion .....	46
5.3 Recommendations and Implications .....	47
5.4 Limitations .....	48



## References:

.....	50
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## Appendices

.....	
Appendix 1 .....	61
Appendix 2 .....	63
Appendix 3 .....	70
Appendix 4 .....	71
Appendix 5 .....	73
Appendix 6 .....	75

## List of Tables

Table (1): Students' Average results in the pretest. ....	35
Table (2): One-way ANOVA test analysis between the control and experimental groups..	42
Table (3): Descriptive statistics and paired T-test results between the pretest and posttest results of both the experimental and control groups. ....	43
Table (4): Descriptive statistics and independent T-test results between posttest results of both the experimental and control groups. ....	45
Table (5): Pearson correlation factor between the pretest and posttest scores. ....	46
Table (6): Reliability Statistics .....	47

## List of Figures

Figure (1): Inquiry-based learning Structure.....	16
Figure (2): Pretest-posttest quasi-experiment design .....	25
Figure (3): Comparison between means' difference of pretest and posttest scores of experimental and control groups. ....	44

## **1. Introduction:**

In the recent decade, teaching has experienced the ultimate shift of developed strategies to encounter students' learning abilities. The developed technologies have been promoting the students' acknowledgment to get involved and equipped with expertise and skills to enhance the huge transformation to solve their daily life problems critically. In fact, prepared teachers, facilities and teaching programs are much needed to improve the professional pedagogical content to emphasize the growth and development of student's critical thinking skills which is mainly provoked by the inquiry-based learning strategies to be implemented in teaching programs.

Creativity has been a major focus to be approached by most of the teaching institutions realizing its major role in enhancing the community's facilities and to influence the future's insight. Starting from this thought, critical thinking skills were targeted to be the field of study for the little thinkers of middle schools to come up with how would the inquiry-based learning impacts these critical skills to be implemented, evaluated and developed. Schools reinforce low-level critical thinking skills (Bassham, Irwin, Nardone & Wallace, 2008).

Whereas students need a high level of understanding of science which can support students solve the daily-life issues. As specified in the 2013 Curriculum Basic Competency.

The students are supposed to demonstrate a rational, critical , reflective, clear and positive attitude

The world is changing rapidly these days as a result of new technologies, and new problems are arising. As a result of these developments, there are high aspirations as well as tough competitions and challenges in the future. Indeed, the various and rapid advancements in technology necessitate that the next generation be prepared and equipped with the knowledge and skills necessary to keep up with them in the future. As a result, efforts to implement a new transformation in the field of education as an integral part of society are required. These days, the value of bettering one's education has skyrocketed (UAE Vision 2030). Basically, teaching science, math, engineering, and technology in a way that benefits students.

It is much needed to cultivate a new generation that is empowered by strong thinking skills that can support their communities and bring up the economies of their countries (Radloff & Guzey, 2016). Basic reasoning is frequently appeared in fields that is beside the school or school classes. so it isn't astounding that a few explores have indicated that when a different program is utilized as the main drive for guidance in intuition, the effect of the exchange of these abilities into understudies believing is less programmed than what we would anticipate (Swartz, 1991). Subsequently, if the capacity to be associated with substance to determine important ends is our motivation, we need to look at how we receive the educating and utilization of intuition abilities in our school programs such that our understudies have the option to choose what thinking aptitudes are appropriate and how they ought to be introduced for profound figuring out how to viably occur.

Then again Inquiry-based learning is a sort of instructional method that issues drive the reasoning and learning measure as opposed to showing suspecting abilities from the earliest starting point

## **1.1 Background of the Research**

Globally, something bettered fashionable instruction happen existence supervised by advance pupils to study STEM matter and major league as their future course, area away from city need to pursue physically the becoming larger need for trained workers as a consequence endure the minimum level of engineer's educators and technicians (Wan Husin and others. 2016). The unification of looking into-located knowledge and project-located knowledge (PBL) bear evolve into an active approach cause it aims to meet the K-12 methodical study of part of material world instruction principle and next-era methodical study of part of material world flag (NGSS) plan (NSTA 2013). To evolve a new willing to oppose creation, advance instructional process and make ready with supplies the learners accompanying the necessary talent to do something to a degree logical, fault-finding thinking, cooperation, artistry, and ideas, political territory exist include in one's beliefs the STEM course of study (Lou and others. 2017).

Science and innovation education comprises of science-related aptitudes, perspectives, qualities, and data needed for people to improve their exploration request, basic reasoning,

critical thinking, and dynamic abilities, to be long lasting students, and to support their sentiments of interest in their current circumstance and the world (MONE, 2005). To create science and innovation proficiency, a wide range of exercises are utilized to urge understudies to partake in request, critical thinking, and dynamic cycles which can be remembered for the science and schooling educational program (Milli Eğitim Bakanlığı (MONE), 2005).

## **1.2 Statement of the Problem**

In most countries, traditional learning has been buried in the archive files especially in the past few years while projects and applications are being implanted in the students' minds to understand the main intelligence of the real life science. Inquiry based learning has been adopted to help develop life skills by having the student as the focus of the learning strategy which reveals an active learning and better understanding and retention of knowledge.

Contemporary science change developments stress the way that requests in science instructing are of extraordinary significance and that science ought to be educated to understudies by methods for request (American Association for the Advancement of Science, 1990; National Research Council, 1996). Science and innovation courses are basically founded on perception in grade school. In this way, numerous faculties can be engaged with the learning cycle, and understudies are empowered to effectively take an interest in classes and increase solid encounters (Nas, 2000).

## **1.3 Purpose and Question of the Study**

In the UAE, skilled exist excellent consideration to the process of instructional growth by way of the exercise of productive plan of action and approaches and the exercise of new effective approaches to a degree asking-located knowledge plan of action. To reach a goal the key instructional aim, make or become better the academic goal reached of the person actively learning and their partnership fashionable asking-located instruction, this importance bear raised. As little it exist popular concerning asking-located education fashionable the UAE, skilled exist an next need for supplementary researches to check into

thoroughly the impact of looking into-located knowledge in contact the person actively learning' urgently important thinking.

Inquiry based learning has been studied in various fields and approaches. The rationale of this study is to investigate the impact of inquiry based learning on middle school critical thinking skills of students in creating and modeling solutions to foster the creativity and deepens the prior knowledge and build on the conceptual knowledge framework. Most of the modern schools intended to encourage students to seek for external researches and teamwork in order to improve their self-directing skills that capture them out of the traditional lecturing. Although some teachers are still following the teacher-centered learning, they prefer the inquiry based learning but facing the lack of time management and subjects' materials availability inhibits their reliability to go through it smoothly.

The aim of this research was to examine the effects of use of critical thinking based, guided-inquiry instruction on students' physics learning and critical skills. The researcher used a quasi-experiment, with post-test only control group design.

The research subjects were 50 experimental group students and 40 control group students. The data were collected through critical thinking test with five description questions to see the student's critical thinking skills that have been implemented. Then, the data were analyzed using excel statistics and SPSS software.

To obtain a clearer picture about the effectiveness and the validity of the inquiry based learning, this research intends to investigate the following question:

- How does inquiry-based learning influence the critical thinking skills for high school students?

The current paper consists of 5 main chapters. The introduction is the first chapter that emphasizes the importance of inquiry based learning nationally and internationally, illustrates the background of the study, then addresses the research problem, then it presents the purpose and questions of this study, finally it emphasizes the significance of the study. The second chapter illustrates the theoretical framework and literature review, the inquiry based approach in schools' education. The third chapter addresses the methodology and approach used to collect data in the current study, in addition to the population and the sample of the study. Instruments, research procedure, and ethical considerations also are

presented in chapter three. The fourth chapter lays out a detailed summary of the analysis of the data and the key findings of the study. At last, the 5th chapter explains the main effects and states the conclusion as well as the recommendations and limitations.

## **1.4 Significance of the Study**

The significance of this examination is centered around testing the effect of inquiry-based learning on understudies' basic thoroughly considering assisting understudies with perceiving the issue and recognize the impediments. At that point inspect and dissect the thoughts that permit understudies to research the arrangements at that point widen their work by developing another arrangement and team up to sort out another or better arrangement, and in the long run the understudies used to assess, improve and report on their result. All through the investigation, the students consistently utilized the incorporation between disciplines through inquiry-based learning. Moreover, the estimation of examination comes from the vital discoveries of exploration on the adequacy of fusing the inquiry-based learning approach with STEM guidance in upgrading understudies' 21st century abilities, for example, critical thinking, inventiveness, participation, and basic reasoning (Mill operator, Sonnert and Sadler 2018). Indeed, the reconciliation of both STEM educational program and the IBL approach shows the capacity to improve the appreciation, interdisciplinary mindfulness and the eagerness of understudies to adequately coordinate the basic reasoning orders. It does this by drawing in them under the assistance of an instructor in certifiable issues (Lin, et al 2018) other than expanding the interest of understudies in seeking after STEM vocations later on (Roberts, et al 2018). As expressed by numerous analysts, IBL is among the best ways to deal with upgrade training as it can considerably improve the accomplishment and basic considering understudies (Specialty and Capraro 2017; Han 2017). As of late, numerous analysts have shown a developing revenue in learning based on the inquiry instructional tests to discover its impact on learning for understudies.

## **1.5 The Structure of the Dissertation**

The current paper comprises of 5 principle sections. The presentation is the primary section that accentuates the significance of inquiry-based learning broadly and universally, shows the foundation of the examination, at that point tends to the exploration issue, at that point it presents the reason and inquiries of this investigation, at long last it stresses the meaning of the examination. The subsequent section shows the hypothetical structure and writing survey in the UAE instructive framework known to U.A.E. instruction history, the inquiry-based learning approach. The third part tends to the technique and approach used to gather information in the current examination, notwithstanding the populace and the example of the investigation. Instruments, research technique, and moral contemplations additionally are introduced in section three. The fourth section spreads out a nitty gritty rundown of the examination of the information and the critical discoveries of the investigation. Finally, the fifth section clarifies the fundamental impacts and expresses the end just as the proposals and limits.



## **Chapter 2: Theoretical Framework and Literature Review**

The current chapter discusses the study's theoretical framework and relevant literature review.

### **2.1 Theoretical Framework**

Overview and discussion of the main theories and models that form the present study theoretical framework is included in the theoretical framework section. A few past examinations with respect to basic reasoning aptitudes were inspected by Svecova, et al. (2013) and Chukwuyenum (2013) which stressed the learning cycle to actualize and hone the basic thinking abilities. Duron's investigation (2006) additionally recommended that the learning cycle need to underscore understudies' basic reasoning abilities which plan to create significant and more charming learning encounters. The significance of basic reasoning aptitudes dependent on the above information from the past contemplates is never again be denied, on the grounds that dependent on the consequences of the study directed by PISA (Program for International Students Assessment), Indonesia is still far underneath the global normal. Indonesia positions the third from the base in the science execution whenever saw from the normal score acquired in the division of people (OECD, 2016). The low degree of the understudies' basic reasoning aptitudes is affected by two elements. To start with, the educational plan is generally planned with expansive material targets so the instructor is more centered around the material fruition. In other words, the understudies are just ready to finish the estimation yet can't interface the idea to the genuine circumstance so it impacts on understudies' learning results. The instructors actually do the traditional learning as the learning exercises in the study hall in which the educating depends on changes by and by and the consequence of the educator's instructional ideas isn't maximal. As an outcome, the understudies latently tune in and duplicate in which the educator asks and the understudies answer sometimes (Barak, 2007; Priyadi, 2018). An answer for beat the low-level of basic reasoning aptitudes is by executing a guided request learning model (Bamiro, 2015). Using guided request learning model, the educators can give the chances to understudies to learn, think basically, and examine with peers (Ibe, 2013).

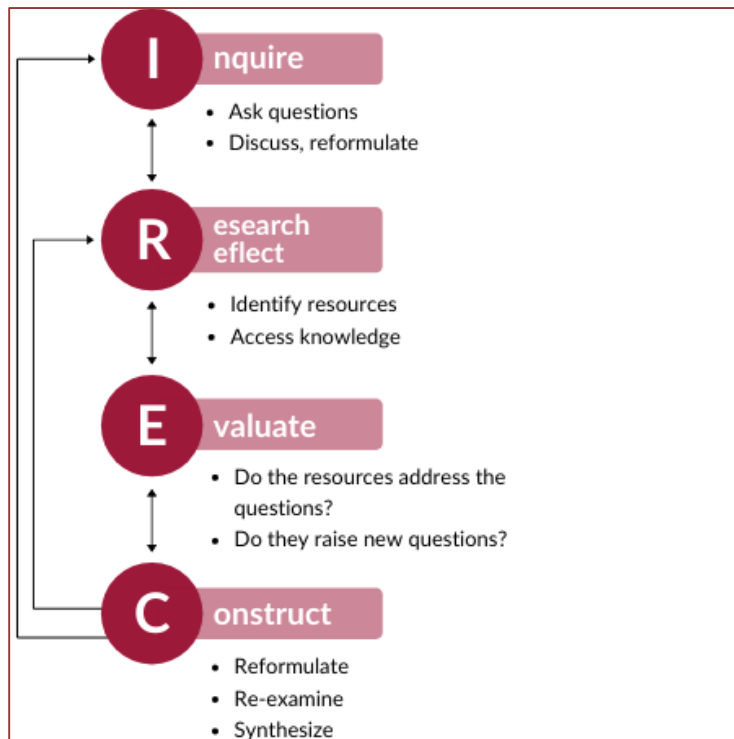


Figure 1: Inquiry-based learning structure

Dynamic learning can make the course more pleasant for the two instructors what's more, understudies, and, in particular, it can make understudies think fundamentally. For this to occur, instructors must surrender the conviction that understudies can't become familiar with the current subject except if the instructor covers it. While it is valuable for understudies to increase some presentation to the material through pre-class readings furthermore, outline addresses, understudies truly don't comprehend it until they effectively accomplish something with it and think about the importance of what they are doing. There have been numerous meanings of basic thoroughly considering the years. Norris (1985) placed that basic reasoning is choosing normally what to for sure not to accept. Senior and Paul (1994) proposed that basic reasoning is ideal perceived as the capacity of scholars to assume responsibility for their own reasoning. Harris and Hodges (1995) expressed basic assessment as the way toward showing up at a judgment about the worth or effect of a book by analyzing its quality. The scientific classification offered by Benjamin Bloom around 50 years back offers a clear method to group instructional exercises as they advance in trouble (Bloom, 1956). The lower levels require less reasoning aptitudes while the more elevated

levels require more. The hypothesis of basic reasoning started fundamentally with crafted by Bloom (1956), who distinguished six levels inside the psychological area, every one of which identified with an alternate degrees of intellectual capacity. Information zeroed in on recalling and discussing data. Appreciation zeroed in on relating and sorting out recently learned data. Application zeroed in on applying data as per a standard or guideline in a particular circumstance. Examination was characterized as basic thinking zeroed in on parts and their usefulness in the entirety. Combination was characterized as basic suspecting zeroed in on assembling parts to frame a new and unique entirety. Assessment was characterized as basic reasoning centered after esteeming and making decisions dependent on data.

Notwithstanding the learning model, another angle identified with beating the understudies' low basic reasoning aptitudes is offices and media utilized by the educator in the learning cycle. Data and correspondence turned into the most significant segments of current training. Data and correspondence instruction are minded everywhere on the world and practically all instructive associations had data and correspondence divisions (Cereci, 2019). As the data and innovation field has quick turn of events, the data and innovation use in the training field can uphold the learning cycle, and one of which is the utilization of macromedia streak. The introduction of the macromedia streak is straightforward on the grounds that it can envision reenactments and movements that make the pictures look genuine items. In this way, utilizing activity can influence understudies' reasoning cycle (Tasker and Dalton, 2006).

Inquiry based learning has an assortment of hidden methodologies including understudy focused connections, understudy examinations and involved exercises, and the utilization of models and applications. This kind of educating permits understudies to participate in science by methods for cycles, for example, addressing, investigating, associating, watching, thinking, and reflecting. Numerous investigations have shown that these methodologies have the capability of upgrading students' metacognition and argumentation; may help with creating/improving students' inspirational mentalities toward science (Mooney and Laubach, 2002; Oliver-Hoyo and Allen, 2005); effectsly affect their science accomplishment and enthusiasm for science (Areepattamannil, 2012); and keep up their inspiration and commitment in the subject (Heflich, Dixon, and Davis, 2001). Two as of late

distributed meta-investigation reports (Furtak, Seidel, Iverson, and Briggs, 2012; Minner, Levy, and Century, 2010) affirmed the beneficial outcome of request put together instructing changes with respect to understudy learning accomplishments in science, especially when instructors effectively guided understudy exercises with regards to request based learning.

Inquiry based learning has been advanced by various science training affiliations (American Association for the Advancement of Science, 1993; Mullis, Martin, Ruddock, O'Sullivan, and Preuschoff, 2009; National Research Council, 2001; Organization for Economic Co-Operation and Development, 2009). In any case, it has not been very much executed in the homeroom (Kazempour, 2009; Zhou, 2014). Instructor readiness has been recognized as a critical factor for such a hole between hypothesis/strategy and practice (Kazempour, 2009; Richardson and Liang, 2008; Ruiz-Primo, Li, Tsai and Schneider, 2008; Sadler and Klosterman, 2009). Numerous new and experienced educators have not scholarly through request, yet rather through latent learning (Friesen and Jardine, 2010). As instructors tend to educate in a manner they were educated (Britzman, 1991; Lortie, 1975), it has demonstrated to be a test for educators to move to encouraging request based homerooms (Potvin and Dionne, 2007).

A few analysts (Landsman and Gorski, 2007; Sandholtz, Ogawa, and Scribner, 2004; Sheldon and Biddle, 1998; Wong, 2007) propose that the current instructive pattern to normalize educational plans and spotlight on test scores sabotages teachers' capacity to address basic deduction in the homeroom. The accentuation on "educating to the test" diverts the taking in measure from 58 Asian Journal of University Education understudy focused guidance and spots the accentuation on the substance. In the event that the attention is on learning, understudies ought to be given the opportunity to investigate content, break down assets, and apply data. Tragically, understudies are not normally instructed to think or adapt autonomously, and they seldom "pick up" these aptitudes all alone (Ladsman and Gorski, 2007; Lundquist, 1999; Rippen, Booth, Bowie, and Jordan, 2002). Basic reasoning isn't an intrinsic capacity. Albeit a few understudies might be normally curious, they require preparing to turn out to be methodically explanatory, reasonable, and liberal in their quest for information. With these aptitudes, understudies can get sure about their thinking and apply their basic intuition capacity to any substance territory or then again discipline

(Lundquist, 1999). Basic reasoning is regularly contrasted with the logical strategy; it is a methodical and procedural way to deal with the cycle of reasoning (Scriven and Paul, 2007). Similarly as understudies gain proficiency with the cycle of the logical strategy, they should likewise gain proficiency with the cycle of fundamentally thinking. Four hindrances frequently block the joining of basic speculation in training: specifically, absence of preparing, absence of data, biases, and time imperatives.

By and large, an inquiry-based learning exercise first beginnings with a meeting to present the issue, community oriented gathering work and an introduction of discoveries. In Inquiry-based learning draws near, understudies don't simply learn by social occasion information, however through making a comprehension of the ideas they face. Through a critical thinking, the student researches thoughts inside a unique circumstance, and considers the new ideas with his earlier information. Lipman (2003) contends that request starts when there is a distinction in what we experience. This catches our eye and requests our response and examination. In introducing issues to drive the securing of psychological aptitudes, issues are intended to be like certifiable circumstances. The understudies draw in with the issue and the issue request measure makes intellectual cacophony that animates learning. In working with genuine world situations, understudies utilize the parts of basic idea and activities that are related relying upon the crowds and settings included.

Past investigations have indicated that understudies' basic reasoning capacities are essentially higher when the materials are educated through request based picking up contrasting and customary showing techniques Wongkam et al (2014). In this investigation, the educator surveys the understudy's earlier information and draws in the understudy's enthusiasm for new ideas through short exercises to assist the understudy with utilizing their earlier information so as to produce new thoughts, investigate questions and conceivable outcomes. Request based learning is a procedure in instruction that understudies seek after strategies and practices like those of expert researchers to build information (Keselman, 2003). It very well may be clarified as a cycle of finding new relations, with the understudies making theories and testing them by doing tests or having perceptions (Pedaste, Mäeots, Leijen, and Sarapuu, 2012). Regularly it is seen as an way to deal with tackling issues and includes the use of a few critical thinking aptitudes (Pedaste and Sarapuu, 2006). Request put together learning depends with respect to dynamic interest

furthermore, student's obligation regarding finding information that is new to the student (de Jong and van Joolingen, 1998). In this cycle, understudies regularly complete a self-coordinated, mostly inductive and incompletely deductive learning measure by doing tests to examine the relations for at any rate one lot of needy and free factors (Wilhelm and Beishuizen, 2003).

## **2.2 Literature Review:**

Fitting appraisal can deliver exact learning achievement information and be utilized as a reason for deciding the development. Appraisal framework is the way toward social occasion and preparing data to decide the accomplishment of learning results of understudies. In accordance with who expressed that evaluation is an announcement dependent on various realities to clarify the attributes of an individual or something. Expressed that evaluation is a few strategies that are precise to gather data and utilized for making decisions about the attributes of an individual or item. Besides, clarified that appraisal implies assessing something; take a choice on an issue dependent on the significance of positive or negative, sharp or dumb, and so on. In view of a portion of these definitions, evaluation is all exercises did by teachers and understudies to survey themselves with the point that learning and learning exercises become better.

The current investigation followed the illustrative successive blended methodology utilizing both quantitative and qualitative models with start and spotlight on quantitative methodology. The blended strategy approach is characterized by Creswell (2009) as the cycle of both quantitative and qualitative information obtaining and investigation inside an examination. As expressed by Lund (2012), the examination of blended strategies approach is more commonsense than subjective or quantitative confined techniques for a total image of the subject testing to give precise responses to complex problems. Joining qualitative and quantitative techniques has two primary preferences. To begin with, consolidating the two methodologies ought to permit information examination to all the more likely improve the outcomes. Creswell, (2009) states that the qualitative methodologies dissect circumstances from the perspective of the members. It is in this way taken from the constructivist theory that respondents had the option to make their comprehension of the condition. Qualitative

analysis subsequently intends to dissect the social significance through members' nervousness and absorption of the wonder inspected (Mayoh and Onwuegbuzie, 2014), this could likewise assist with completing a given type of every day occasions applicable to the members that is identified with the exploration point (Frederick and Erickson, 2012). In which it will assist with accomplishing more extensive and more profound results (Lund, 2012). Quantitative investigation, then again, offers more to theory testing and regularly gives more generalizable and steady consequences of an exploration than subjective methodologies (Lund, 2012). The blended model methodology has the favorable position that you can utilize both quantitative and subjective strategies to get away from their constraints (Lund, 2012). Creswell (2008) advances the preparing and investigation of different information dependent on the way of thinking of realism.

The primary explanation in this investigation to pick and utilize the blended model methodology is that the exploration issue requires both quantitative and qualitative information to be accumulated (Creswell, 2014). Accordingly, the mix of both quantitative and qualitative strategies, according to Creswell (2013), gives better understanding, since this is equipped for responding to investigate questions altogether. The logic theory has thusly been followed, as it is a decent reason for undertaking scholastically sound and normal work in the blended strategy system (Creswell, 2014). The Most significant factor of adjusting logical thinker theory is that the realist reasoning spotlight on the motivation behind the examination instead of the cycle of the exploration.

To approach the aim of this study, a quasi-experimental approach was utilized so as to gather the quantitative information for this exploration. Experimental research is among the best examination strategies to distinguish the circumstances and logical results connections among factors and endeavors to influence a solitary variable (Fraenkel, Wallen and Hyun, 2012). quasi-experimental strategy is characterized as exploratory conditions in which the analysts dole out subjects to classes, yet not arbitrarily, in light of the fact that the experimenter can't make counterfeit test gatherings (Creswell, 2012). In contrast with different strategies, the factors are more controlled than some other kind of examination in trial contemplates and the dangers that could impact the inside legitimacy of the test are diminished (Fraenkel, Wallen and Hyun 2012). Thusly, irregular determination of controls and study bunches in instructive exploration isn't generally achievable, and it will interfere

with the homeroom (Cohen, Manion and Morrison 2007, Creswell 2012). Wherefore, a test bunch plan with normally happening examination bunches is picked to be as nearer as could reasonably be expected (Fraenkel et al. 2012). Hence, one of the significant focal points of the semi test study is to examine the wonders in their regular setting that meets the examination's outside legitimacy while holding medium to high control.

Students have become rote learners, merely believing what is being fed to them, seeing their lecturers or teachers as disseminators of information as a result of the strain and over-reliance on getting good grades. This is information that should not be asked. They're churned into something else. Because of the exam-oriented method, they are followers and have a narrow worldview. This places academic achievement on a pedagogical pedestal.

Malaysia needs active learners who have developed problem-solving, critical thinking, and autonomous skills in order to achieve Vision 2020. Lee (1999, as cited) described learning as "the ability to learn as well as the ability to function cooperatively." Norshima (2011, Norshima, Norshima, Norshima, Nor As a result, the aim of teaching CTS in higher education is to improve students' thought skills as well as appropriate decision-making and undecided.



## **3. Methodology**

### **3.1 Research Design**

The current examination followed the illustrative successive blended methodology utilizing both quantitative and subjective models with start and spotlight on quantitative methodology. The blended strategy approach is characterized by Creswell (2009) as the interaction of both quantitative and subjective information obtaining and investigation inside an examination. As expressed by Lund (2012), the examination of blended techniques approach is more useful than subjective or quantitative segregated strategies for a total image of the subject testing to give precise responses to complex problems. Joining subjective and quantitative strategies has two principle benefits. To begin with, joining the two methodologies ought to permit information investigation to more readily improve the outcomes. Furthermore, this mix would open new lines of thoroughly considered the goal of inconsistencies from the different information sources (Mayoh, Onwuegbuzie, 2015). In addition, such inconsistencies can prompt considerably more idea, thought, arbitration, and investigation. It likewise ensures the legitimate gathering and examination of the outcomes Lund (2012). Quantitative and subjective methodologies have varieties in sure and negative viewpoints that build up each other and henceforth improve the study's discoveries (Mayoh and Onwuegbuzie, 2014). Creswell, (2009) affirm that the subjective methodologies dissect circumstances from the perspective of the members. It is subsequently taken from the constructivist theory that respondents had the option to make their comprehension of the condition. Subjective investigation subsequently intends to dissect the social importance through participants' tension and osmosis of the marvel analyzed (Mayoh and Onwuegbuzie, 2014), this could likewise assist with doing a given type of every day occasions pertinent to the members that is identified with the examination theme (Frederick and Erickson, 2012). In which it will assist with accomplishing more extensive and more profound results (Lund, 2012). Quantitative investigation, then again, offers more to theory testing and frequently gives more generalizable and steady aftereffects of an exploration than subjective methodologies (Lund, 2012). The blended model methodology has the benefit that you can utilize both quantitative and subjective strategies to get away from their impediments (Lund, 2012). Creswell (2008) advances the preparing and investigation of

different information based on the way of thinking of sober mindedness. The realist theory possibly acknowledges thoughts as substantial when they support practice. Pragmatics consider that there are a wide range of translations of the world and examination that there can never be any single view, and there can be numerous possibilities (Saunders, Lewis and Thornhill, 2012). Exploration question is the main determinant of the examination technique, as per sober mindedness research Reasoning. Johnson and Christensen (2012) proposed the utilization of both quantitative and subjective methodologies. It makes all issues be investigated by the specialist and give a superior comprehension of the examination.

The fundamental explanation in this investigation to pick and utilize the blended model methodology is that the exploration issue requires both quantitative and subjective information to be assembled (Creswell, 2014). Accordingly, the mix of both quantitative and subjective strategies, according to Creswell (2013), gives better arrangement, since this is equipped for addressing research questions completely. The logic reasoning has along these lines been followed, as it is a decent reason for undertaking scholastically intelligent and normal work in the blended strategy approach (Creswell, 2014). The Main factor of adjusting practical person theory is that the realist methods of reasoning spotlight on the motivation behind the examination instead of the interaction of the exploration.

Quasi-experimental approach was utilized to gather the quantitative information for this examination. Exploratory research is among the best exploration strategies to recognize the circumstances and logical results connections among factors and endeavors to influence a solitary variable (Fraenkel, Wallen and Hyun, 2012). Quasi-experimental approach is characterized as exploratory conditions in which the scientists allot subjects to classes, yet not arbitrarily, on the grounds that the experimenter can't make fake trial gatherings (Creswell, 2012). In contrast with different techniques, the factors are more directed than some other kind of exploration in test examines and the dangers that could impact the inward legitimacy of the test are decreased (Fraenkel, Wallen and Hyun 2012). In this way, irregular determination of controls and study bunches in instructive examination isn't generally practical, and it will interfere with the study hall (Cohen, Manion and Morrison 2007, Creswell 2012). Wherefore, an exploratory gathering plan with normally happening correlation bunches is picked to be as nearer as could be expected under the circumstances

(Fraenkel et al. 2012). Along these lines, one of the significant preferences of the semi test study is to dissect the marvels in their normal setting that meets the investigations outside legitimacy while holding medium to high control.

In the quantitative part, a pretest-posttest quasi-experiment was carried out in order to fulfill the study purpose to find the impact of IBL approach on students' critical thinking. As such, the purpose is to find the change due to IBL approach, which is the independent variable on the students' critical thinking, which is the dependent variable for the experimental group.

The design of the experiment is shown in figure 2.

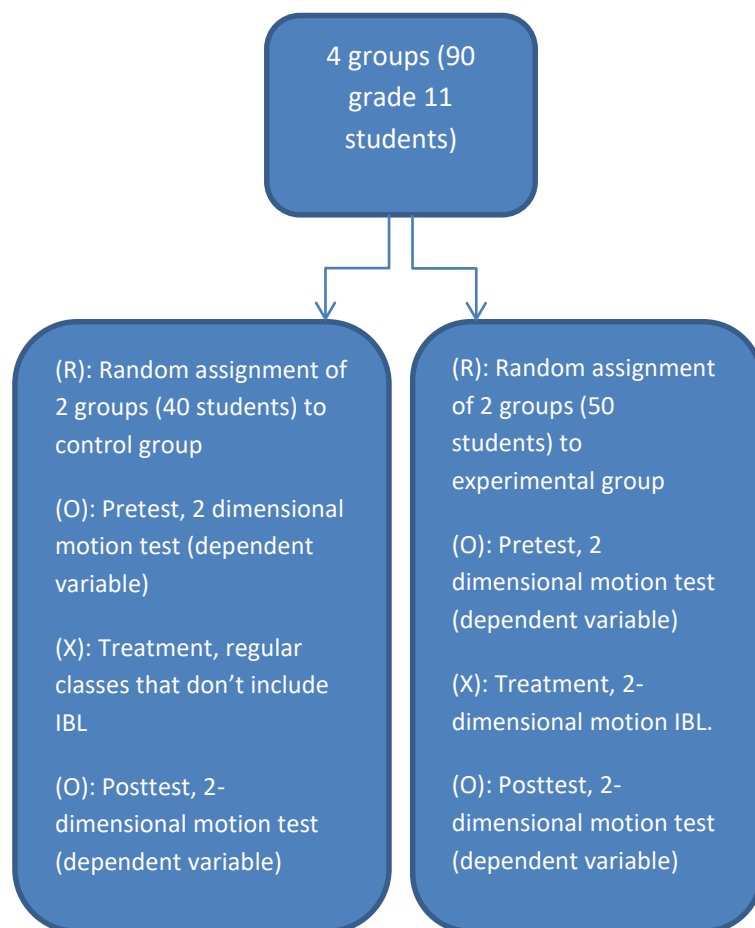


Figure (2): Pretest-Posttest quasi experimental design

After finishing the experiment and collecting the data quantitatively, 5 open-ended questions were used through face-to-face semi-structured interview to collect the data qualitatively (See Appendix 1).

Explanatory sequential mixed-methods approach was utilized in the current study in which the data are collected and analyzed quantitatively first, and then qualitative data were collected in order to fully explain the quantitative data results (Creswell, 2014). It is called descriptive because quantitative data findings were later explained using qualitative data. Therefore, the quantitative process is performed in a series before the qualitative phase (Creswell, 2014).

The reason behind choosing this approach is the gap to be studied. In the case where the data are not available in the literature the researcher start with the qualitative data first then follow up with the quantitative data in order to generalize the results. If there is available information in the literature, on the other hand, the researcher begins with quantitative data collection, then analyses is carried out with the qualitative data so that the results of the current study can be fully explained (Creswell 2014).

### **3.2 Site**

The current examination was completed in Sharjah tuition based schools inside the UAE setting. Because of the MOE\'s solid consideration regarding the scholastic change measure and the presentation of STEM and IBL training in schools educational plans (UAE Vision, 2030); the chose school is appropriate for completing this investigation. The ebb and flow study was done in tuition based school in Sharjah that follows the American educational program, which embrace the NGSS norms where the scientist works. The clarification why this school was chosen in light of the extraordinary consideration that the US pays to current training to help the economy. This consideration was reflected in the educational plans of science, software engineering and arithmetic. Cutting edge Science Guidelines (NGSS) accentuation in their exercises on IBL rehearses, so all American-framework schools across the globe that execute NGSS become impacted by this obligation to arrive at the IBL to a

specific level. What's more, instruction organizations in the U.A.E. implement guidelines on schools to present creative educational programs that expansion dynamic learning, improve relational abilities, construct a helpful and animating learning climate, empower an imaginative showing climate just as basic reasoning abilities (MOE, 2010).

### **3.3 Study Procedure**

The current examination followed various stages. Initial, a pretest was given to the two gatherings test and controlled gathering, yet just on the exploratory gathering were applied IBL exercises. At that point, the trial bunch went through various stages. Toward the start, the instructor straightforwardly introduced to understudies the subject of two dimensional movement to present them with a reasonable thought of shot movement. The understudies were accordingly haphazardly separated into bunches during the subsequent stage and needed to utilize all that they figured out how to build up a thought that shows two dimensional movement at that point to assemble their own analysis. During their examination, the educator taught and offered them three distinct thoughts: ordinance, boat in a waterway, b-ball. Indeed, the educator allowed the understudies the chance to make their own methodology for their examinations with the proposed materials to permit them the chance to show their appreciation of the subject in their exploration. At that point, understudies demonstrated their investigations on papers and afterward continued in making them, auditing their examination themselves. At long last, understudies were approached to make formal composition to explain how their investigation is made and what sort of movement their thought reflects. The posttest was then led with the two gatherings to gauge the effect of the treatment on the trial gathering and to evaluate the distinction between the two classes. In a semi trial plan, "the analyst doesn't utilize irregular task of members to groups\" (Fraenkel el al. p.275) be that as it may, to limit the dangers to the interior legitimacy of the exploration, the flawless gatherings are haphazardly doled out to the treatment. So the test gathering can in a perfect world build up their accomplishment in the material science classes by inquiry-based learning models.

### 3.4 Sampling and Participants

The current investigation was led in a K-12 American educational plan school over a five-week time span with 90 evaluation five understudies, from the young lady's part in tuition based school in Sharjah, UAE. The analyst encouraged every one of the material science classes. As an American school, the language of conveying the exercises and correspondence is the English language. At this school, understudies enter grade one at six years old and finish grade 12 at age of 18. In the center high area, a large portion of the classes have 30 understudies in each class in normal where young men and young ladies are isolated in various classes from grade 4 until secondary school. The all out number of the members is 90 evaluation eleven young ladies' high understudies. The explanation for picking this example for this investigation is that the analyst is the instructor for these classes. The members were just young ladies between the ages of 16-17 years. Contrasts among control and trial bunch during a semi trial are normal like age, students' accomplishment levels in science and various abilities that could influence the free factors (Fraenkel et al. 2012). Therefore, a pretest-posttest semi test plan with normally happening examination bunches was viewed as the best way to deal with increment the study's inside legitimacy. The examining strategy in the flow study is a bunch arbitrary testing where existing bunches or unblemished gathering, which are the classes, have effectively been chosen by the specialist to be arbitrarily appointed to test and control gatherings (Fraenkel, Wallen and Hyun, 2012). Three classes were haphazardly separated into two gatherings, two test and two benchmark groups.

The majority of the students had the same cultural background where most of them were Emirate students. Based on the pretest results students' average scores in critical thinking test which represent an equal student distribution in control groups and experimental groups as presented in table 1 below.

<b>Groups</b>	<b>Number of Students</b>	<b>Mean</b>	<b>Standard Deviation</b>
<b>Group A (control)</b>	20	2.9	1.97
<b>Group B (control)</b>	20	2.95	2.235
<b>Group C (experiment)</b>	25	3.08	1.705
<b>Group D (experiment)</b>	25	3.16	1.929

Table (1): Students' Average results in the pretest.

### 3.5 Instrumentation

Data collected by qualitative and quantitative methods in two different ways. A test was developed by the researcher in order to collect the data needed for the quantitative part (See Appendix 2). The test consists of 10 multiple-choice questions of critical thinking that tests the critical skills of students and how it would change after studying through inquiry-based learning for a period of time. The five weeks inquiry study focuses on teaching the students the main concepts of understanding the motion in two dimensions in addition to the factors affecting this motion that occurs in real life applications. Moreover, students applied the main driven formulas related to the two dimensional motion through guided inquiry learning in the physics lab where they could spend their efforts in investigating the topic and following the major skills of the inquiry study through modeling their own experiments. Accordingly, 90 copies of the test were printed out and distributed to the student before and after the experiment. Then, Qualitative data were collected through semi-structured interviews using five open-ended questions related to the aim of the research (See Appendix 1). The researcher interviewed ten students from the experimental group 5 students from each class in the school where they were asked to express their IBL experience. Then their responses to open-ended questions are taped in order to get participants' perspectives (Creswell, 2014). The respondent has the right to decide his responses, explanations and how much to talk in semi-structured interviews (Kasim and Al-

Gahur, 2015). In fact, it is at the discretion of the interviewer to address the different subjects and the nature of the questions (Corbetta, 2003). In fact, Gray (2004) suggests that this style of interview provides the interviewer the freedom to analyze and evaluate the interviewee's perspectives.

On account of its accentuation on dissecting factual information, SPSS is an incredibly integral asset for controlling and unraveling study information. Fun certainty: The information from any overview gathered by means of Alchemer can be traded to SPSS for point by point investigation. Sending out review information to SPSS's restrictive .SAV design makes the way toward pulling, controlling, and examining information perfect and simple. Thusly, SPSS will naturally set up and import assigned variable names, variable sorts, titles, and worth marks, implying that negligible legwork is needed from scientists. When review information is traded to SPSS, the chances for factual examination are basically perpetual. So, make sure to utilize SPSS when you need an adaptable, adjustable approach to get excessively granular on even the most unpredictable informational indexes. This gives you, the scientist, more opportunity to do what you excel at and recognize patterns, create prescient models, and make educated determinations.

The interviews consisted of five questions; the first three questions focused on the experiments they performed and the steps they went through in order to accomplish their understanding and if they faced any difficulties through the experiment and how did they solve it, in addition to how they thought about conclusions related to two dimensional motion through deep investigation as they were recording and observing outcomes. The next two questions asked the participants to express their experience through IBL and the new skills they developed through this experience. Also they had the opportunity to look forward to where they see themselves



working in the future. The interviews and the test included questions about real-world issues, teamwork, problem solving, technology use, critical thinking and creativity.

### **3.6 Validity and Reliability of Study**

Legitimacy and unwavering quality checks for rebellious being utilized in a investigate is imperative as expressed by Creswell (2014). Legitimacy is the degree to which a address tests what it was implied to degree to generalize the discoveries (Johnson 2014). Legitimacy tests incorporate legitimacy of substance estimations, questions and legitimacy of the arrange (Johnson 2014). The test utilized in the quantitative portion and the meet questions within the subjective portion was reexamined by a college teacher who prescribed changes to certain things to affirm the legitimacy of the instruments utilized in this investigate. Besides, two science instructors who are educating review five changed the test to set and fix the substance of the test. In expansion, one English instructor changed the test in arrange to eliminate any dialect issues within the test. Quasi-experimental investigate points to appear the circumstances beneath ponder in real-world circumstances and hence improve outside legitimacy of the ponder (Heinsman & Shadish, 1996).

A variety of the pretest-posttest arrangement is the obstruction with time-arrangement arrange. A period course of action could be a bunch of estimations taken at extends all through a few indistinct time outlines. For occasion, a gathering organization may evaluate its laborers' benefit each week for a year. In an obstruction with time course of action arrange, a period course of action like this one is "interfered" by a treatment. In one model demonstrate, the treatment was the diminish of the work shifts in a generation line from 10 hours to 8 hours (Cook and Campbell, 1979). Since productivity extended or maybe quickly after the shortening of the work shifts, and in light of the truth that it remained raised for a long time hence, the examiner contemplated that the shortening of the developments caused the increase in productivity. Take

note that the barged in on time-arrangement setup takes after a pretest-posttest arrange in that it joins estimations of the dependent variable both when the treatment. It is not normal for the pretest-posttest plan, in any case, in that it incorporates different pretest and posttest estimations. Reliability applies to a set of test scores remaining consistent or stable if a test or assessment technique provides accurate results, the scores will be identical on any occasion (Johnson 2014). Test and retest is one way of measuring the reliability of a research tool using correlation coefficient (Johnson 2014). The reliability calculations of the test used in the study after the students did the pretest and posttest data are presented in the next chapter.

The analyst being the instructor, who did the arranging for the ventures and carried out the stages of the inquire about within the put where the investigate was conducted, guaranteed the dependability of the information collected and the comes about. Additionally, the analyst was with the understudies continuously and he was mindful of collecting the information from the understudies by conducting the pre, posttests and the interviews. The researcher's cooperation in these steps in collecting information has progressed the unwavering quality and legitimacy of the inquire about as he had a clear thought around the considered wonders.

### **3.7 Data Analysis**

After conducting the stages of the study, collected data from the quantitative and qualitative parts were analyzed in order to answer the research question. As stated before, the current research followed the explanatory sequential approach, as a result, the quantitative data were collected and analyzed first then the qualitative data were collected to support and solidify the results. Quantitative data were collected using the critical thinking test. Experimental and control group results were collected and saved in an Excel file and then statistically analyzed using the SPSS software. Authoritatively named IBM SPSS Statistics, most clients actually allude to it as SPSS. As the world norm for sociology information investigation, SPSS is

generally pined for due it's clear and English-like order language and amazingly exhaustive client manual. SPSS is utilized by economic scientists, wellbeing specialists, study organizations, government elements, training analysts, advertising associations, information excavators, and a lot more for the preparing and breaking down of review information. While Alchemer has ground-breaking worked in revealing highlights, with regards to inside and out measurable examination scientists consider SPSS the top tier arrangement. Most top examination offices use SPSS to dissect review information and mine content information so they can take advantage of their exploration projects. Parametric investigation was required since there were more than 30 members (Field, 2009). In arrange to reply the investigate address graphic and inferential measurable tests have been used to discover in the event that there's a noteworthy measurable distinction between the exploratory bunch and control gather within the cruel of the students' comes about within the pre and posttest and inside each bunch in arrange to test the ponder speculation (Field, 2009). Subjective information was collected utilizing semi-structured interviews. Students' answers were sound taped and analyzed. Examination of the subjective portion for this considers (semi-structured interviews) will receive the sort of themes (Crsewell 2014). Since this portion is subjective, the researcher gathered reactions from all understudies and after that analyzed them in arrange to indicate the most themes and points of view. This strategy of ponder is alluded to as the inductive prepare in which the analysts determine significance from information collected within the field (Creswell 2014).

### **3.8 Ethical Considerations**

When conducting research, ethical issues should be foreseen (Bryman & Bell, 2011). Gajjar, (2013) points out that alignment with ethical standards is essential in research because it can help validate study goals such as inventiveness and trustworthiness and anomaly avoidance.

Examination combinations assume an amazing part in forming further exploration, practice, strategy and public insights. In like manner, the moral issues related with how points of view of various gatherings are incorporated or blue-penciled in an exploration blend report should be given satisfactory consideration. Any examination amalgamation is naturally affected by subjectivities related with numerous layers of translation, choice and portrayal. In outlining an examination blend, it is imperative that synthesists consider: numerous interests and impacts of various partners; possible effect of the amalgamation on various partners; synthesis's' own different and moving characters inside the combination; synthesis's' methodological situating inside the union; status agreed to creators and members of the essential exploration contemplates remembered for the union; impacts of subsidizing organizations; governmental issues of who/what gets distributed; and inclinations presented through normal systems for recovering essential exploration considers. I have brought up essential issues and issues to structure and educate basic dynamic all through an amalgamation interaction.

In arrange to guarantee the pertinence of all moral benchmarks within the show ponder, the analyst counseled with the Essential School Director, Head of Scholastics and Head of Science. Amid the assembly, the analyst clarified the reason of the research and how it'll be conducted in their school. In truth, an official letter from the British College in Dubai was sent to school administration asking authorization to embrace this inquire about (See Reference section 3). The analyst guaranteed that the characters of the understudies were mysterious. School title was assured for the school administration that it'll stay mysterious and the comes about will be utilized for the reason of the inquire about as it were (Creswell, 2014). School confirmation was

educated that they seem pull back from taking an interest in this consider at any time and without any punishment. The members have had the flexibility to take an interest in this try and have been educated that they can pull back from the think about in case they think they ought to do so at any time. They were also told that they would value their integrity and confidentiality. Consequently, in respect to what was previously stated, all the recommended ethical standards were discussed during this review, focusing on all the points accepted with the school administration. After collecting the data, data analysis and the results are presented in the next chapter.

## **Chapter 4: Results and Data Analysis**

The current study was carried out in order to study the impact of implementing IBL approach on high school students' critical thinking through physics inquiry based learning approaches in the UAE. This chapter presents a comprehensive and thorough analysis of the results after collecting qualitative and quantitative data. A pretest-posttest quasi-experimental design was used in order to collect the data quantitatively. After completing the quasi-experiment, many interviews with the students were carried out in order to collect the data qualitatively where they were asked to provide a feedback about their inquiry-based experimental work and evaluate their experience.

### **4.1 Quantitative Results**

In order to meet the study aim, a pretest-posttest quasi-experimental design was implemented to assess the impact of implementing inquiry-based learning approach on high students' critical thinking through physics classes. Therefore, the aim is to assess the effect of inquiry-based learning approach, which is the independent variable on the high school student's critical thinking, which is the dependent variable for the experimental group against the control group where inquiry-based learning approach was not used. This research was carried out at a K-12 private school in Sharjah that follows American curriculum. The participants were ninety and ten grade eleven students. One hypothesis have been formulated in conjunction with the research intention to direct the study's analysis to address the study question: what is the impact of implementing inquiry-based learning approach on the critical thinking of high school students?

The hypothesis that guided the research analysis was: There would be a statistically significant difference in student critical thinking between students who have been taught using the inquiry-based learning approach and those who have not.

The SPSS statistical tool was used to interpret quantitative data by using different forms of statistical tests in order to address the research question and analyze the data collected. First, in order to test the influence of an independent variable on dependent variables, the data obtained from the pretest was analyzed using One-way ANOVA test for the experimental and control groups in order to assess whether the groups are equal and the sampling is appropriate.

In insights, single direction investigation of change (abridged one-way ANOVA) is a strategy that can be utilized to think about methods for at least two examples (utilizing the F dispersion). This procedure can be utilized uniquely for mathematical reaction information, the "Y", typically one variable, and mathematical or (normally) clear cut information, the "X", consistently one variable, thus "one-way".

The ANOVA tests the invalid theory, which expresses that examples on the whole gatherings are drawn from populaces with similar mean qualities. To do this, two evaluations are made of the populace fluctuation. These assessments depend on different presumptions (see beneath). The ANOVA delivers a F-measurement, the proportion of the fluctuation determined among the way to the change inside the examples. On the off chance that the gathering implies are drawn from populaces with similar mean qualities, the difference between the gathering means ought to be lower than the change of the examples, following as far as possible hypothesis. A higher proportion hence suggests that the examples were drawn from populaces with various mean values.

Normally, nonetheless, the single direction ANOVA is utilized to test for contrasts among at any rate three gatherings, since the two-bunch case can be covered by a t-test (Gosset, 1908). When there are just two intends to think about, the t-test and the F-test are same; the connection among ANOVA and t is given by  $F = 0.05$ . An augmentation of single direction

ANOVA is two-path investigation of change that inspects the impact of two diverse clear cut autonomous factors on one ward variable.

Second, expressive measurements were connected to compare the cruel scores of test bunch and control bunch in pretest and posttest where matched t-test was utilized in arrange to discover on the off chance that there's any measurably contrast between their pretest and posttest scores for both bunches. At last, the contrast between control and test bunches in posttest scores were analyzed utilizing an free T-test, to decide whether the two gather scores contrast measurably altogether.

The t score is a proportion between the contrast between two gatherings and the distinction inside the gatherings. The bigger the t score, the more distinction there is between gatherings. The more modest the t score, the greater similitude there is between gatherings. A t score of 3 implies that the gatherings are multiple times as not the same as one another as they are inside one another. P-values are from 0% to 100%. They are typically composed as a decimal. For instance, a p estimation of 5% is 0.05. Low p-values are acceptable; They demonstrate your information didn't happen by some coincidence. For instance, a p-estimation of .01 methods there is just a 1% likelihood that the outcomes from an analysis occurred by some coincidence. By and large, a p-estimation of 0.05 (5%) is acknowledged to mean the information is substantial.

#### **4.1.1 Equivalency and adequacy between experimental and control groups in the pretest.**

Ninety and ten grade eleven girls' students in four different classes were the participants in this research. Randomly, the four classes were divided into two groups. Class A (20 girls students) and class B (20 girls students) where the control group with a total number of 40



students. The experimental group consists of class C (25 girls students) and class D (25 girls students) with a total number of 50 students. To order to assess the equivalence of the 4 classes the four classes have been pretested and the results compared. Table 1 in chapter 3 showed the averages for each class, the averages are as follow: class A (2.9), class B (2.95), class C (3.08), and class D (3.16). The averages for all classes are close to each other and showed that there is no difference between the classes. In order to find if there is any statistically significant difference between the averages of all four classes One-way ANOVA test has been used. The results are presented in table 2 below. Students' results in the pretest for all classes are presented in Appendix 4.

<b>Pretest</b>					
	<b>Sum of Squares</b>	<b>df</b>	<b>Mean Square</b>	<b>F-Value</b>	<b>P-Value</b>
<b>Between Groups</b>	.950	3	.317	.083	.969
<b>Within Groups</b>	327.950	86	3.813		
<b>Total</b>	328.900	89			

Table (2): One-way ANOVA test analysis between the control and experimental groups.

Table 2 indicates that there is no statistically significant difference between the pre-test scores for the students of the four classes composed of the experimental and control groups where the P-value = 0.969 > 0.05. That indicates a strong degree of equivalence between them. Therefore, experimental and control groups have similar starting points prior to treatment, as a result the current study may be considered suitable for the current classes.

#### **4.1.2 Differences between pretest and posttest results of the experimental and control groups.**

The first level of analysis is to compare students' pretest and posttest scores for both experimental and control groups to determine the impact of the inquiry-based learning approach on students' achievement. A paired t-test and descriptive statistics were used to

determine whether there is any significant difference between the students' pretest and the posttest results for both experimental and control groups. The results are shown in table 3 below. Full analysis presented in Appendix 5. Students' results in the posttest for all groups are presented in Appendix 4.

Group		Mean	N	Std. Deviation	Std. Error Mean	t	df	Sig. (2taile)
Experimental Group	Pretest	3.12	50	1.802	.25497	16.681	49	.000
	Posttest	7.82	50	1.223	.17306			
Control Group	Pretest	2.925	40	2.080	.32892	7.059	39	.000
	Posttest	5.375	40	1.764	.27893			

Table (3): Descriptive statistics and paired T-test results between the pretest and posttest results of both the experimental and control groups

Based on the paired t-test results presented in table 3 above it is observed that there is a strong significant difference between the pretest and posttest results for the experimental group  $t(50) = 16.681$ ;  $P < 0.05$  where the significant value  $p = 0.000$ . For the control group it showed also that there is a statistically significant difference between the pretest and posttest results where  $t(40) = 7.059$  and  $P = 0.000 < 0.05$ . Moreover, Table 2 above indicates that the scores average in the experimental group was 3.12 out of 10 with a standard deviation of 1.8. The scores mean of the experimental group improved to 7.82 with standard deviation of 1.223 after being subjected to the inquiry-based learning approach for almost 5 weeks. Likewise, the control group's scores mean in the pretest was 2.9 out of 10 with a standard deviation of 2.08 and their scores mean was 5.375 with a standard deviation of 1.764 after 5 weeks learning about the projectile topic without the use of inquiry-based learning approach. The difference between scores means of the pretest and posttest for the experimental group was found to be 4.7, which is greater than the difference between means for the control group scores in the pretest and posttest, which was found to be equal to 2.45. Figure 5 below present the comparison between the means difference of both groups.

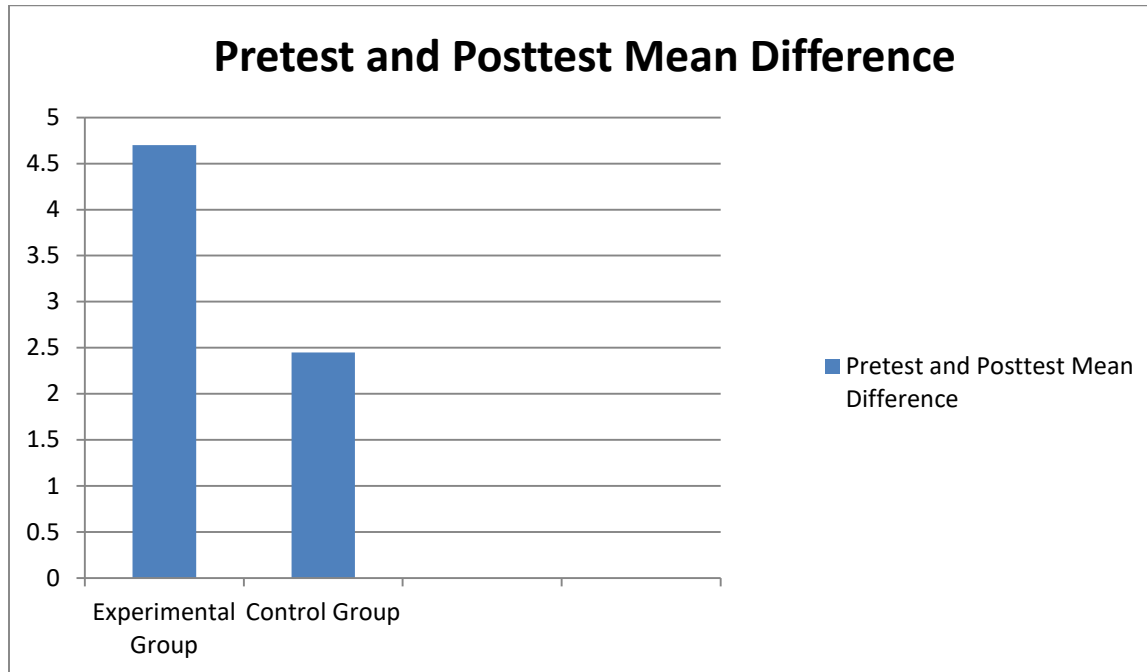


Figure (3): Comparison between means' difference of pretest and posttest scores of experimental and control groups.

Figure 2 shows that the experimental group participated students had a higher scores compared to control groups. Furthermore, the results showed that experimental group standard deviation reduced more than the control group reduced after conducting the experiment, which reflecting that the use of inquiry-based learning reduced the variation between the experimental group students outcomes. Such results partially address the research question that the critical thinking of the students was significantly improved for both classes who engaged in inquiry-based learning approach more than the students who did not.

### 4.1.3 The differences between the control and experimental groups in the posttest scores.

An independent t-test was conducted in order to answer the research question by comparing the posttest critical thinking outcome of the experimental group and control group to assess whether there is a statistically significant impact of inquiry-based learning approach on high-school students' critical thinking in physics classes or not. The results of the independent t-test are presented in table 4 below. Full analysis is shown in appendix 6.

**Table (4): Descriptive statistics and independent T-test results between posttest results of both the experimental and control groups.**

The results shown in table 4 indicated a high statistically significant difference between the experimental and control groups where  $t(154) = 7.5$  with a P value equals to  $0.000 < 0.05$ . In addition, the mean for the experimental group is 7.82 and for the control group was found to be 5.37 as presented in table 4 above. These results revealed that the implementation of inquiry-based learning approach effected the critical thinking of high-school students in

Group		N	Mean	Std. Deviation	t	df	Sig.(2taile)
Posttest	Control	40	5.375	1.764	7.5	154	.000
	Experimental	50	7.820	1.223			

physics in a positive way compared to Non-IBL approaches.

The study's hypothesis was confirmed, as there was a statistically significant difference in the scores of the high school students who participated in the experimental group where they learned the two-dimensional motion topic through inquiry-based learning approach and

those who were in the control group where they learned the topic without the use of inquiry-based learning approach.

#### 4.1.4 Reliability of the study

Test and retest is one way of measuring the reliability of a research tool using correlation coefficient (Johnson 2014). After conducting the posttest and pretest, Pearson correlation factor was calculated in order to indicate the reliability of the test. The results are shown in table 6 below.

Table (5): Pearson correlation factor between the pretest and posttest scores.

		Pretest for all students	Posttest for all students
Pretest for all students	Pearson Correlation	1	0.81**
	Sig. (2-tailed)		.000
	N	90	90
Posttest for all students	Pearson Correlation	0.81**	1
	Sig. (2-tailed)	.000	
	N	90	90

As shown in table 5 above there is a strong relation between students' results in the pretest and posttest, which indicate a high reliability of the critical thinking test.

Furthermore, the Cronbach  $\alpha$  coefficient was used to evaluate the consistency and reliability of the energy transformation test. Typically,  $\alpha$  0.70 (Nunnally 1967) is the accepted norm to make the scale internally consistent. Nonetheless, for newly developed measures, Nunnally suggests a minimum standard of  $\alpha$  0.60. Table 5 below presents the reliability statistics of the current research.

Table (6): Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.896	.897	2

Cronbach's  $\alpha$  coefficient for the pretest and posttest was found to be 0.896, which indicates that, the test have high internal consistency.

## 4.2 Qualitative Results

After conducting the quasi-experiment and collecting the information from both control and test bunches, face-to-face semi-structured interviews were performed with 10 understudies from the exploratory bunch. The point of these interviews is to discover profound meaning, cemented and to affirm the comes about from the quantitative portion. The collected information were analyzed utilizing the clear strategy of examination, which uncovered the reactions of the members and displayed their cites outlining their understanding of the perspectives examined. All of the members those who were met expressed that they delighted in this sort of venture and they had upgraded their learning. The interviews consisted of 5 questions (see Appendix 1) were the first three questions were centered on the way they have worked on and the steps they have taken in order to finish their critical questions and whether they have encountered any challenges through working on the procedural solution and how they have overcome them and how their methodology will help others. Questions also focused on what students think about inquiry-based learning and whether it helped them to understand the topic better than normal teaching methods and to explain how it helped them. In addition, students were asked about the skills they developed

after completing their inquiry-based learning process and asked the students about their future career, and what they would like to be in the future.

#### **4.2.1 High school students' understanding and satisfaction of the inquiry-based learning approach.**

The first three questions focused on measuring participants views of the inquiry-based learning approach, and to what degree this approach was found to be an effective and enjoyable. The answers from students showed that the IBL process and steps that they have to take to finalize their work have been fully understood. One student said, **“When we worked on the topic starting with the inquiry question, then modeling our experiment to investigate whether our procedure will work or not, we found that this way of learning is much more effective as we were extremely enjoying the methods we were creating to come up with conclusions that help us to understand how we can analyze and predict results, in addition; hypothesizing such a topic required many steps of our procedures to be repeated which helped us think more logically about the motion of an object in two dimensions”**

Moreover, students had been able to explain the main goal of their experiments and their impact on others. Students ' responses showed that they understood that their experiments' topic are related to their real life because they claimed that their innovations can benefit people in various ways. Some of the students' answers are shown below.

**“Our inquiry-guided experiments helped us to build critical hypothesis and criticize our claim about some real life examples where we can find multiple beneficial uses of the concepts of two dimensional motion study such as the arrow-dart game that requires concentration and considers the dimensions before targeting”**

**“Our experiments to build some examples of cannon or basketball were guiding us indirectly to understand the trajectory of an object by interpreting and analyzing the**

**collected data after creating assumptions and argumentations about the interpretations collected through the observations recorded”**

In addition, students’ answers also showed that they liked working as a team in their experiments. It made it easier and more enjoyable for them to learn about projectile motion through using the guided experimental work. As a result, IBL helped students to develop their communication skills and learned to work as a group.

**“Our experiments weren’t running very well at the beginning, but after multiple trials to approach an answer for our inquiry questions, we could analyze the collected data that drove us to misconceptions”**

**“ We figured out many contradictions in the results of our experiments as a first attempt but later through the well-guided communication and teamwork we were able to realize the gaps we didn’t fill while going through the procedures that helped us fix our mistakes to come up with more logical results”**

Furthermore, students shared some of the technical problems they faced while experiencing the two dimensional motion experiments, how it affected their results, and how did they solved these problems. The following are quotations from the responses of the students:

**“When we placed the target way further from the starting point of throwing the basketball, we couldn’t find a way to reach the target so we were just wasting time but then we figured out that not only the horizontal distance needs to be considered but also the height of the target we are supposed to reach.”**

**“It’s wasn’t only about the dimensions we consider during the experiments, but we noticed that each of our team members is skilled in a specific part of our experiment as we did a huge mistake first by keeping the trials done by all of the members, then by focusing on collaborative roles in our team, we could critically work on the logic of the outcome”**



All of these answers were comprehensive enough to show the extent to which the students approached validating their abilities to work logically on the major skills of their critical thinking in order to adhere the main concepts of our study.

#### **4.2.2 Inquiry-based learning impact on students' skills.**

During the interview, a question is suggested to ask the students about how the inquiry-based learning strategy approach affected their understanding of the two-dimensional motion topic and if it better than normal teaching. The aim of this question is to measure if the Inquiry-based learning approach has a positive impact on the high-school students' comprehension of the scientific concepts. Students' responses showed that after finishing their experiments the students had better understanding of the projectile motion topic. **"Inquiry-based experiments are better because when you learn by creating investigative scenarios that makes you learn faster than normal lecturing, because when someone come and tell you that launching a cannon ball requires starting conditions to be considered so you can target your point you can't understand it but when you do it and see it you will understand it and it will be easy."** In addition, after doing their inquiry learning students were able understand and connect the importance of the projectile motion applications in real life. **"Conducting this practice helped us understand how projectile motion is already existing in our real life for easier understanding to how targets can be approached from the first time when initial conditions are stated correctly from the beginning."** Moreover, results showed that the inquiry-based learning approach helped students to be independent learners by giving them the opportunity to do it by themselves. For example, **"This project was interesting because I did it myself with my group and learned from what I did and it is more interesting than listening to the teacher telling me that without trying it."**

Students' responses also indicated that inquiry-based learning approach provided the students the chance to work as groups and develop teamwork skills. For example, **“Learning by doing our inquiry-based experiments to investigate the two-dimensional motion let us to be in a group to finish fast and it is better to work in group instead of working alone and made the topic easier and sharing ideas, tips and constructive instructions helped to avoid multiple mistakes and eventually to avoid repeating many steps so we could work more cooperatively to approach our target”**

The aim of the fourth question was to investigate the impact of implementing the inquiry-based learning approach on developing high school student skills and equip them with the required skills that they might need in their future such as problem solving, critical thinking, teamwork, self-learning, self-esteem and engineering skills. The following are some examples of the students' answers.

**“By stating different initial conditions to launch the cannon ball model, I learned how to test things and how to collect different information and data and make calculations which helped to motivate us as a group to analyze, graph and figure out deductive conclusions about what we are supposed to consider for calculating vertical and horizontal dimensions”**

**“When I tried the experiment the first time, it was a bit tough to figure out the main concepts I need to follow but then I learned about technology skills and how to connect things in real life to technology. Also it helped me to learn how to take appropriate measurements to enhance our model experiments in order to avoid the percentage of error that we might get by several attempts, also I understood that technology is really facilitating our life as all of the effort we did in our experiments doesn't usually take time when using a well-designed machine.”**

**“Practicing such inquiry-based experimental learning was really joyful since when we created the procedure to investigate the two-dimensional motion it helped me to develop my engineering skills and when we did the calculation, I learned to solve mathematical equations to link it to engineering and physics.”**

The last question asked the students after they finish their experiments about where do they see themselves working in the future. Some of the students' answers reflected that inquiry-based learning approach increased a positive interest for students to peruse engineering careers in the future.

**“Building a model to investigate its behavior and to manage its steps and the scenarios to come up with constructive results could really encourage me to get more involved in the studies that provokes my engineering skills so I can build and construct such incredible machines for useful purposes in life”**

As a summary, the quantitative and qualitative results showed that pupils had positive perspective and perceptions towards the inquiry-based learning approach in physics. In addition, the inquiry-based learning approach has had a positive impact on students' comprehension and critical thinking of physics where the scores means in the critical thinking posttest of the students showed that students had a better improvement in analyzing, interpreting and deducing by referring to assumptions in the critical thinking test for the experimental group compared to the controlled group. In addition, the results showed that there is a statistical difference between the experimental and controlled group's scores means where the independent t-test results showed that  $t(110) = 7.5$  with a P value equals to  $0.000 < 0.05$ . Moreover, qualitative results showed that inquiry-based learning approach has made the learning process easy and enjoyable. Furthermore, this approach helped in equipping students with the essential skills that will prepare them for the workplace in the future.

Based on the quantitative and qualitative results presented in this chapter, these findings are addressed in the light of earlier studies and relevant recommendations are presented in the next chapter.

## **Chapter 5: Discussion, Conclusion, Recommendations and Limitations**

Inquiry-based learning approach has a major impact on the critical thinking skills and motivation of learners. Providing differentiated strategies based on student interests and skills helps evaluate learners with different unique skills. In addition, inquiry-based experiments provide a cooperative working environment for learners, enabling them to develop more expertise in sociocultural and communication. Integrating Science, Math, Engineering, and Technology disciplines in this study showed huge changes to the level of the student. By using the inquiry-based learning approach, the student has shown improvement in their skills. The idea of curriculum integration enhanced student learning, as it helped them to gain further information that led to a deeper and stronger understanding of the subjects.

This chapter addresses the findings of the study, analyzes them in the context of theoretical framework and earlier studies, provides the conclusion and provides suitable recommendations for further studies and limitations of the study.

### **5.1 Discussion**

The study was conducted at a private American school in the UAE in Sharjah. The students from the 11th grade were the participants. The aim of the study was to investigate the impact of implementing inquiry-based learning approach on the high school students' critical thinking through physics experimental studies compared to non-inquiry based learning instructions in private school in Sharjah, UAE. The study took a period of six weeks in the first term. As mentioned earlier in the chapter three and four, the current study was carried out into two steps: quantitative and qualitative. The results of this study revealed that the current study was consistent with previous studies.

The main question of the research was to investigate the impact of inquiry-based learning on students' critical thinking. It was hypothesized that there would be a statistically significant difference in the students' critical thinking results between the students who were taught using the STEM PBL approach and those who did not. A pretest posttest quasi-experiment was used in this study in order to investigate the impact of inquiry-based learning on students' achievement in the critical thinking test. The results showed that the students had a major improvement in their progress through the development of their achievement and the development of their skills where the scores means for the experimental and control groups in the posttest was found to be 7.8 and 5.3 respectively. Additionally it was found that there is a statistical difference in the achievement of the students who were exposed to the inquiry-based learning in the experimental group compared to the control group where the independent t-test results between the scores means for both groups in the posttest showed that  $t(90) = 7.5$  with a P value equals to  $0.000 < 0.05$ . The findings of the current study indicate that PBL inquiry-based learning enhances engagement collaboration, interest, understanding, awareness, and skills, which in turn enhances their productivity and achievement as the students clearly stated in the interviews (Lou, Chou, Shih & Chung 2017).

Also, the fruitful inclusion of each understudy, getting them energetic about new and various undertakings was a huge noticed result. In the light of a few past examinations on the significant contrast between understudies getting the hang of utilizing PBL and IBL and understudies contemplating a similar substance utilizing conventional showing techniques at a similar period, it very well may be discovered that IBL gives more prominent self-capacity to learning IBL teaches and expands understudy accomplishment contrasted with Non-IBL training (Bilgin, et al. 2015; Han 2017).

As stated in the literature review and as shown in the results, STEM-PBL has revealed an important effect on students' efficiency. Many researchers have recognized the value of STEM PBL to improve learners' performance by enhancing their critical thinking (Ejiwale, 2012). Han (2014) claimed that if the learning environment is STEM PBL, student achievement increases significantly as well as their critical thinking. This demonstrates coherence with the findings of the current research. In the inquiry-based STEM education process it is important to integrate the interdisciplinary STEM approach with instructional approaches including PBL, problem-based learning, and inquiry-based learning. (Khalil and Osman 2017).

Through working in groups, students are given additional opportunities to develop different skills such as data analysis, problem solving, critical thinking and communication skills (Baran et al. 2016; Khalil and Osman 2017; Dejarnette 2016). Therefore, it is also possible to accept the ideas of others, to be an effective team member, to be a leader, and to use techniques to solve problems are all made available. As a result, this will increase the quality of education and student's achievement (Sofroniou and Poutos 2016).

There are some explanations why the correlation between STEM-IBL and the student achievement could be relatively good. The most important factor is when the learners begin to combine more knowledge between the disciplines they acquire and develop more skills and knowledge that will help improve their achievement and performance. Inquiry-STEM approached support and improve the 21st century's skills which in effect improve students' success and prepare them for their future careers.

Students' answers in the interviews showed that they considered working in groups to be an interesting part of experimental inquiry-based learning approach. Students enjoy working in

collaborative student-centered environment where they improve their communication skills, make decisions, and take responsibilities. The positive attitude of students to inquiry-based experiments is an interesting part of this research. All of them agreed during the interviews on the inquiry-based experiments positive critical thinking achievement and motivation impacts. Students were satisfied with the cooperative atmosphere. Moreover, the result demonstrates student satisfaction with the inquiry-based learning. During the experiments, students have shown their excitement in working together in groups. This suggested STEM PBL and IBL's success as a student-centered approach, through their excitement for projects subjects (Han, 2015). Han (2015) suggested that students work cooperatively in decision-making groups that are a central driving force in inquiry education, group work that influences and enables learners reach social maturity. Tseng et al. (2013) proposed that STEM PBL should be introduced as a key factor in growing student motivation to learn and choose future STEM professions. Smyrnova Trybulska et al. (2016), in their study, emphasizes the need for students to be well prepared with STEM-related skills, especially at all the educational levels.

A few variables decide separation, which gives every student suitable movement dependent on their abilities and requirements (Bilgin, Karakuyu and Ay 2015). Aside from understudy's psychological level and their various capacities, the school setting, family, the more extensive local area and the material are on the whole contemplations that should be considered when arranging STEM projects (Capraro et al. 2016). Han et al. (2015) guaranteed that an ideal methodology for meeting the interesting scholastic capacities and wants of every person and giving freedoms to students to show their learning in different manners couldn't be guaranteed. Assortments of instructing and learning rehearses must be utilized to improve students' capacities, and exercises need to incorporate whole gatherings, little gatherings and people. Having this assortment of schools raises understudies ' level of accomplishment and inspiration.



Guyotte et al. (2015) reasoned that fruitful groups' formation improved the performance of learners. Han, Capraro and Capraro (2015), on the other hand claimed that STEM PBL affects various learners differently.

IBL encourages learners to improve their skills of the 21st century, such as critical thinking, problem solving, creativity, communication and teamwork, in order to equip them with the required skills for STEM carriers (El Sayary, Forawi and Mansour 2015; Akundi 2017; Edmunds; UAE Vision 2021). In its ability to give real meaning, it includes students more in real life events, and improve student's interdisciplinary skills in the 21st century; this is now recognized as an important learning model. (Drake, 2012). Researchers and curriculum reformers have indicated that incorporation is one means of achieving and satisfying aspirations including those focused in STEM education (Moonesar & Mourtada 2015).

Additionally, the NGSS, part of this study's theoretical framework, outlined measurable performance requirements per each grade, each purpose represents three key aspects of scientific learning: interconnected scientific and engineering practices, and core insights into the discipline for the advancement of students ' skills for the 21st Century (NRC 2012; NSTA 2013). This is directly related to the outcome of the current study in which STEM PBL had a major effect on the skills of the students of the 21st century.

Results from the interviews indicated that most of the participants stated that the STEM PBL approach helped them in developing their 21st-century skills (Han 2017), enabling them, by engagement in real-world activities, to develop their collaboration and communication skills and facilitate real-life solutions. According to Lou et al. (2017), IBL approach increases the motivation of learners in STEM education by means of projects, research, problem solving, practical activities and decision-making (Roberts et al. 2018). In addition, students' responses

showed that students had positive understanding reflecting on the effect of IBL on learners' choice of the future career. This indicates that students agreed that the IBL approach helps prepare them and improve their participation in potential STEM fields, as well as providing them with a strong basis for selecting STEM fields to pursue in the future (UAE Vision 2030; Stipanovic and Woo 2017). In order to improve STEM education system and the future involvement of students in the STEM programs and careers, it is important to adopt an effective education approaches such as PBL (Akundi 2017; Miller, Sonnert & Sadler 2018).

Additionally, in light of the understudies' answers in the meeting it showed that understudies appreciate STEM PBL sort of training and directions contrasted with different methodologies as it creates understudy revenue by working together with colleagues and presents them with another learning climate (Hwang, Tu and Wang, 2018). These outcomes are lined up with Liu and Chien perceptions (Lai and Hwang, 2015). Papert, (2000 in Hwang, Tu&wang, 2018) states that the assumptions for understudies to advance to a more elevated level through this cutting edge instructive methodology will be sensationalized science, which will expand their capacity and excitement to know more. Indeed, Jonassen and Carr, (2000) claims that learning by configuration, fixated on constructivism, is supported between all the diverse showing approaches since it permits students to consider the vital parts of the substance of science to convey it to others in their plan. This encourages students to draw on what they know in blend with what they need to create without limitations (Hwang et al. 2018). In this way, by overseeing it themselves, students may start their contemplations and utilize their work plan or instruments. This can likewise urge students to be completely included as they are effectively associated with advancing efficiently towards significant learning, just as the fruitful culmination of their plan (Minovic et al. 2011). Such discoveries are additionally applicable to the hypothetical system of this exploration, in which positive information and self-advancement will prompt better results and more noteworthy accomplishments among students (Pegrum et al.

2015). While improving their understanding understudies can interface with previously existing information and new information through the use of basic idea examination that will permit them to expand their experience and hold their insight much more (Pegrum, Bartle and Longnecker, 2015). For this reason, understudies ought to be dynamic in the learning interaction to make significant learning in science schooling.

Furthermore, through learning communication skills, learners can consider the views of each other and appreciate the importance of cooperation (Pheeraphan, 2013). Vygotsky (1978) found out that children could develop valuable communication skills by interacting and working with people (Wang et al. 2016). By having the work plans for the project and experiments, learners may share ideas and learning interaction to overcome the difficult challenges, they face in order to fulfill their mission (Wang, Huang, & Hwang, 2016). That through interactive learning, students improve their comprehension (Beyhan & Baş, 2010). Thus, this constructivist paradigm demonstrates that learners are active agents in the learning process and gain a better understanding. Therefore, students must develop knowledge and learn it according to their unique way of seeing their world.

The discoveries of the current investigation uncover that while actualizing the request based learning approach, the understudies defeat a few unique issues. A similar sign was additionally noted in the Study by Capraro and Sun Yung Han (2015) that the IBL approach improves understudy accomplishments, especially in numerical abilities. Nonetheless, the current investigation interviews showed that the members as a rule asked themselves an assortment of inquiries that pushed them to investigate, work together, and convey to sort out arrangements. Moreover, Han (2015) featured the significance of likening the cooperation through the STEM PBL approach to help the students cooperate to accomplish all the abilities of the 21st century.

A similar finding even happened in the current examination when the understudies did their activities in gatherings. In the current investigation, understudies figured out how to work as a gathering to assist them with accomplishing their objectives. The current investigation discoveries line up with Han (2015) results that the STEM PBL approach should be actualized by gathering the students that uncovered beneficial outcomes towards the understudies' accomplishment of 21st century abilities. Students who are effectively engaged with agreeable learning will accomplish a more significant level of accomplishment contrasted with different understudies who learned dependent on customary methodologies (Slavin, 2014). IBL upholds understudies to improve 21st-century abilities like cooperation, basic reasoning, advancement, critical thinking and correspondence to make a solid and steady STEM profession age (Husin et al, 2016; Akundi 2017; El Sayary, Forawi and Mansour 2015).

The discoveries of the examination are promising from an educational perspective. This methodology is exceptionally viable for understudies with low certainty and propelling abilities, or the individuals who need to improve their capacity to demonstrate, thinking, and tackles issues. The current examination has shown that STEM PBL is a compelling methodology for improving understudies' arrangement, accomplishment, and abilities.

## **5.2 Conclusion**

The current study was carried out in order to investigate the impact of implementing the inquiry-based learning approach on high school students' critical thinking through physics topics in the UAE. The mixed method approach was utilized in order to fulfill the current research purpose. In order to collect quantitative data, a pretest posttest quasi-experimental research design was carried out with ninety grade 11 high school students in four classes who participated for five weeks in the study from private school in Sharjah that follows the American curriculum. Semi-

structured interview was carried out with 10 students from the experimental group in order to collect the qualitative data. Students' answers during the interviews indicated that students considered the inquiry-based learning approach beneficial as it gave them the chance to work and interact with each other, to try and use their expertise to finalize their experimental modeled projects, as well as its positive impact on their skills and achievements (Han, Capraro and Capraro, 2015). In addition, this study showed that applying inquiry-based learning for high school students in teaching Physics helped motivate them and engage them in teamwork. In addition to developing skills such as critical thinking, creativity, problem solving and a deeper understanding and interpretation of scientific knowledge, learners build their own awareness by working with their team members (Hwang et al. 2018). Additionally, learners can practice leadership skills through group guidance, negotiation, and discussion, as well as acquire responsibility and strong self-esteem. Gaining academic and communication skills together will provide learners with the key 21<sup>st</sup> century.

### **5.3 Recommendations and Implications**

STEM education is widely demanded. The development of STEM education calls for effective strategies and approaches like IBL to be implemented. Based on the results of the research and the associated literature, more research is required in order to enhance the implementation of IBL approach and students' achievement in critical thinking test is recommended with the following guidelines. One of the most important reasons for implementing the inquiry-based learning approach is to improve the achievement of the learners and to increase their motivation to peruse professions in the future. The current study measured the impact of implementing the inquiry-based learning approach on the high school students' achievement in critical thinking test through physics inquiry based experimental learning but the study was carried out on grade 11 girls' students. It is recommended in the future to carry out a research to investigate the impact of implementing the inquiry-based learning approach on the learners' motivation and

interest. Moreover, the current study did not highlight the challenges that may face the implementation of inquiry-based learning in the UAE, so it is recommended to carry out a research about these challenges.

Admins play a key role in the implementation of inquiry-based learning approach studying their perceptions and their contributions and help in the implementing inquiry-based learning approach is recommended for future studies. While the research sample included high school students in American curriculum school, it is recommended to carry more similar studies with elementary and middle schools that follows different curricula.

The results of the current study encourage schools to develop their curriculums to be based on the inquiry-based learning approach as it has a great influence on students' critical thinking and skills development which is widely required in this century for the digital development occurring. Moreover, teachers are the key factor for the success of the implementation of the inquiry-based learning approach; the current study results guide the teachers to implement this approach frequently in order to improve their students' critical thinking, but this study also requires studies to be done for the teachers to be trained and qualified in practicing such learning strategies.

## **5.4 Limitations**

Although current study showed that inquiry-based learning approach has a significant effect on grade eleven students' critical thinking through physics classes but it had some limitations. The first limit is the number of participants, and an increase in the number of participants provides more reliable results. Moreover, the participants are only of one grade level students from one American curriculum school in Sharjah. Including different grade levels in different science classes from different schools with different curriculums from different emirates will help to

generalize the results of the study. In addition, the research was conducted on one strand of the science curriculum, which limits the findings of the study. Finally, Because of this study's quasi-experimental nature, concerns to internal and external validity that need to be addressed. Since the participants were already in groups (classes), sampling randomization was restricted to intact (class) random sampling, rather than individual random sampling. In addition, considering the teachers professional levels would have an impact on such study as it needs to be compared. Also to get deeper into the strands of this study, gender can be taken into consideration to study whether it would have an impact differently on the students' critical thinking improvement.

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# Appendices

## **Appendix 1**

### **Interview Questions:**

1. How the inquiry-based learning strategy approach affected their understanding of the two-dimensional motion
2. How can you connect your inquiry-based learning experiments to real life application?
3. How did the inquiry-based learning improve your teamwork skills?
4. After completing your task, what skills do you think you have developed?
5. Where do you see yourself working in the future?

## **Appendix 2**

### **Critical Thinking test**

This Critical Thinking test measures your ability to think critically and draw logical conclusions based on written information. Critical Thinking tests are often used in job assessments in the legal sector to assess a

candidate's analytical [critical thinking](#) skills. A well known example of a critical thinking test is the [Watson-Glaser Critical Thinking Appraisal](#).

The test comprises of the following five sections with a total of 10 questions:

1. Analysing Arguments
2. Assumptions
3. Deductions
4. Inferences
5. Interpreting Information

Each question presents one or more paragraphs of text and a question about the information in the text. It's your job to figure out which of the options is the correct answer.

6. **Share this**
7. **Like**

#### **1. Analysing arguments**

Below is a statement that is followed by an argument. You should consider this argument to be true. It is then up to you to determine whether the argument is strong or weak. Do not let your personal opinion about the statement play a role in your evaluation of the argument.

**Statement:** *It would be good if people would eat vegetarian more often.*

**Argument:** *No, because dairy also requires animals to be kept that will have to be eaten again later.*

**Is this a strong or weak argument?**

☐

Strong argument

☐

Weak argument

## 2. Analysing arguments

Below is a statement that is followed by an argument. You should consider this argument to be true. It is then up to you to determine whether the argument is strong or weak. Do not let your personal opinion about the statement play a role in your evaluation of the argument.

**Statement:** *Germany should no longer use the euro as its currency*

**Argument:** *No, because that means that the 10 billion Deutschmark that the introduction of the euro has cost is money thrown away.*

**Is this a strong or weak argument?**

- ☐ Strong argument
- ☐ Weak argument

## 3. Assumptions

*Overfishing is the phenomenon that too much fish is caught in a certain area, which leads to the disappearance of the fish species in that area. This trend can only be reversed by means of catch reduction measures. These must therefore be introduced and enforced.*

**Assumption:** *The disappearance of fish species in areas of the oceans is undesirable.*

**Is the assumption made from the text?**

- ☐ Assumption is made
- ☐ Assumption is not made

#### 4. Assumptions

*As a company, we strive for satisfied customers. That's why from now on we're going to keep track of how quickly our help desk employees pick up the phone. Our goal is for that phone to ring for a maximum of 20 seconds.*

**Assumption:** *The company has tools or ways to measure how quickly help desk employees pick up the phone.*

**Is the assumption made from the text?**

- ☐ Assumption is made
- ☐ Assumption is not made

#### 5. Deductions

Assume only the following statements and consider them as facts:

1. *All reptiles lay eggs*
2. *All reptiles are vertebrates*
3. *All snakes are reptiles*
4. *All vertebrates have brains*
5. *Some reptiles hatch their eggs themselves*
6. *Most reptiles have two lungs*
7. *Many snakes only have one lung*
8. *Cobras are poisonous snakes*

**Conclusion:** *Some snakes hatch their eggs themselves.*

**Does the conclusion follow the statements?**

- ☐ Conclusion follows
- ☐ Conclusion does not follow

## 6. Deductions

*(Continue with the statements from question 5.)*

**Conclusion: Some animals that lay eggs only have one lung.**

**Does the conclusion follow the statements?**

- ☐ Conclusion follows
- ☐ Conclusion does not follow

## 7. Inferences

*In the famous 1971 Stanford experiment, 24 normal, healthy male students were randomly assigned as 'guards' (12) or 'prisoners' (12). The guards were given a uniform and instructed to keep order, but not to use force. The prisoners were given prison uniforms. Soon after the start of the experiment, the guards made up all kinds of sentences for the prisoners. Insurgents were shot down with a fire extinguisher and public undressing or solitary confinement was also a punishment. The aggression of the guards became stronger as the experiment progressed. At one point, the abuses took place at night, because the guards thought that the researchers were not watching. It turned out that some guards also had fun treating the prisoners very cruelly. For example, prisoners got a bag over their heads and were chained to their ankles. Originally, the experiment would last 14 days. However, after six days the experiment was stopped.*

**The students who took part in the research did not expect to react the way they did in such a situation.**

**To what extent is this conclusion true, based on the given text?**

- ☐ True
- ☐ Probably true
- ☐ More information required
- ☐ Probably false
- ☐ False

## **8. Inferences**

*(Continue with the text from 'Stanford experiment' in question 7.)*

**The results of the experiment support the claim that every young man (or at least some young men) is capable of turning into a sadist fairly quickly.**

**To what extent is this conclusion true, based on the given text?**

- ☐ True
- ☐ Probably true
- ☐ More information required
- ☐ Probably false
- ☐ False

## **9. Interpreting information**

*The Dutch flag*

*There is an official protocol for the use of the Dutch flag. This protocol applies to government agencies. Citizens and companies are expected to follow this protocol, but they are not obliged to do so.*



- *A flag is a tribute to the nation and should therefore not be hung outside at night. Hoisting the flag therefore happens at sunrise, bringing it down at sunset. Only when a country flag is illuminated by spotlights on both sides, it may remain hanging after sunset. There is a simple rule of thumb for the time of bringing down the flag. This is the moment when there is no longer any visible difference between the individual colors of the flag.*
- *A flag may not touch the ground.*
- *On the Dutch flag, unless entitled to do so, no decorations or other additions should be made. Also the use of a flag purely for decoration should be avoided. However, flag cloth may be used for decoration - for example in the form of drapes.*
- *The orange pennant is only used on birthdays of members of the Royal House and on King's Day. The orange pennant should be as long or slightly longer than the diagonal of the flag.*

**Conclusion: One can assume that no Dutch flag will fly at government buildings at night, unless it is illuminated by spotlights on both sides.**

**Does the conclusion follow, based on the given text?**

- ☐ Conclusion follows
- ☐ Conclusion does not follow

## **10. Interpreting information**

*(Continue with the text from 'Dutch flag protocol' in question 9.)*

**Conclusion: If the protocol is followed, the orange pennant will always be longer than the horizontal bands/stripes of the flag.**

**Does the conclusion follow, based on the given text?**

- ☐ Conclusion follows
- ☐ Conclusion does not follow

## Appendix 3



January 2020

To Whom It May Concern,

I am a Master students in the British University in Dubai BUID since 2018. I am conducting a research study about the impact of Inquiry-based learning approach on high school students' critical thinking skills.

The purpose of this letter is to take the permission from your school to conduct my study in your educational organization in the academic year 2019-2020. This study requires implementation of Inquiry-based learning in selected classes in the high school and interviews with selected IBL students. The study will take around 4 weeks where students will be involved in different IBL experiments.

All collected data will remain confidential and will be used for this research. Participating in this study is completely voluntary. You may discontinue your participation in this study anytime. If you have any enquiries about this research, feel free to contact me, or the director of the study supervision: Prof. Sufian Forawi.

Thank you for your cooperation in this academic endeavour.

Best Regards,

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## Appendix 4

### 1. Students' Scores in Pretest

Class A	Class B	Class C	Class D
3	0	3	2
2	3	2	4
5	2	4	4
0	6	4	3
3	2	6	1
1	4	1	0
3	2	0	5
0	1	6	3
4	7	2	4
5	0	3	3
2	0	4	6
6	2	1	1
1	3	7	8
3	7	3	2
3	5	4	3
4	3	3	1
7	6	4	0
4	1	1	4
0	2	2	4
2	3	3	2
		4	5
		3	3
		2	2
		1	6
		4	3

## 2. Students' Scores in Posttest

Class A	Class B	Class C	Class D
3	8	8	7
8	3	7	8
7	5	8	9
5	9	9	7
6	6	9	8
4	7	7	8
6	4	8	10
5	4	10	9
7	6	8	7
4	3	7	6
5	5	8	8
7	4	7	8
3	6	10	7
5	8	9	8
3	4	5	7
6	6	9	8
9	3	7	9
6	8	7	7
5	3	6	8
4	5	9	5
		9	6
		7	9
		8	10
		6	7
		8	9

## Appendix 5

### Differences between pretest and post-test results for the experimental and control groups.

#### Paired T-test Analysis

##### Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Exp. Group Pretest	3.1200	50	1.80295	.25497
	Exp. Group Posttest	7.8200	50	1.22374	.17306
Pair 2	Control Group Pretest	2.9250	40	2.08028	.32892
	Control Group Posttest	5.3750	40	1.76414	.27893

##### Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Exp. Group Pretest & Exp.Group Posttest	50	.176	.220
Pair 2	Control Group Pretest & Control Group Posttest	40	.357	.024

##### Paired Samples Test

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Experimental Group	Exp. - Exp.	-4.70000	1.99233	.28176	-5.26621	-4.13379	-16.681	49	.000
Control Group	Control - Control	-2.45000	2.19498	.34706	-3.15199	-1.74801	-7.059	39	.000

## Appendix 6

### The differences between the control and experimental groups in the posttest scores

#### Independent T-test Analysis

**Group Statistics**

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Posttest	Control	40	5.3750	1.76414	.27893
	Experimental	50	7.8200	1.22374	.17306

**Independent Samples Test**

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
Posttest	Equal variances assumed	7.517	.007	-7.748	88	.000	-2.44500	.31558	-3.07215	-1.81785
	Equal variances not assumed			-7.448	66.913	.000	-2.44500	.32826	-3.10023	-1.78977