Relative Effectiveness of Inquiry Training Model and Guided Discovery Learning on Critical Thinking of Secondary School Students

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Abstract

Inquiry Training Model and Guided Discovery Learning are two teaching approaches which are known to hold potential in development of critical thinking in students. This study investigated the relative effectiveness of these two approaches. A pre-test post-test quasi-experimental design with a 3 2 factorial matrix was adopted. 126 students belonging to three different sections of the eighth standard of a school were selected as the sample. Two classrooms, consisting of 42 students each, were taken as experimental groups in which the Inquiry Training Model and Guided Discovery Learning were applied and the third classroom was the control group which received conventional lecture-demonstration method. The study revealed that both Inquiry Training Model and Guided Discovery Learning were equally effective in developing critical thinking in students and that both these approaches were better than the conventional lecture demonstration method.

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INTRODUCTION

The quality of learning is enhanced if students are taught to think critically. Deep learning involves examining new facts and ideas critically, and tying them into existing cognitive structures and making numerous links between ideas as against surface learning, which involves new facts and ideas are accepted uncritically and attempts are made to store them as isolated, unconnected, items [Compiled from Biggs (1999), Entwistle (1988) and Ramsden (1992)]. Development of critical thinking ability is essential for the students of science as it helps them in their future career in engineering, medicine, research and such other fields that have applications of science. Not only that, critical thinking enables individuals to resist superstitious beliefs, extremist views and narrow mindedness that are the root causes of unrest, miseries and violence in the society and develop positive attitudes essential for building up a progressive minded society.

Clement and Lockhead (1980) observes that "We should be teaching students how to think. Instead, we are teaching them what to think." Development of critical thinking through curricular intervention has, therefore, gained interest in the recent times.

Schafersman (1991) observes that many secondary school students do not possess the 'higher-order' intellectual skills we should expect of them. According to him, nearly seventy per cent cannot solve a problem which is not directly given in the textbook. People could be influenced through effective science education to think critically on issues related to their personal and professional areas and on issues related to social, political and economic aspects.

Traditional teaching methods give emphasis more on providing content than on developing thinking skills of students. Education must help not merely to increase the knowledge of the pupils but go beyond that by developing their skills of understanding, analysis, interpretation, higher order thinking skills and application abilities. Science education, in particular, must help in developing scientific attitude and critical thinking in students.

At the school level, science education can be improved by adopting suitable teaching methods that promotes scientific attitude, knowledge cognitive processes and critical thinking. Constructivist approaches to learning focus on learning environments in which students have the opportunity to construct knowledge themselves, and negotiate this knowledge with others. Guided Discovery Learning and the Inquiry Training Model are the examples of learning contexts that cater for knowledge construction processes.

To be a skilful thinker, one needs to learn meaningfully, think flexibly and be able to make reasoned judgments. It is crucial to ensure that the young generation is able to think independently, generate creative initiatives and solve unexpected problems, while remaining intellectually proficient. We cannot assume that students will spontaneously pick up these skills without being taught explicitly (Kong, 2006).

Lecture demonstration method,

which is the most widespread and traditional, has certain drawbacks as it tends to make students passive listeners, rather than critical thinkers.

Development of critical thinking is essential to equip students to meet the challenges of the modern times. With expanding contents in science with addition of new research findings, inventions and discoveries, it is practically impossible to attempt to deliver all science knowledge through the school curriculum. Students who possess inquiry skills, discovery skills and critical thinking skills are capable of seeking out knowledge they need and apply it effectively for their use. Teacher's role would shift from content delivering to that of a facilitator in learning. Many researchers have observed that learning takes place better when students construct knowledge themselves. Learning takes place when the student acquires knowledge, and also skills for interpretation, analysis, synthesis, evaluation and application. Critical thinking is essential for deeper learning.

Educational psychologists advocate constructivist approaches for development of critical thinking. Inquiry Training Model and Guided Discovery Learning are two such approaches to teaching, with former focussing on learning through inquiry and the latter on discovery. In the Inquiry Training Model classroom students learn the skills of inquiry and use it to solve problems. In Guided Discovery Learning the teacher minimally intervenes in the learning process and provides guidance to the students, who are provided with facilities to find solutions to the problems themselves by performing experiments in the classroom.

The Delphi report (1990), which is a consensus report developed by forty-six experts from various disciplines, including science and education, presents a number of characteristics of a critical thinker. It defines a critical thinker as follows:

"The ideal critical thinker is habitually inquisitive, well-informed, trustful of reason, open-minded, flexible, fair-minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in the selection of criteria, focused in inquiry, and persistent in seeking results which are as precise as the subject and the circumstances of inquiry permit."

The six cognitive skill components of critical thinking, as per Delphi report are: analysis, interpretation, inference, evaluation, explanation and self regulation.

The present study could provide a great deal of insights on various practical aspects of their implementation in the classrooms.

Not many studies seen conducted that evaluate the effectiveness of Inquiry Training Model and Guided Discovery Learning in promoting critical thinking and to compare their effectiveness. This study investigates the relative effectiveness of Inquiry Training Model and Guided Discovery Learning. Further, this study has helped to get an understanding of the classroom processes that occur in development of thinking.

Inquiry Training Model

Inquiry Training Model was developed by Suchman (1961), which was intended to engage students in causal reasoning, become precise in asking questions, building hypothesis and testing them. It was also intended to teach students a process to investigate and explain unusual phenomenon and help develop their thinking abilities. The Suchman Inquiry Training Model is most commonly used in science and social studies.

In Inquiry Training Model the students engage in open-ended, student-centred, hands-on activities like data gathering, verification, experimentation, explanation, and analysing in order to solve the problem presented to them. These learning activities are expected to help development of cognitive skills for searching, data processing, logic and scientific inquiry.

Inquiry training begins by presenting students with a puzzling event. When faced with such a situation the students are naturally motivated to solve the puzzle. They are then prompted to ask questions to the teacher in order to find the solutions. The teacher must not answer the questions directly. She may just say 'yes' or 'no' to each question. The students are required to ask only such questions that contain an idea or guess which the teacher either confirms or rejects. Whenever the question cannot be answered by a 'yes' or 'no', the teacher asks the students to re-phrase the question so that it can be answered by a 'yes' or 'no'. The students eliminate irrelevant variables and discover the relationships that exist between the relevant variables. Next, the teacher asks students to organise the data and formulate an explanation for the puzzle. Finally, students analyse their pattern of inquiry and propose improvements. In this way the students are trained to think and inquire for a solution to a puzzling event with the assistance of the teacher.

Phases of Inquiry Training Model

There are five phases under this model as listed below:

- **Phase I:** Confrontation with the problem; explain inquiry procedures; present the problem.
- **Phase II:** Data gathering, verification; verify the nature of objects and conditions; verify the occurrence of the problem situation.
- **Phase III:** Data gathering, experimentation; isolate relevant variables; hypothesis and test casual relationships.(Students organise the information obtained so that they can derive an explanation for the puzzling event).
- **Phase IV:** Formulating and explaining—formulate rules or explanation
- **Phase V:** Analysis of the inquiry process—analyse inquiry strategy and develop more effective ones. The students are asked to analyse the problem-solving strategies they used. This operation helps students to establish a focus in their inquiry and to facilitate discussion of the problem situation.

These phases were used in the designing of lesson plans for Experimental Group I.

As opposed to passive learning, that

suppresses student inquiry, classrooms based on Inquiry Training Model encourage inquiry by training them in inquiry skills.

This teaching model has various attributes in it that stimulate autonomous learning through inquiry and questioning skills to various degrees. It has been observed from relevant literature that very few studies have been conducted to assess how far teaching based on Inquiry Training Model is effective in improving science achievement in secondary school students. Moreover the existing studies give inconsistent results. Understanding about the effectiveness of Inquiry Training Model in improving achievement in students and the conditions that facilitate its effective application in science classrooms will help improve science education.

Guided Discovery Learning

In guided discovery, the teacher devises a series of statements or questions that guide the learner, step by logical step, making a series of discoveries that leads to a single predetermined goal. In other words the teacher initiates a stimulus and the learner reacts by engaging in active inquiry thereby discovering the appropriate response. Guided discovery seems to offer a happy medium between the pure discovery and expositional learning as some of the efficiency of expositional learning is maintained along with the benefits of the pure discovery process which can be well adapted to most situations (Bibergall, 1966). Kersh and Wittrock (1962) stated that guided discovery is the most motivating of the three types. The reason appears to be that the reinforcement given by a teacher in the form of encouragement and support (even if the pupil does not discover the correct answer) motivates the child to continue working and she in turn becomes more motivated.

Guided discovery helps students personalise the concepts under study, creating an understanding that cannot be matched using any other method of instruction. In guided discovery learning the teacher should guide the students toward the discovery. This can be accomplished by providing appropriate materials, a conducive environment, and allotting time for students to discover.

Martin (1997) in his book has proposed a lesson plan format for guided discovery learning. Carin and Arthur (1970) also gave lesson plan format for discovery learning. From these books and various literatures related to discovery learning and guided discovery learning, five phases were identified, which are as follows:

Phases of Guided Discovery Learning

(i) *Motivation and Problem Presentation*

At this phase the teacher creates the learning situation to lead the student to the discovery. The problem may be presented which is motivating and inspiring through various methods like demonstration, narration, questioning, etc.

(ii) *Selection of Learning Activities*

At this phase, the students with the help of the teacher select the learning

activities to solve the problem presented before them.

(iii) *Data Collection*

During the data collection phase of the lesson, the students work within groups. In the groups, students negotiate ideas and learn from one another. The students involved in the activity record their observations in their data collection sheet. When the students engage themselves in setting apparatus and doing experiments the teacher walk around the room to assess them and answer their questions. The teacher provides all necessary directions to them at all stages.

(iv) *Data Processing*

In the data processing phase, the students get involved in interpretation and analysis of the data collected. They discuss about the observations they have made. The teacher asks questions about the topics and indirectly guides them to discover learning contents. The students work with the data recorded in the data collection sheets and get involved in drawing graphs, analyse, and interpret. Based on these analyses the students make predictions.

(v) *Closure*

In the closure phase of a lesson, the students review the learnt contents in order to recollect prior knowledge

These phases have been used in the designing of lesson plans for Experimental Group II.

The responsibilities and the role of a teacher in a guided discovery learning environment become multifold when compared to conventional classroom teacher. The teacher has to create an intellectual climate; plan and sequence learning activities; prepare instructional materials; assist students in selecting proper activities and so on.

In such a context, understanding about the relative effectiveness Inquiry Training Model and Guided Discovery Learning on developing critical thinking in students and the conditions that facilitate their effective application of these in science classrooms will help improve science education. This approach to teaching has various attributes in it that stimulate the critical thinking skills to various degrees. A study of the present nature is expected to throw light into unexplored areas of development of the said skill.

The present study can provide a great deal of information on the nature of teacher behaviour in classroom aimed at promotion of critical thinking. Moreover, the present study will be helpful for future researches in identifying teacher behaviour aspects. It could also bring up various problems in actually implementing this in the classroom.

Objectives

1. To determine the relative effectiveness o f Inquiry Training Model or Guided Discovery Learning approaches in teaching in developing critical thinking of secondary school students.
2. To determine whether Inquiry Training Model is better than the conventional teaching method (lecture demonstration) in developing critical thinking.

3. To determine whether Guided Discovery Learning approach is better than the conventional teaching method (lecture demonstration) in developing critical thinking.

Research Questions

Based on information gathered from review of related literature the following research questions were formulated for the present study:

1. Which is the better model of teaching in developing critical thinking—Inquiry Training Model or Guided Discovery Learning?
2. Is Inquiry Training Model better than the conventional teaching method (lecture demonstration) in developing critical thinking?
3. Is Guided Discovery Learning approach better than the conventional teaching method (lecture demonstration) in developing critical thinking?

Methodology

In order to answer the said research questions, a quasi experimental design was adopted with a 3 2 factorial matrix consisting of a pre-test at the beginning of the experiment and post-test at the end.

The Sample

Purposive sampling technique was used, wherein the sample was drawn from three intact divisions of Class VIII students of a government run vocational higher secondary school in Meppayur village of Kozhikode District, Kerala State. Each classroom had 42 students. In all, there were 126 students, 66 boys and 60 girls, belonging to the age group of 13-14 years.

Two of the divisions were chosen as the experimental groups and the third was the control group. One of the experimental groups was taught through Inquiry Training Model and the other through Guided Discovery Learning. The control group received conventional lecture demonstration method.

Instrumentation

The Standard Progressive Matrices Test (Raven, 1958) was used to measure intelligence. A Critical Thinking Test was developed and standardised as part of the study for measuring the critical thinking of the students.

The cognitive skills given in the Delphi Report (1990) were used for constructing the critical thinking test. There were 44 multiple choice test items in the test, related to seven cognitive skills, namely, interpretation (seven items), analysis (eight items), evaluation (seven items), inference (eleven items), explanation (six items) and self regulation (five items). The duration of the test was one hour. The test was standardised and its reliability was established by Test-retest method (0.76) and by Split half method (0.85). To establish the face validity, the items of the test were subjected to experts' evaluation.

In order to get a better understanding of the whole process a semi structured interview was also used. It helped to gather the students' reaction on the instructional method used, the classroom environment, the role of the teacher and the role of the students.

Procedure

At the start of the experimental treatment, a preliminary test to measure intelligence was administered to all the groups, with a view to partial out the effect of intelligence on the treatment results. Pre-tests on critical thinking was then administered to all the three groups to measure their entry level critical thinking abilities.

The experimental treatment lasted for five months. During this time, 50 school periods, each with 40-45 minutes duration, were used for the study.

The students were taught from the science topics given in the eighth standard science textbook published by the Government of Kerala. The three units in chemistry taught were (a) water, (b) solutions and (c) acids and bases and the four units taught in physics were (a) sound, (b) static electricity, (c) electric current and (d) heat. The same units were taught in both the experimental groups and in the control group using different methods mentioned above. At the end of the treatment period, post-tests in critical thinking were administered to all the three groups.

Analysis and Interpretation

The three null hypotheses tested in this study were:

$H_0$1: There is no significant difference in critical thinking between the Experimental Group I and the Experimental Group II.

$H_0$2: There is no significant difference in critical thinking between the Experimental Group I and the control group.

$H_0$3: There is no significant difference in critical thinking between the Experimental Group II and the Control Group.

To test the null hypotheses, a unvaried analysis of covariance (32 ANCOVA) was performed on the post test scores. Before ANCOVA analysis, the mean scores were analysed.

Table I shows the means scores of the total sample, boys and girls (maximum score was 44) in the critical thinking tests (post and pre) in the Experimental Group-1, Experimental Group-1I and the control group.

Table I

Mean scores in critical thinking of experimental group-I and the control group

Group	Gender	N	Mean Score			
			Pre-test	Post test	Gain	% Gain
Experimental Group-I	Boys	22	15.91	24.86	8.95	56%
(Inquiry Training Model)	Girls	20	15.00	23.25	8.25	55%
	Total	**42**	**15.48**	**24.10**	**8.62**	**56%**
	Boys	22	13.68	17.41	3.73	27%
Control Group	Girls	20	12.25	15.95	3.70	30%
	Total	**42**	**13.00**	**16.71**	**3.71**	**29%**
Experimental Group-II	Boys	22	15.32	22.64	7.32	48%
(Guided Discovery Learning)	Girls	20	13.55	21.40	7.85	58%
	Total	**42**	**14.48**	**22.05**	**8.47**	**52%**

Table I reveals that there was a positive gain in the scores for critical thinking in all the three groups. For the Experimental Group-I the gain was +8.62 or +56% and for the Experimental Group-II it was +8.47 or +52%. The gain was moderate (+3.71 or +29%) for the control group.

The mean scores displayed in the table suggest that there is very little difference in the mean scores of boys and girls of the Experimental Group-I (+8.95 and +8.25 respectively), Experimental Group-II (+7.32 and +7.85) as well as the control group (+3.73 and +3.70).

In order to test whether there is any statistically significant gain in the scores from pre-test to post-test, 32 ANCOVA analysis was carried out on critical thinking post-test scores, with pre-test scores and intelligence as covariates. The results are tabulated in Table II.

Table II shows that difference in the mean scores of experimental group-I, experimental group-II and the control group is statistically significant, as indicated by the F value, F=47.665, p<0.001. The results of 32 ANCOVA procedures do not indicate which of these group means is statistically different from one another. To evaluate where the difference among the groups occurred, the post-hoc test was carried out, the results of which are shown in Table III.

Table II

32 Analysis of covariance associated with critical thinking of Experimental Group-I, Experimental Group-II and the Control Group

Test of Between Subjects Effects

Dependent variable: Critical thinking

Source of variation	Sum of squares	df	Mean square	F	Sig
Pre-critical thinking	806.815	1	806.815	148.426	0.000
Intelligence	20.657	1	20.657	3.800	0.054
Group	518.191	2	259.096	**47.665**	**0.000**
Gender	0.923	1	0.923	0.170	0.681
Group* Gender	5.019	2	2.510	0.462	0.631
Error	641.423	118	5.436		
Total	58802.000	126			
Corrected Total	3487.714	125			

Table III

Scheffe Post-hoc test result for critical thinking (total sample) of Experimental Group-I, Experimental Group-II and Control Group

Dependent variable: Critical thinking post-test

(I) Group	(J) Group	Mean Difference (I–J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Experimental Group–I	Control Group	7.3810*	0.935	0.000	5.0637	9.6982
	Experimental Group–II	2.0476	0.935	0.095	-0.2696	4.3648

Control Group	Experimental Group–I	-7.3810*	0.935	0.000	-9.6982	-5.0637
	Experimental Group–II	-5.3333*	0.935	0.000	-7.6506	-3.0161
Experimental Group–II	Experimental Group–I	-2.0476	0.935	0.095	-4.3648	0.2696
	Control Group	5.3333*	0.935	0.000	3.0161	7.6506

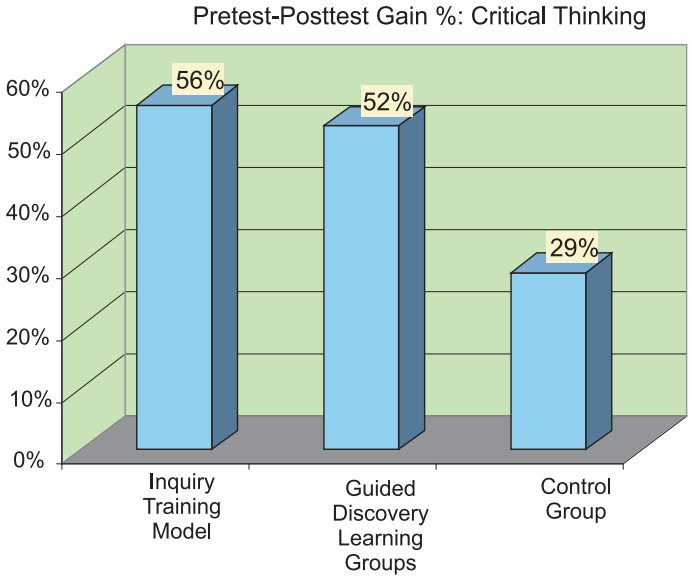
* The mean difference is significant at the .05 level.

The difference in the mean scores of Experimental Group-I and Experimental Group-II is not statistically significant, as indicated by the sig value, which is greater than 0.05. This reveals that both the experimental interventions are equally effective in developing critical thinking in students. Hence, the first null hypothesis [$H_0$1] stating that there is no significant difference between the Inquiry Training Model and the Guided Discovery Learning in developing critical thinking of secondary school students is accepted.

Table III reveals that the difference in the mean of the Experimental Group-I and the Control Group is statistically significant, as indicated by the sig value, which is less than 0.05. The mean difference between the Experimental Group-I and the Control Group is 7.3810. The positive difference shows that the mean of the pre-test scores in critical thinking of Experimental Group-I is higher than the Control Group. Also, 22 ANCOVA analysis shows that the difference in the mean post-test scores in critical thinking of the experimental group-I and the control group is significant with F=70.654, p<0.001. Hence, second null hypothesis [$H_0$2] stating that there is no significant difference in critical thinking between the Experimental Group-I and the Control Group is rejected. This indicates that the experimental treatment through Inquiry Training Model (mean= 24.10) is more effective than the Control Group (mean=16.71) in developing critical thinking.

The mean difference in scores between the Experimental Group II and Control Group is 5.3333. The positive difference shows that the mean pre-test scores in critical thinking of Experimental Group II is higher than the Control Group. Further more 22 ANCOVA analysis shows that the difference in the mean post-test scores in critical thinking of the Experimental Group-II (Guided Discovery Learning) and the control group is significant with F value, F=102.943, p<0.01. Hence, the null hypothesis [$H_0$3] stating that there is no significant difference in critical thinking between the Experimental Group II and control group is rejected. This indicates that there has been a significant increase in critical thinking due to the experimental treatment through Guided Discovery Learning (mean=22.95) as compared to the Control Group (mean=16.71). This result is in tune with Gurumurthy (1990) who has found that cognitive skills are increased due to intervention through Guided Discovery.

Graph I : Percentage pre-test to post-test gain in critical thinking of the Experimental Group-I, Experimental Group-II and the Control Group



The percentage gain (gain/pre-test score 100) in critical thinking is represented in Graph I.

It reveals that there has been increase in critical thinking in all the three groups. But there is relatively more gain in mean critical thinking scores of Inquiry Training Model and Guided Discovery Learning groups as compared to the control group. While in the control group the gain is only 29%, in Inquiry Training Model and Guided Discovery Learning it is 56% and 52% respectively.

Even though there is a small difference in the mean critical thinking scores of Experimental Group-I and Experimental Group-II, this difference is not statistically significant as revealed from the ANCOVA and post-hoc analysis. This indicates that both Inquiry Training Model and Guided Discovery Learning are effective in developing critical thinking in students.

From the Graph-I it is clear that there exist a difference in the mean score of critical thinking of Experimental Group I and the Control Group. The difference in the mean scores of Experimental Group-I and Control Group in critical thinking, is statistically significant as revealed from the ANCOVA and post-hoc analysis. This result indicates that the Experimental Group I is more effective than the Control Group in developing critical thinking.

From the Graph I it can also be clearly seen that there exist a difference in the mean score of critical thinking of Experimental Group II and the Control Group. ANCOVA analysis and post-hoc analysis reveal that the difference in the mean scores of Experimental Group-II

and Control Group in critical thinking is statistically significant. This result indicates that the Experimental Group II is more effective than the Control Group in developing critical thinking.

Insights from semi-structured interview

The following collections of comments from students were received in response to the interview on Inquiry Training Model classes:

"We enjoyed learning in the Inquiry Training Model classes"

"I realised that my friends think not like me when given a problem."

"In regular classes there is no need to think"

Similarly, students' responses were positive on Guided Discovery Learning classes also, as revealed from the following comments to open ended questions:

"My interest in the science subject has increased due to the Guided Discovery Learning science classes."

"We were all the time discussing various topics; so how can we get bored?"

"In Guided Discovery Learning we learnt to handle apparatus and do experiments ourselves."

These student reactions show that they like the new teaching approaches they were administered in the experimental classrooms. Some students believed that their ability to think has increased.

Findings of the Study

No statistically significant difference was found between the Experimental Group-I and the Experimental Group-II with respect to the development of critical thinking, indicating that both Inquiry Training Model and Guided Discovery Learning are equally effective in fostering critical thinking of students. The study also revealed that both these approaches were more effective in developing critical thinking than the conventional lecture-demonstration method. It was also observed that the classrooms tailored for developing critical thinking do not create boredom in students as students' active participation in learning is encouraged.

It was also observed that the teachers need to be efficient in communication and interaction with students to effectively implement Guided Discovery Learning and Inquiry Training Model to develop critical thinking. Besides, teacher needs to be proficient in the subjects taught and a critical thinker herself to effectively stimulate the students to think critically on subjects.

Discussion

Inquiry Training Model and Guided Discovery Learning require a different social climate in the classrooms than the conventional classroom in which the students are passive learners and have different teacher-student relationship and teacher behaviour. As against the teacher-centred classrooms, these approaches require a continuous two-way communication between the teacher and the students and student-centred, inquiry/activity oriented classes that are focussed on thinking development of students. This corresponds to the findings of Terenzini, et al. (1995) that high level of classroom interaction promotes thinking.

The study confirms the findings of (Swartz and Parks, 1994) that the more explicit the teaching of thinking, the more

students will learn the processes of thinking and their applications and that of Gokhale (1995) that collaborative learning fosters critical thinking. Both approaches in the present study involve collaborative learning which could have contributed to the critical thinking development. Furthermore, classroom culture that promoted free thinking might have contributed to the results.

Conclusion

Depending on the nature of contents taught, application of either Inquiry Training Model or Guided Discovery Learning or both could be adopted even in combination with other methods of instruction. Teacher training needs to be tailored to equip the teachers with skills in conducting classes using these teaching methods.

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