The development of critical thinking skills in physics and sociology curricula

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Abstract: The present study aims to compare the impact of guided inquiry and traditional teaching methods on critical thinking skills of second-grade high school students in physics and sociology courses. Given the purpose, a total of 190 second grade high school students were chosen through random, multi-step and cluster sampling methods in the form of 8 classes and placed into 8 experimental and control groups in physics and sociology courses. A pre-test post-test design was administered to the control group. In order to collect information about participants, two tools were employed. The demographic information was collected by a researcher–made questionnaire and the thinking skills information was determined by Watson - Glaser test. Two- factor covariance method was utilized for data analysis. Results showed that the impact of guided inquiry teaching method on the critical thinking skills of students in inference and conclusion subscales, and the effect of subject in conclusion and interpretation subscales was significant.

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Introduction:

One of the main objectives of teaching is to further stimulate the mental capacity of the learner as a researcher (Lu & Ortlieb, 2009). In this regard, the primary goal of education is considered as training scholars (Reed, 1998; Murphy, 2004). As for the critical thinking concept, a great number of definitions have been offered. For instance, the critical thinking can be defined as an implicit reasoning in critical research, an important tool for social responsibility, consideration of evidences in background information, theories, methods and criteria, and also critical thinking as reflective thinking (Carter et al., 2006). It is also a combination of attitudes, knowledge and skills (Behrens, 1996). According to Watson – Glaser, critical thinking skills include subscales such as inference, deduction and recognition of assumptions, interpretation, and evaluation of arguments (Sendag & Odabas, 2009). Despite being of great importance, the critical thinking is often neglected. Research findings indicate that most individuals are poorly skilled at basic reasoning skills (Van Gelder, 2004), identifying and solving complicated problems (Eyler & Giles, 1999; Wolcott & Lyntch, 1997; King & Kitchener, 1994; Suliman & Halabi, 2006). Cultural and educational factors play a key role in this regard. Individuals' poor thinking skill is associated with the kind of education they receive. Content teaching is not scientifically sufficient by itself (National research council, 2007). Studies show that in most of schools, the learners have no critical intellectual challenge with their courses and are not supported to improve and develop their conceptual reasoning skills (Goodlad & Keating, 1994). Two of distinctive human features can be learning and thinking abilities, on the basis of which two teaching models of learning oriented and reflective oriented models are created. The main goal of education is to transfer cultural heritage and develop thinking ability, regarding the first and the second models respectively (Lipman, 1991). According to some experts, the students' poor thinking skill arises from the dominancy of traditional teaching methods or learning oriented model (Mangena & Chabli, 2005).Traditional teaching method of sciences, as expected, does not increase high-level thinking skills (Halpern, 1999). Instructors are not very interested in research-based teaching methods because of being more time consuming compared to lecture-based model (Lujan & Dicarlo, 2006; Lewittes, 2007). Due to this process, educating students to be critical and creative thinkers has been failed (Lu & Ortlieb, 2009).An extensive modification in teaching must be noted. The proposed modification causes students to develop understanding of scientific concepts along with reasoning and thinking skills (Jan, Van, Douwe & Nico, 2001). Teachers, as curriculum administrators, play an important role in developing thinking skills (De leon- carillo, 2007). Ennis (1997) considered the promotion of critical thinking in its curriculum; two questions always seem to arise. The first question is “Should we have separate course, or should we embed critical thinking in standard course that we are teaching anyway?” he considered a third alternative that is called the mixed approach. So the curriculum question become “Should critical thinking taught separately, embedded or both?” He distinguished between two types of embedding of critical thinking in subject-matter instruction: infusion and immersion. Infusion take place when critical thinking principles are somehow made explicit with immersion although the treatment of the subject matter might will be very deep and involving critical thinking principles are not made explicit.Some exports believe that critical thinking must be improved through variant courses. They think that content knowledge in each course is correlated with thinking skills and research methods thereof and consequently, these two can not be thought separately. In this respect, research findings indicate that adding one critical thinking-related course to curriculum content does not increase critical thinking skills (Grriffin & Everett, 2002). Regarding this issue, the utilization of guided inquiry method has been supported with the purpose of improving critical thinking skills (linn, 1983; Paul & Elder, 2003).In inquiry methods, students are encountered with one challenge out of different problems and afterward, other students pursue the appropriate principals and methods (Bullard & Felder, 2007). Focus on active learning methods, especially the inquiry method, is the basic solution for the problems arisen from applying traditional methods (Lujan, Heidi & Dicarlo, 2006).This proposed teaching method encourages students to learn independently, get involved in critical thinking, solve the problem, ask question, search, and discover the solution (Unesco, 1999). Teaching through the inquiry method results in increased understanding of sciences, improvement of academic achievement, more utilization of critical thinking, development of skills to achieve and analyze the information, and improvement of laboratory skills (Prince & Felder, 2006). The research results indicate the significant effect of problem-solving on the learners’ critical thinking (Sendag & Odabas, 2009). The research results also represent that critical-based writing assignments and participatory teaching methods are positively correlated with critical thinking skills (Asgari, 2007; Hoseini, 2009).Regarding the continuous weakness in critical thinking, and considering the overlap of science structure and scientific research method with thinking structure, this research seeks to investigate whether the guided inquiry teaching method within the curriculum framework can be effective in the improvement of students’ critical thinking skills? In order to respond to the question above, physics and sociology courses were selected among high school courses, and the following hypotheses were outlined and examined:

1) There is a mean difference between critical thinking skills in guided inquiry and traditional groups.
2) There is a mean difference between critical thinking skills in two courses of physics and sociology.

Treatment procedure:

The teacher’s teaching method and lesson plan in the present study was developed on the basis of guided inquiry strategy. First, the researcher attempted to instruct the experimental group’s teachers and thereafter, justify and teach the students to cooperate with the teacher. The treatment classes were managed with inquiry method together with collaboration in group arguments. In this model, after the subject was proposed by the teacher, the students in groups attempted to define the problem, study available sources and offer their viewpoints. In sociology, students offered solutions and argued them among the group. Afterward, each group’s representative reported the results to the whole class. The teacher directed the students through offering essential clues. The students took notes of their viewpoints in their individual or group work folder. The results of group activities were written on the class board and were reviewed by the class in a teacher-led process. Later, being directed to modify their proposed solutions into correct ones, the students wrote the final results on the board. Finally, the students analyzed the problem-solving process by their teacher’s assistance and offered other models and applied solutions. At the end of each session, the instructor introduced the main problem to be examined in next session and asked them to study about it using the internet and other available sources. The class was organized in small face-to-face groups. Each group’s members were selected through group assessment and each group chose a director responsible for coordinating with teacher, summarizing, and presenting group activities to the class. Superior groups were privileged with marks assigned by the teacher. Physics course was instructed through group inquiry method within the framework of proposing problem, collecting and classifying information, theorizing, examining, conducting group arguments about the results, presenting the results in the form of an organized phrase or a formula, and analyzing performed stages to reform them. In traditional groups, teachers continued the usual teaching method.

Materials and methods

To conduct the present study, the quasi-experimental research design was applied. From the variant quasi-experimental designs, non-equivalent pretest-posttest controls design seems very appropriate. The most common quasi-experimental research design consists of two groups of experimental and control. The proposed design is a two-factor design consisting of the independent variables of teaching method and course as its factors. Given the design, the selected classes are randomized into two experimental and control groups. The critical thinking pretest was taken by both groups. Following the pretest, the experimental group received an instruction based on the guided inquiry teaching method, whereas the control group was instructed in the common traditional way. At the end of the treatment period, all participants took the critical thinking posttest.

Participants

Participants of this study were drawn from the whole second-grade high school students of Malayer city (a total of 3341 students, 1548 females and 1793 males), in 2010-2011 academic year.

Sample and sampling method

Sampling method used in this study is a combination of simple random, multi-step and cluster samplings. Given this purpose, through the utilization of random sampling, four high schools were selected out of the city high schools and afterward, four classes (two physics and two sociology classes) out of second-grade classes in each high school, were randomized into two experimental and control groups. Therefore, the class as a cluster was the last sampling unit. The selected sample included a total number of 190. Of these, 95 participants were female and 95 participants were male. In addition, the participants were homogeneous in a number of controllable features, such as age, academic grade, field of study, intelligence, and, place of study. Number of participants in each group (experimental and control), was recommended to be 15 at least (Cohen & Manion, 2000), following other previously-conducted researches which have utilized the same sample size.

Data Collection Procedure

In this study, the data was collected using two measuring tools. The data related to critical thinking skills was determined through Watson-Glaser test (form A) and the participants' demographic information was collected by a researcher-made questionnaire.

Watson-Glaser test of critical thinking

The Watson-Glaser test of critical thinking is a paper-pencil multiple-choice test with 100 questions, suiting to the reading level of a first-grade high school student. The test questions cover two substances: usual topics such as weather-based topics or scientific facts, and controversial topics concerning economy, politics, and social issues. The Watson-Glaser test of critical thinking essentially consists of 5 subscales to assess the critical thinking components, including conclusion, inference, recognition of assumptions, interpretation and, evaluation of arguments. The participants selected the best choice for each of the above five skills. These tools were repeatedly used in measuring the school and university students' critical thinking at the beginning and end of a curriculum, comparing the participants' critical thinking in different educational levels, and examining the correlation between the critical thinking and other variables (Behrens, 1996).

The validity and reliability of Watson-Glaser test of critical thinking test

The convergence method was applied to determine the construct validity of the Watson-Glaser test of critical thinking test. The correlation between California critical thinking scores and Watson-Glaser test scores was estimated to be 64% (r=64%). The significant and positive correlation indicated both tests measure the same construct. As a result, the Watson-Glaser test of critical thinking test has convergent validity. The test reliability was determined by Kuder-Richardson (73%) and test-retest (68%) methods (Asgari, 2008). In the present study, test reliability was also computed through Kuder-Richardson on the research sample (66%).

Findings

A) Descriptive: table 1 shows posttest mean scores and standard deviation for critical thinking in guided inquiry and traditional groups.

Table (1) shows that critical thinking mean score for students in the experimental group was approximately two scores higher than that in the control group. Table 2 shows Mean and standard deviation of critical thinking posttest in guided inquiry and traditional groups based on the subject.

Table (2) shows that critical thinking mean score for physics students in the experimental group was approximately three scores higher than that in sociology.

B)Inferential: Table 3 shows the results for analysis of co-variance test comparing posttest mean scores of critical thinking in two groups of experimental and control based on the subject.Regarding the findings shown in table (3), the impact of guided inquiry teaching method on critical thinking skills was significant. Therefore, the first hypothesis was confirmed on the account of the revealed mean difference between the critical thinking skills in guided inquiry and traditional groups. The impact of subject was significant, whereas its interaction with the teaching method was not so. Therefore, the second hypothesis was confirmed on the account of the revealed mean difference between the test results of critical thinking skills in physics and sociology courses, showing that the students in physics obtained a higher posttest mean score in critical thinking skills. Table 4 indicates analysis of co-variance test for comparing posttest mean scores related to critical thinking subscales in experimental and control groups based on the subject.

According to the results stated in table (4), the impact of guided inquiry teaching method on conclusion subscale was significant. But the subject impact was non-significant, the interaction between subject and teaching method was not so. The impact of guided inquiry teaching method on inference subscale was significant. However, the subject impact was non-significant, the interaction between subject and teaching method was not so. For interpretation subscale, the impact of teaching method was not significant. Concerning the interpretation subscale, subject was significant, however the interaction between subject and teaching method was not so. Regarding assumptions subscale, the teaching method impact was not significant but the subject was significant and their interaction were not significant. Regarding argument appraise subscale, teaching method, subject and their interaction were not significant.

Discussion

Data analysis lends credence to the fact that guided inquiry teaching method had significantly increased critical thinking of second-grade high school students. These findings were in line with the other researchers' findings on thinking skills teaching (Schwartz, et al., 2003; Prince, Michael & Felder, 2006; Lu & Ortlieb, 2009; Lewittes, 2007). The results of test analysis related to critical thinking skills subscales indicated that the mentioned impact was created in conclusion and inference subscales. Therefore, we can conclude that students' critical thinking skills in both conclusion and inference subscales can be increased through the utilization of guided inquiry teaching method, yet in other subscales no considerable difference was observed. Critical thinking is a complex time-consuming process, requiring preparation for high-level intellectual functions. According to some researchers, being a long-term process, critical thinking must be improved from elementary school (Badri, 2007). Thus, 12 treatment sessions was less likely to create sufficient impact on critical thinking components.

In addition, the utilization of traditional method in other classes and cultural backgrounds can be considered as other factors that restrict the improvement of students' critical thinking skills and avoid realization of some subscales. In this respect, a number of theorists believe that critical thinking is a culture-related feature (Durkin, 2008; Atkinson, 1997). In the present study, critical thinking instruction was administered in relation to the curriculum. Many of experts assume that content knowledge in each course is correlated with the thinking skills and research methods thereof. As a result, these two can not be separately instructed (Paul & Elder, 2003; Lipman, 1991; Linn, 1983).

As results show, the impact of subject in assumption and interpretation subscales was significant. Physics students indicated higher improvement in these skills. This distinction can stem from the laboratory nature of physics course. According to experts, laboratory activities play a distinctive role in sciences curriculum and students' involvement in such activities is greatly advantageous.

These activities are sufficiently capable to improve critical thinking skills in form of research experiences. The main components in the structure of a scientific discipline have been formed through employing scientific research methods and thinking about that discipline, and the only way of understanding and applying these components can be through the utilization of thinking skills in that scientific discipline. Therefore, the course nature influences research and teaching methods affecting students' thinking skills (Linn, 1983; Paul & Elder, 2003). The guided inquiry teaching method in this study was proposed and administered using structure-oriented perspective, especially the social one. In this perspective, students' collaboration in knowledge building, utilization of problem-solving, and group discussion were emphasized, resulting in the improvement of students' thinking skills.

Table 1: Mean and standard deviation of critical thinking posttest in guided inquiry and traditional groups

Group	Mean	S.D
Experimental	52.97	6.78
Control	50.76	5.61

Table 2: Mean and standard deviation of critical thinking posttest in guided inquiry and traditional groups based on the subject

Group	Subject	Mean	S.D
Experimental	Sociology	51.45	6.86
	physics	54.52	6.39
Control	Sociology	49.36	6.90
	physics	51.95	4.92

Table 3: Covariate analysis to comparison of mean in post test of critical thinking based on the subject

Source	ss	df	Ms	F
Covariant(pretest)	281.83	1	281.83	8.23*
Covariant(mean)	176.23	1	176.23	5.15*
Covariant(intelligence)	20.30	1	20.30	.593
group	165.76	1	165.76	4.84*
subject	128.07	1	128.07	3.74*
interaction	.389	1	.389	.011

p<.05

Table 4: Covariate analysis to comparison of mean in post test of critical thinking sub scales based on the subject

Sub scale	source	ss	df	Ms	F
Conclusion	**Covariant(pretest)**	107.85	1	107.85	14.85*
	Covariant(mean)	15.07	1	15.07	2.07
	Covariant(intelligence)	19.39	1	19.39	2.67
	group	32.85	1	32.85	4.38*
	subject	14.32	1	14.32	1.97
	interaction	1.62	1	1.62	.223
Inference	**Covariant(pretest)**	28.11	1	28.11	7.47*
	Covariant(mean)	50.28	1	50.28	9.65*
	Covariant(intelligence)	.207	1	.207	.04
	group	22.28	1	22.28	4.27*
	subject	4.71	1	4.71	.905
	interaction	5.63	1	5.63	1.85
assumption	**Covariant(pretest)**	63.65	1	63.65	16.53*
	Covariant(mean)	5.51	1	5.51	1.43
	Covariant(intelligence)	2.15	1	2.15	.559
	group	1.60	1	1.60	.418
	subject	16.8	1	16.8	4.36*
	interaction	.229	1	.229	.o6
interpretation	**Covariant(pretest)**	38.31	1	38.31	5.86*
	Covariant(mean)	7.58	1	7.58	1.16
	Covariant(intelligence)	3.5	1	3.5	.535
	group	4.04	1	4.04	.619
	subject	17.15	1	17.15	2.62*
	interaction	16.48	1	16.48	2.52
Argument apprise	**Covariant(pretest)**	24.13	1	24.13	5.136*
	Covariant(mean)	10.02	1	10.02	2.13*
	Covariant(intelligence)	.084	1	.084	.018
	group	2.13	1	2.13	.453
	subject	.136	1	.136	.029
	interaction	1.57	1	1.57	.339

P<.05

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