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Anthropologist, 20(1,2): 369-376 (2015)
PRINT: ISSN 0972-0073 ONLINE: ISSN 2456-6802
DOI: 10.31901/24566802.2015/20.1-2.39

The Effect of Inquiry-Based Laboratory Application on Thinking Styles of Students

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KEYWORDS Chemistry Inquiry-based Learning. Teacher Candidate. Thinking Styles

ABSTRACT The aim of this study is to determine the thinking styles of teacher candidates and examine the impact of inquiry-based laboratory applications on thinking styles. This research was designed as an experimental model based on a control group with pre- and post-tests. Data were collected by applying the "Thinking Styles Inventory". The thinking styles of teacher candidates developed differently, depending on traditional laboratory and inquiry-based laboratory applications. When post-test scores of thinking styles were examined, there was an increase in the scores of teacher candidates. Therefore, it can be concluded that traditional laboratory and inquiry-based laboratory applications are effective for developing the thinking styles of teacher candidates.

INTRODUCTION

Educational institutions should be able to both contribute to changes and raise individuals who can extract new information from current situations that lead to changes and think creatively and critically (Gurol 1995). Chambers and Andre (1997) emphasized that different methods help students deal with alternative concepts and direct experiences are more effective for application training. When the role of laboratory in engineering and science education is considered, it has been pointed out that constructive education, which adopts the basic role of experimentation in building information and places importance on the role of students' self-management during the learning process, recently changed direction (Abdulwahed and Nagy 2008).

Application of science is only possible by an open-ended process based on research and invention, experimental design based on observation, and educational devices that will show effectively how the scientific process works in the real world (Switzer and Shriner 2000). Science educators have highlighted that "doing science activities" is an effective way for students to learn, keep information in mind, and use scientific information (as cited in Seifert et al. 2009). Instead of giving students literal information, approaches that teach where and how to find and use the information into the forefront and expose students to learning-teaching processes have started to become important. One of these approaches is the inquiry-based learning approach (Caliskan 2008). Research is a term that is used to inquire, look for information, and begin searching for facts in science. Many science educators have stated that science education should emphasize research (Hossand 2005). According to the Standards of National Science Education, research helps students understand scientific concepts, realize what they know and how they know it in science, comprehend the nature of science, develop the required skills to be an independent researcher, and to develop skills, attitudes and abilities related to science (Hossand 2005).

Individuals who have the ability to research are individuals who know how to reach the required information, where to use that information, and how to combine the new information with other information. Inquiry-based learning is a process in which learners learn, ask questions, search thoroughly, and then build new meanings, comments, and information. In inquiry-based learning, the new information is used to support an idea or an argument or to develop an answer to a question or solution. Moreover, this information is presented via short activities (Al 2004); in inquiry-based learning, the teacher presents a complicated situation and expects students to solve this problem by testing the scores and col-

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lecting data (Woolfolk 2001). Babadogan and Gurkan (2002) arranged the basic features of inquiry-based learning as building a thinking frame based on the student, determining the aim and target behavior, putting the teacher into the form of a class leader who controls everything, predicting the reactions of students related to the subject, turning the class into a learning laboratory, and caring about each student. Inquiry-based learning is an approach by which problem solving, case, project, drama, role play, observation, discussion, group work, and laboratory methods can be effectively applied (Buyukkaragoz and Civi 1999). The inquiry-based learning model is composed of describing the problem, forming hypotheses, designing experiments with mentors, applying, observing, recording, and discovering the relationship between variables, and forming conclusions. Applied activities or laboratory training have important roles in increasing science success and cognitive development (as cited in Ertepinar and Geban 1996). Therefore, the primary aim of this research is to make teacher candidates gain research skills. Inquiry-based learning, which requires the participation of students in the learning process, develops higher thinking skills (Lim 2001). In applications of inquiry-based learning, there is an increase in the information level of students, especially as a result of laboratory activities (Bryant 2006).

Thinking cannot be formularized as a course material to be taught, learned, and evaluated; thinking includes planning, ranking, creating structural drafts, deciding on what is important, and reflecting a student's own idea as a result of their own activity (Nodding 2008). The theory of spiritual self-management explains the thinking styles of individuals. Thinking styles are primarily described as ways of using the skills that we have; the basic concept of this theory is that people manage or somehow control the daily activities that they require and prefer the styles that they can easily apply while they manage their activities. In addition, individuals can change the thinking styles that they use, depending on the formal demands of the situation that they are in and their environment, suggesting that styles can be partially socialized (Sternberg 1997).

Some of the basic features of thinking styles were generally described by Sternberg (1997): styles are not abilities, but preferences; styles are neither good nor bad; harmony between teacher and learner or learner and material is more important; styles can change according to missions and situations; some people prefer more definite styles while some prefer weak ones; some people can easily move between styles and some cannot; styles socialize people; styles are learned through interaction with the environment; styles can change throughout life and people can change their styles in time; styles are measurable; the style that is valuable now may not be valuable in any other time; and while styles may lead to success at school or work, they may not lead to success in other areas.

Comprehending thinking styles help teachers differentiate their teaching and maximize learning outputs (Sternberg 1997). Theory of thinking styles is used in areas of problem solving, deciding, and managing. Thinking styles illuminate personal and organizational problems; this theory is used as supporting material to match the roles of individuals (Sternberg 1997). Various studies examined implementation of thinking styles by integrating them with a syllabus and they reached the same results: when the student teaches the subject in which he/she has actively participated, he/she is able to develop his/her ability to think and, by doing so, the concept of learning based on thinking was formed (Swartz 2008).

The Aim of the Study

Considering the different thinking styles will contribute to the development of learning and teaching methods (Sternberg 1997). Therefore, the aim of this study is to determine the thinking styles of teacher candidates and to examine the impact of inquiry-based laboratory applications on the thinking styles of teacher candidates.

In this study, the questions below were asked:

1) What are the thinking styles of teacher candidates?
2) Is there a significant difference between students' scores of pre-test thinking style in the experimental group and those of the control group?
3) Does the inquiry-based laboratory application have a significant impact on the thinking styles of teacher candidates?
4) Does the traditional laboratory application have a significant impact on the thinking styles of teacher candidates?

METHODOLOGY

Research Design

This research was designed as an experimental study model based on pre-test and post-test of a control group. In the pre-test and post-test model of a control group, test subjects are subjected to measuring related to the dependent variable both before and after experimental study. In this model, test subjects are divided into two groups: experimental and control (Karasar 1999). Experimental and control groups were determined according to the method of objective sampling. The working group of the study was composed of 107 teacher candidates who studied at the Faculty of Education, Hacettepe University, during the Fall Term.

Research Instruments

In the study, data were collected by applying the “Thinking Styles Inventory”. The Thinking Styles Inventory was developed by Sternberg-Wagner (1992) to determine the thinking styles of individuals. There are 104 articles in the original “Thinking Styles Inventory” which is in the model of a 5-point Likert scale. In each article of this inventory, there is a situation that presents which thinking patterns and styles the individual will choose in case of facing a problem or information and it is demanded from the individuals to show on the scale how often they form this behavior. Positive statements of this inventory are graded as: Always: 5, Often: 4, Sometimes: 3, Rarely: 2, and Never: 1. The scale is composed of total 13 sub-dimensions with 5 main headlines. These are:

A) Functional Style: legislative, executive, judicial;
B) Formal Style: monarchic, hierarchic, anarchic, oligarchic;
C) According to level: global, local;
D) According to content: internal, external,
E) According to tendency: progressive, conservative.

In the original inventory, each sub-dimension is composed of 8 articles. After the grades from one dimension are gathered, the scale grade for all 13 dimensions for each individual is acquired.

Theoretically, since scoring for each article changes from 1 to 5, the highest score that can be obtained from a sub-dimension of the scale is 40 and the lowest score is 8; higher scores indicate a greater propensity for that thinking style. The adaptation of the scale into Turkish was made by Sunbul (2004). According to the results of factor analysis, the Turkish form of the scale is composed of 13 factors. Reliability coefficients calculated for all sub-dimensions of the scale are, in order: legislative thinking style 0.709, executive thinking style 0.743, judicial thinking style 0.783, monarchic thinking style 0.701, hierarchic thinking style 0.786, anarchic thinking style 0.713, oligarchic thinking style 0.720, global thinking style 0.713, local thinking style 0.722, internal thinking style 0.821, external thinking style 0.861, progressive thinking style 0.832, and conservative thinking style 0.854.

Data Analyses

Data obtained in the study were analyzed by the SPSS 15.0 program. Arithmetic average, standard deviation, and t-test were used to test the research questions.

Experimental Process Steps

Research was carried out in the experimental and control groups for one semester (14 weeks) by the researcher.

While inquiry-based laboratory application was done in the experimental group, traditional laboratory study was done in the control group.

At the first week of the application, the “Thinking Styles Inventory” was applied to the students as a pre-test.

A presentation was given to the students of the experimental group to inform them about the inquiry-based laboratory application. The students were informed about how the inquiry-based laboratory would be carried out during the laboratory study, how determining the topic and researching it would be carried out, how experiments would be done, how the study would be evaluated, and how presentations would be given. How experiments would be done and how experiment reports would be prepared was explained to the control group.

Students of the experimental and control groups studied chemical equilibrium, oxidation-reduction reactions, acid-base titration, and reaction rate.

In the experimental group, in which an inquiry-based laboratory application was applied, students formed pairs. Then, pairs were assigned a study topic via lottery. Students discussed the experiments, analyzed the experiments in detail, repeated the experiments when they met unwanted results, and suggested innovations for experiments. They prepared their reports in accordance with their data.

Traditional laboratory methods were applied in the control group. In the traditional laboratory method, students carried out their experiments as described in the experiment brochure; have available devices, chemical substances and mechanisms that they used and observed the results. They wrote experiment reports.

At the end of the application process, a thinking styles inventory was applied to the experimental and control groups as a post-test.

Research was carried out within 14 weeks in both groups.

RESULTS

Grades of mean and standard deviation regarding thinking styles were examined as a result of descriptive analysis that was carried out to determine teacher candidates' thinking styles. Results are shown in Table 1. Teacher candidates had higher average legislative, progressive, and hierarchic thinking styles, and lower average conservative, oligarchic, and global thinking styles.

Table 1: Means and standard deviations regarding the thinking styles of teacher candidates

Thinking styles	*N*	*Mean*	*Std. deviation*
Legislative thinking	107	4.2944	.35449
Executive thinking	107	3.8481	.51339
Judicial thinking	107	3.6682	.55321
Monarchic thinking	107	3.5754	.46414
Hierarchic thinking	107	3.8959	.48129
Anarchic thinking	107	3.3645	.47593
Oligarchic thinking	107	3.0467	.55006
Global thinking	107	3.2457	.56492
Local thinking	107	3.5047	.53211
Internal thinking	107	3.4379	.72080
External thinking	107	3.7263	.64102
Progressive thinking	107	3.9599	.60666
Conservative thinking	107	3.0374	.65475

An independent sample t-test was applied to determine whether there is a difference between thinking styles as a result of the pre-test application of teacher candidates in experimental and control groups. Results are given in Table 2. Score averages regarding the thinking styles of experimental and control groups before application are in Table 2 and their scores were tested

Table 2: Pre-test t-test results regarding the thinking styles of experimental and control groups

Thinking styles	*Groups*	*N*	*Mean*	*Std. deviation*	*t*	*p*
Legislative Thinking	Control group	57	4.3377	.40156	1.384	.169
	Experimental group	50	4.2450	.28789		
Executive Thinking	Control group	57	3.8487	.54983	.012	.991
	Experimental group	50	3.8475	.47400		
Judicial Thinking	Control group	57	3.75443	.52129	1.736	.085
	Experimental group	50	.5700	.57707		
Monarchic Thinking	Control group	57	3.6115	.50055	.858	.393
	Experimental group	50	3.5343	.42004		
Hierarchic Thinking	Control group	57	3.8922	.51880	-.084	.933
	Experimental group	50	3.9000	.43984		
Anarchic Thinking	Control group	57	3.4135	.54778	1.167	.246
	Experimental group	50	3.3086	.43984		
Oligarchic Thinking	Control group	57	3.0752	.53528	.570	.570
	Experimental group	50	3.0143	.57015		
Global Thinking	Control group	57	3.2206	.55069	-.489	.626
	Experimental group	50	3.2743	.58500		
Local Thinking	Control group	57	3.5464	.54205	.864	.389
	Experimental group	50	3.4571	.52191		
Internal Thinking	Control group	57	3.4185	.80986	-.301	.764
	Experimental group	50	3.4600	.61108		
External Thinking	Control group	57	3.7594	.68573	.568	.571
	Experimental group	50	3.6886	.59056		
Progressive Thinking	Control group	57	4.0000	.61741	.728	.468
	Experimental group	50	3.9143	.59709		
Conservative Thinking	Control group	57	3.0301	.71313	-.123	.903
	Experimental group	50	3.0457	.58827		

by t-test to determine whether there were significant differences between the experimental and control groups in terms of thinking styles before application (p>.05). This can be commented as experimental and control groups are equal in terms of thinking styles before application.

The results of teacher candidates' thinking styles before and after inquiry-based laboratory application are shown in Table 3. After the inquiry-based laboratory application, the thinking style scores of teacher candidates increased; depending on the experimental applications, there is a significant difference in judgmental thinking, integrative thinking, and traditional thinking styles of teacher candidates. The results of thinking styles after traditional laboratory application are shown in Table 4; the thinking style scores in this group also increased, with significant differences in irregular thinking, integrative thinking, introverted thinking, and traditional thinking, depending on the experimental applications.

DISCUSSION

This study aimed to examine the impact of traditional laboratory application and inquiry-based laboratory application on thinking styles and to determine the thinking styles of teacher candidates. Pre-test data indicated that teacher candidates have higher average legislative, progressive, and hierarchic thinking styles and lower average conservative, oligarchic, and global thinking styles. The dominant features of teacher candidates are: legislative thinking that produces, forms, designs, and does things by using his own methods; progressive thinking that uses new methods and challenges traditions; progressive thinking that does things simultaneously and immediately and likes planning when and how to do things (as cited in Sunbul 2004). Cubukcu (2004) revealed in his study that teacher candidates use executive and hierarchic thinking styles more often than not.

There was no observed difference in pre- and post-test thinking style scores between the groups exposed to traditional or inquiry-based laboratory applications.

Inquiry-based learning is composed of a few steps: suspicion-wonder, describing problem, forming a hypothesis, gathering, analyzing and evaluating information, testing the hypotheses, and researching again but in a different way

Table 3: Results of pre-test and post-test thinking styles of teacher candidates in experimental group

Thinking styles	*Groups*	*Mean*	*Std.deviation*	*t*	*p*
Legislative Thinking	Pre-Test	4.2450	.28789	.467	.642
	Post-Test	4.2175	.38698	.467	.642
Executive Thinking	Pre-Test	3.8475	.47400	1.334	.188
	Post-Test	3.7625	.46170		
Judicial Thinking	Pre-Test	3.5700	.57707	-4.432	.000
	Post-Test	3.9825	.39771		
Monarchic Thinking	Pre-Test	3.5343	.42004	-1.113	.271
	Post-Test	3.6143	.55007		
Hierarchic Thinking	Pre-Test	3.9000	.43984	-.281	.780
	Post-Test	3.9200	.40628		
Anarchic Thinking	Pre-Test	3.3086	.37560	-.614	.542
	Post-Test	3.3600	.50671		
Oligarchic Thinking	Pre-Test	3.0143	.57015	-.453	.653
	Post-Test	3.0600	.65757		
Global Thinking	Pre-Test	3.2743	.58500	-2.852	.006
	Post-Test	3.5171	.43378		
Local Thinking	Pre-Test	3.4571	.512191	-.894	.376
	Post-Test	3.5257	.45491		
Internal Thinking	Pre-Test	3.4600	.61108	-.769	.445
	Post-Test	3.5543	.64125		
External Thinking	Pre-Test	3.6886	.59056	-.129	.898
	Post-Test	3.7000	.47094		
Progressive Thinking	Pre-Test	3.9143	.59709	.435	.666
	Post-Test	3.8714	.50010		
Conservative Thinking	Pre-Test	3.0457	.58827	-3.229	.002
	Post-Test	3.3000	.54014		

Table 4: Pre-test and post-test t-test results of thinking styles of teacher candidates in control group

Thinking styles	*Groups*	*Mean*	*Std.deviation*	*t*	*p*
Legislative Thinking	Pre-Test	4.3348	.40460	.776	.441
	Post-Test	4.2634	.54234		
Executive Thinking	Pre-Test	3.8504	.55464	-.415	.680
	Post-Test	3.8973	.65240		
Judicial Thinking	Pre-Test	3.7522	.52575	.434	.666
	Post-Test	3.7031	.64955		
Monarchic Thinking	Pre-Test	3.6276	.49011	-.506	.615
	Post-Test	3.6709	.56419		
Hierarchic Thinking	Pre-Test	3.9056	.51347	-.779	.439
	Post-Test	3.9796	.54852		
Anarchic Thinking	Pre-Test	3.4184	.55151	-.943	.350
	Post-Test	3.5230	.66633		
Oligarchic Thinking	Pre-Test	3.0689	.53798	-2.928	.005
	Post-Test	3.3648	.66222		
Global Thinking	Pre-Test	3.1939	.51718	-4.349	.000
	Post-Test	3.6012	.61678		
Local Thinking	Pre-Test	3.5740	.50489	-.144	.886
	Post-Test	3.5893	.59501		
Internal Thinking	Pre-Test	3.4464	.78910	-2.588	.012
	Post-Test	3.7321	.55833		
External Thinking	Pre-Test	3.7551	.69117	.119	.906
	Post-Test	3.7398	.68436		
Progressive Thinking	Pre-Test	4.0204	.60329	.644	.522
	Post-Test	3.9490	.54784		
Conservative Thinking	Pre-Test	3.0230	.71754	-2.891	.005
	Post-Test	3.3571	.72383		

(Obenchain and Morris 2003). The post-test scores of teacher candidates increased after inquiry-based laboratory application, with significant increases in judicial, global, and conservative thinking styles. Teacher candidates in the experimental group like evaluating and judging people and things (judicial thinking), showing interests in pictures, generalizations and abstracting things (global thinking), and doing things by using correct methods that were tried beforehand and following traditional ways (conservative thinking), in accordance with inquiry-based laboratory application. Özdemir and Sert (2010) Ozdemir and Sert (2010) researched the impact of project-assisted education on the thinking styles of students ; they determined that there is a meaningful difference between pre-test and post-test scores of control and experimental groups in terms of oligarchic and anarchic thinking styles, concordant with this study. This result shows that thinking styles can be developed by using different methods.

Traditional laboratory application led to significant differences between pre- and post-test averages of teacher candidates in oligarchic, global, internal, and conservative thinking styles. Traditional laboratory applications affect: oligarchic thinking that likes a random approach to a problem and does not appreciate systems, guidance, and nearly all kinds of instructions; global thinking, described as being interested in pictures, generalizations, and abstract things; internal thinking, described as working alone, focusing on his own ideas, and being self-sufficient; and conservative thinking, described as doing things by using correct methods that were tried beforehand and following traditions.

At the end of the study, it was noted that there was a development in the thinking styles of teacher candidates as a result of traditional laboratory application and inquiry-based laboratory application, indicated by increased post-test scores. According to Sunbul (2004), a high score is an indicator that shows that related thinking styles are at high levels.

Ertepinar and Geban (1996) revealed that inquiry-based activities increased the comprehension of the concepts of teaching and learning science. As a result of constructive syllabus application, developing comprehension of science concepts is more possible than by using the traditional laboratory approach (Liang and Gabel 2005; Nuangchalerm 2013; Stefanova 2014). According to the study of Cristianson and Fisher

(1999), students in the group that had a constructive laboratory/discussion application better understood the subject than those in traditional application group. Abdulwahed and Nagy (2008) revealed that a constructive laboratory model application significantly increased meaningful learning for the students' engineering career and motivation. Because of the importance of constructive laboratory application and inquiry-based laboratory application in science, applications that allow different thinking styles should be used.

Thinking styles are like unique signatures of individuals. Any learning or thinking style is better or worse than the others (Sofo 2004). When the literature is examined, the interaction between teacher's and students' thinking styles has a weak but a positive impact on the participation of students (Betoret 2007); students think that they will get better grades or be evaluated positively when they have the same thinking style as their teachers (Sternberg and Grigorenko 1995). There is a meaningful relationship between thinking styles and academic success (Grigorenko and Sternberg 1997), such that a mutual meaningful relationship between learning and thinking is determined (Cano-Garcia and Hughes 2000), which demonstrates the importance of thinking styles.

CONCLUSION

The importance of this research comes from its emphasis on how the inquiry-based chemistry laboratory application affected thinking styles. The teacher is seen as a source of knowledge in the eyes of students and parents; in other words, the student is seen as a passive individual who takes what he/she is given, whereas the teacher is seen as an individual who greatly conveys the knowledge. This research aims to make students play an active role in learning processes, give them the ability to question, and improve their thinking styles in accordance with their skills during the education process. Thinking styles are the ways in which individuals choose to use their skills they have; during the research, the students were made to be aware of their skills and were asked to make use of their different thinking styles during the process of questioning. Thus, the students were able to make use of the thinking styles they previously had used less in the new learning environments. Thinking styles are used in areas like problem solving, questioning, and decision making, and a teacher who knows how to make use of those thinking styles effectively will ensure the improvement of thinking styles by giving different tasks to his/her students. This research has significance in giving teacher candidates the knowledge of how to use different thinking styles to educate individuals who will be able to hypothesize, research, question, and come to a conclusion. Therefore, it is very important to increase the number of studies in this field as well as contribute to the literature with new resources.

RECOMMENDATIONS

According to the results obtained from this study, inquiry-based learning applications can be used to reveal skills and information.

- Laboratory applications can be designed to contribute to developing the thinking styles of students.
- Laboratory applications that allow students to improve themselves at the laboratory, show their performance, and evaluate themselves should be used.
- Activities that develop the thinking styles of individuals should be used.
- Arrangements that allow students to benefit from thinking styles they have should be used at secondary schools and universities.
- Different activities should be used by considering the fact that individuals show appropriate behaviors' to different thinking styles.
- Scientific research methods that allow students to use and develop thinking styles in studies carried out in a laboratory should be used.
- Sometimes, research can be repeated using different students and test subjects.

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