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THE EFFECTS OF PROCESS-BASED TEACHING MODEL ON STUDENT TEACHERS' LOGICAL/ INTUITIVE THINKING SKILLS AND ACADEMIC PERFORMANCES

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Abstract. *The aim of this study is to analyze the effects of Process-based Teaching Model on student teachers' logical and intuitive thinking skills as well as their academic performances at chemistry laboratory applications. The sample of this research consisted of 60 preservice teachers studying of Faculty of Education in Hacettepe University. Data were obtained via the "experimental desing with pre/posttest control group" evaluated both qualitatively and quantitatively. The experimental group was taught within the process-based teaching model while the control group received training in traditional teacher centered education. The scores obtained by participating experimental and control groups from Logical/ Intuitive Thinking Scale, Performance Test and Structured Grids as one of the alternative measurement and evaluation techniques were compared and contrasted. To determine the student teachers' logical and intuitive thinking styles, the "Logical/ Intuitive Thinking Scale" developed by Pacini and Epstein (1999) and adapted by Turk (2011). The study concluded that teaching chemistry using process-based teaching model improved students' academic performance as well as their logical and intuitive thinking skills.*

Key words: *logical and intuitive thinking, process-based teaching model, teacher education.*

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Introduction

In the ever-changing world, there is a need for individuals who embrace innovations and developments while being aware of their responsibilities. For a community to reach modern levels, it is never enough to transfer knowledge, beliefs and emotions to individuals directly. Today, individuals are required to produce knowledge rather than consuming it. An individual in a modern world neither accept the transferred knowledge directly nor expect to be shaped or directed; they interpret knowledge and participate actively in process of constructing the meaning. Individuals of the modern world have different ways of perceiving, understanding, approaching, problem solving and learning. Creating learning environments where learners actively participate is closely related to choosing appropriate methods and techniques. Therefore, learning process that involves thinking and research shall be enriched with well-structured teaching techniques and students shall be encouraged to be active participants in the classroom (Bonwel & Eison, 1991).

One of the teaching methods promoting active participation of students in their learning processes is the "Process-based Teaching Model" (PBT). Process-based Teaching is the teaching/ learning method, where students think through improving their process awareness, learn independently, make their own decisions, solve problems and make plans. Process-based Teaching involves all characteristics of active learning while promoting students to learn systematically and openly through plans on how to learn or solve (Ashman & Conway, 1993). Process-based Teaching has been defined in the literature in various ways, each of which are supportive of active learning while focusing on its encouraging aspect for discovery learning. According to Wong (1992) Process-based Teaching involves process design and modeling with the aim of problem solving, planning on a topic and completing during the attainment of certain academic knowledge as a cognitive psychology. Vermut (1995) defines Process-based Teaching as teaching of specific knowledge and thinking strategies coherently and explains its aim as supporting the development of comprehension and practice-based learning styles. According to De Jong (1995), Process-based Teaching focuses on a students' improving his/her awareness while explaining a qualified education using social, affective and cognitive activities. Additionally, within the Process-based Teaching model, students make use of technological tools in global links and research, communicate with others and work cooperatively (Nancy, 1997). In this respect, Process-based Teaching enables students to grow up with the active-learning awareness all throughout their lives (Bolhuis, 2000). The planning process is very important in Process-based Teaching as effective planning enables students to attain new knowledge and make connections with their existing knowledge. Teachers play important roles at this phase. Using Process-based Teaching plans, teachers can enable students to understand academic topics successfully while promoting them to attain learning and teaching responsibilities (Ashman, Wright & Conway, 1994). In this way, Process-based Teaching requires teachers to guide their students in planning, increasing their thinking capabilities and improving their thinking processes. Figure 1 displays the characteristics of Process-based Teaching and the stages of the planning process (Duman, 2008).

A NEW APPROACH IN TEACHING/LEARNING:PROCESS-BASED TEACHING MODEL			
As the learning/teaching method, strategy and technique: Learning to learn, problem solving, learning, individual learning and cooperative learning		Program Model:Presenting framework for all students in effective communication, structural classroom environment and activities	
STAGES OF PROCESS-BASED TEACHING MODEL			
↓	↓	↓	↓
Introduction to Learning/teaching Process Stage	Establishment of Learning/teaching Process Stage	Consolidation of Learning/ teaching Process Stage	Incorporation of Learning/ teaching Process Stage

Figure 1: Process-based teaching model.

Each phase in Figure 1 can be analyzed in the form of a reversed pyramid. The state of these phases indicates wide program scopes planned by students depending on skills they attain from the bottom to the top. Each section of the pyramid is determined according to the scope of knowledge depending on the application of Process-based Teaching. During the phases, the percentage of improvement in students and teachers depends on the teaching styles of teachers as well as the competencies of students (Duman, 2008). Process-based Teaching contributes to improving students' thinking processes and increasing their learning capacities. However, the process of attaining, using and developing thinking styles requires approaches that explain individual differences through wider perspectives. Logical and intuitive systems are able to affect individuals' reasoning, decision making and problem solving processes and are initiated by the logical-intuitive self. According to the Logical-Intuitive Self Theory, thinking and reasoning has two different processing systems namely the logical system and intuitive system, each of which function according to their own rules. Both processing systems have unique schemes and beliefs (Epstein, Pacini, Denes-Raj, & Heier, 1996; Teglasi & Epstein, 1998). These systems work parallel to each other and interactively and the adaptive behavior is defined by the common effect of these two systems. In determining the effective system on the behavior, the characteristics of the task individual characteristics and the context is taken into consideration (Denes-Raj & Epstein, 1994; Epstein, Pacini, Denes-Raj, & Heier, 1996; Klaczynski, 2001; Klaczynski & Cottrell, 2004; Teglasi & Epstein, 1998, Witteman, Bercken, Claes & Godoy, 2009). Logical thinking system is guided by the culturally transmitted rules of logic, while intuitive system is guided by the intuitive cognitive shortcuts. Kirkpatric and Epstein (1992)

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reported that individuals moved from intuitive thinking towards more analytical and logical thinking when they are motivated.

Studies on logical and intuitive thinking styles mainly focus on cognitive shortcut utilization, misjudgments, personal characteristics and developmental aspects. There are almost no studies on learning processes in terms of cognitive variables affecting these processes. As Cognitive Experiential Self Theory explains, two systems are not independent from each other and they work in parallel to each other. This state of functioning parallel to each other enables development of schemes that unite factors affecting processing and storing of knowledge when the two systems are coherent. Therefore, analysis on these systems and affecting factors are important to learning processes. The studies on Process-based Teaching concluded that it improved students' inner motivations as well as their cognitive awareness (Duman, 2008). The materials used in the Process-based Teaching model facilitate cognitive and affective attainments depending on interaction with peers or teachers in small groups or individually while enabling students to make planning and evaluating activities. The study by Naglieri and Johnson (2000) emphasized the importance of the planning stage in Process-based Teaching Model. Planning is defined as a mental phase, which enables cognitive control over self-regulation and observation in using knowledge and process. Process-based Teaching has been reported to be effective on students in planning thinking individually; studying by reasoning and planning as well as sharing learnt knowledge and skills (Duman, 2008; Houck, 1993; Lowenthal, 1986; Moersch, 1997; Volet, 1995). Therefore, while Process-based Teaching contributes to increasing students' thinking capacities and developing thinking process, it integrates students' individual differences into teaching process. Most of the recent studies in the field of chemistry are related to the effects of learning disorders, misconceptions, methods and techniques on students' performances (Baram-Tsabari & Yarden 2009; Baram-Tsabari, Sethi, Bry & Yarden, 2006; Chiu, Chou & Liu, 2002; Sanger, Phelps & Fienhold, 2000; Scherz &Oren 2006; Zhang & Campbell, 2011).

Research Focus

The purpose of this study is to analyze the effects of Process-based Teaching model on student teachers' algorithmic and conceptual achievements in the topic of acids and bases as well as their logical/intuitive thinking skills.

Methodology of Research

General Background of Research

In the study, both quantitative and qualitative research methods were used. In the quantitative research area, the pre-test and post-test assessment model with experiment and control groups was used. The experimental group received education within the Process-based Teaching model at the laboratory, while the control group was taught in the traditional teacher centered education. Qualitative research methods were made use of in the study to support the picture displaying the student teachers' states, reveal the conflicting points as well as providing data reliability. Qualitative research methods provide the opportunity to make a profound examination of problem states; and aim to comprehend a social or personal situation that has more than one point of view (Bogdan & Biklen, 1998; Richardson & Ginsburg, 1999). Within the framework of this aim 10 participants have taken part in the study. Case study which is one of the qualitative research methods is used in the research. The data were collected from 10 student teachers via semi structured interviews (Berg, 1998; Bogdan & Biklen, 1998). The data gathered are analyzed through content analysis. In order to provide fair opportunities to participating students with different thinking and learning styles, student achievement was assessed through both traditional and alternative measurement and evaluation techniques.

Sample of Research

The sampling of the study consisted of student teachers randomly chosen from students of Hacettepe University, Faculty of Education, being 60 in total as 39 females and 21 males. Students were distributed into two groups as experimental and control groups bearing 30 in each. In developing the achievement test of the study, the sampling was extended to 275 student teachers for the reliability and validity studies of the test.

Instrument and Procedures

Logical/Intuitive Thinking Scale (LITS)

To determine the student teachers' logical and intuitive thinking styles, the "Logical and Intuitive Thinking Scale" developed by Pacini and Epstein (1999) and adapted by Turk (2011). The scale consisted of two dimensions as logical thinking and experiential thinking. Experiential thinking dimension had a single sub dimension as Intuitiveness (11 items), while the logical thinking dimension had two sub dimensions as Logical Thinking Pleasure (6 items) and Logical Skill (4 items). In the adaptation of the scale into Turkish, Cronbach Alpha values have been calculated for sub scales. Accordingly, the Cronbach Alpha value for the whole scale was calculated as 0.75, while it was calculated as 0.79 for intuitiveness sub dimension, 0.71 for the Logical Thinking Pleasure sub dimension and 0.62 for the logical skill sub dimension (Turk, 2011).

Achievement Test

In this study, an achievement test was developed to determine the knowledge levels of student teachers on "acids and bases". In this process, the questions in the Scientific Achievement Test developed by Ekmekcioglu (2007) were made use of. The Achievement Test was studied in terms of validity and reliability with the participation of 275 student teachers utilizing the ITEMAN Windows Version 3.50 statistics software. It was concluded that the average difficulty value was 0.70 and the Point-biserial Correlation Coefficient was 0.56 and the Achievement Test on acids and bases was ready for use.

Structured Grids

Structured Grids is one of the alternative assessment and evaluation methods used in determining achievement in situations where individuals could react within the teaching process (Johnstone, Bahar, & Hansell, 2000). Student teachers' basic knowledge on acids and bases as well as their abilities to link them to their daily lives were determined through Structured Grids in addition to the Achievement Test. Structured Grids were administered to another classroom excluding students from the control and experimental groups for pilot study. Required modifications were made in terms of questions that were found challenging to understand or respond to by the student teachers.

Data Analysis

The data of research have been collected using the quantitative and qualitative methods. The quantitative research has been designed in the experimental desing with pre/posttest control group. The quantitative data obtained from the Logical/Intuitive Thinking Scale, Achievement Test and Structured Grids used in the research were analyzed using SPSS 15 package program. The pretest and posttest scores were obtained from experimental and control groups regarding logical/experiential thinking and achievement variables for intergroup and intragroup comparisons. As Epstein (1994) reported that intuitive thinking style and logical thinking style are different structures, only the intuitive and logical thinking sub dimensions were taken into consideration (Turk, 2011). The scores obtained from data collection

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tools were analyzed through the Kolmogorov Smirnov Test and a normal distribution was observed. Therefore, it was thought that parametric tests would be more appropriate to utilize (Sprent & Smeeton, 2007). The qualitative data gathered are analyzed through content analysis. Qualitative analysis is used extensively in qualitative studies to group similar data according to certain concepts and themes, and to organize and interpret the data (Berg, 1998; Bogdan & Biklen, 1998; Richardson & Ginsburg, 1999). The qualitative data were collected from 10 student teachers via semi structured interviews. Because in semi-structured interviews, the questions determined by the researcher in advance are addressed to the interviewee in the same order and the interviewee is given the opportunity to answer the questions however comprehensively they want (Gay, Mills & Airasian, 2006). The semi-structured interview has been done with students for determine their opinion about the applications. The two-question interview form has been prepared as data collection tool by researcher. The interview form has been re-corrected after the suggestions of two experts who are asked for advice about the questions in the form. The whole interview questions have been evaluated in research. It has been decided to videotape recording on data collection for observing the data examine in detailed, to completely observing of students' behaviours on both visual communication and nonverbal communication and provided to validity and reliability of data.

Results of Research

Evaluation Of The Quantitative Data

The quantitative data obtained from control and experimental groups before and after the application were analyzed via the t-test for independent groups, while the data obtained from same groups in different times was analyzed using the t-test for dependent groups.

Table 1. The pretest data obtained from the logical/ıntuitive thinking scale administered to control and experimental groups.

	Groups	N	$\overline{X}$	SD	df	t	p
Logical Thinking	Experimental	31	3.261	.35	58	.096	.924
	Control	29	3.269	.33			
Intuitive Thinking	Experimental	31	3.561	.52	58	4.742	.807
	Control	29	3.563	.52			

Table1 displays that there is no significant difference between the scores obtained from the pretests administered to students in control and experimental groups (p=.924, .807, p>0.05). In other words, the logical/intuitive thinking skills of students in control and experimental groups were not different from each other before the application.

Table 2. The Pretest data obtained from the achievement test and structured grids administered to control and experimental groups.

	Groups	N	$\overline{X}$	SD	df	t	p
Achievement Test	Experimental	31	72.58	14.42	58	1.134	.262
	Control	29	68.13	15.92			
Structured Grids	Experimental	31	40.83	17.08	58	57.2	.569
	Control	29	38.40	15.84			

Table2 displays the achievement levels of student teachers on acids and bases. In other words, there is no difference between the achievement levels of student teachers on acids and bases in control and experimental groups (p=.262, .569, p>0.05).

Table 3. Logical/intuitive thinking scores of experimental group.

	Groups	$\overline{X}$	SD	df	t	p
Logical Thinking	Pretest	3.26	.35	30	51.0	.0001
	Posttest	3.30	.46			
Intuitive Thinking	Pretest	3.56	.52	30	37.5	.0001
	Posttest	3.52	.55			

As Table3 displays, significant changes were observed in the logical/intuitive thinking scores of student teachers in the experimental group after the process-based teaching applications. In other words, the logical and intuitive thinking skills of student teachers in the experimental group improved significantly as a result of the process-based teaching applications.

Table 4. Logical/intuitive thinking scores of control group.

	Groups	$\overline{X}$	SD	df	t	p
Logical Thinking	Pretest	3.26	.33	28	2.508	.498
	Posttest	3.26	.34			
Intuitive Thinking	Pretest	3.56	.54	28	2.965	.522
	Posttest	3.56	.54			

The logical/intuitive thinking scores of student teachers in the control group as a result of the traditional laboratory applications did not change as values in Table4 display (p=.498, .522, p>0.05). In other words, traditional laboratory applications did not affect student teachers' logical/intuitive thinking skills.

Table 5. Comparison of pre/posttest results obtained from the achievement test and structured grid administered to the experimental group.

	Groups	$\overline{X}$	SD	df	t	p
Achievement Test	Pretest	72.58	14.42	30	28.017	.0001
	Posttest	84.95	9.42			
Structured Grids	Pretest	41.16	16.89	30	23.55	.0003
	Posttest	55.06	24.41			

Table5 displays values indicating the increase in the achievement levels of student teachers in the experimental group on acids and bases as a result of the applications in the study. In other words, the achievement levels of student teachers in the experimental group on acids and bases improved as a result of the process-based teaching applications.

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Table 6. Comparison of pre/post test results obtained from the achievement test and structured grid administered to the control group.

	Groups	$\overline{X}$	SD	df	t	p
Achievement Test	Pretest	68.13	15.9	28	3.03	.265
	Posttest	68.17	15.9			
Structured Grids	Pretest	40.06	14.1	28	1.13	.325
	Posttest	35.73	18.1			

Table6 displays values indicating the achievement levels of student teachers in the control group on acids and bases before and after the applications in the study. This could be interpreted that the achievement levels of student teachers in the control group, who received traditional laboratory teaching on acids and bases, did not change significantly as a result of the applications ($p=.265, .325, p>0.05$).

Evaluation of the Qualitative Data

After the applications in the study, 10 of the student teachers were invited to semi-structured interview with purposefully prepared questions by the researcher. The video-taped interview data were analyzed inductively and 2 themes were formed: (1) the student teachers' definitions about the applications encouraged thinking or not, (2) Student opinions on logical/intuitive thinking during applications. Content analysis was used in data analysis. The percentage values calculating is made to analysing of interview data. The findings obtained from the responses of the student teachers to the questions are summarized in tables without disclosing their names.

Table 7. Percentage values indicating whether the applications encouraged thinking or not.

	Sample Student Expressions	%
Yes	Absolutely yes, I felt that I needed to think differently to solve the problem (S1, S3, S4). I noticed that I reached conclusions more easily when I thought (S5, S6).	85
No	No, I didn't think more differently (S10).	15

That process-based teaching Model applications encouraged student teachers to think more is indicated by the percentage values on Table7.

Table 8. Student opinions on logical/intuitive thinking during applications and their percentage values.

	Sample Student Expressions	%
Logical Thinking	I can say that I tried to find the logical one (S1, S2, S5, S6). I learnt that I should do reasoning when working in a laboratory. (S3, S8, S10, S11, S12, S13, S14, S15, S22, S23).	90
Intuitive Thinking	I noticed that I shouldn't avoid my intuitions (S4, S9). My intuitions helped me evaluate the results (S7).	10

Statements in Table8 indicate that student teachers were encouraged to think logically during the application while taking their intuitions into consideration from time to time.

Discussion

The impressive developments in technology, education, communication and economy lead to rapid and intensive social changes and developments. This process of change promotes individuals to constructed logical infrastructure that the new living conditions and opportunities require. This logical infrastructure could be constructed when individuals are able to use the learnt knowledge to attain competence in creating their own methods, rules and models with the help of logical thinking (Soylu, 2004). Another way of thinking which individuals require in their lives is the intuitive thinking. Although logical thinking system does not have important effects on the intuitive thinking system, it is affected by it without recognition by the individual (Denes-Raj & Epstein, 1994; adopted by, Turk, 2011). The research on these two thinking systems reported that intuitive thinking affected logical thinking in terms of various aspects such as decision making, personal characteristics, developmental path and gender (Wong, Kwong & Ng, 2008).

In this study, while the student teachers in the experimental group received training in Process-based Teaching approach, the student teachers in the control group were taught within the traditional laboratory teaching approach. It was aimed to discuss the effects of this application on student teachers' logical and intuitive thinking skills as well as their performances. The study was conducted at a laboratory environment as learning by experiencing has important effects on the learning process (Kolb, 1985). Another reason for the choice of laboratories as the learning environment is that education is a social experience and the learning that occurs as a result of experiences is affected by the social environment (Appleton, 1997; Vygotsky, 1978). The studies in the literature proved that laboratory applications contributed positively to the positive attitudes of student teachers towards chemistry classes as well as their perceptions and such affective characteristics (Cronholm, Höög & Martenson, 2000; Hofstein, Ben-Zvi, & Samuel, 1976; Lang, Wong, & Fraser, 2005; Okebukola, 1986; Townsend, 2012; Wolf & Fraser, 2008; Wong & Fraser, 1996). Therefore, the application of the Process-based Teaching Model in a laboratory environment would enable to understand whether the Process-based Teaching model in a laboratory environment affected the logical/intuitive thinking systems. It should be mentioned that laboratory applications are quite effective on encouraging the improvement of mental development, scientific questioning and problem solving skills (Lunetta, 1998). Moreover, laboratory applications not only provide scientific knowledge but also contribute to the development of students' development in scientific thinking, observation and interpretation skills (Taitelbaum, Mamlok, Carmeli & Hofstein, 2008) According to Lucas (1971), students could understand how scientists think and obtain new knowledge through research in the laboratories. Laboratory environments are accepted as environments where students learn scientific topics, develop their research skills and create a different learning environment (Hofstein & Lunetta, 2003).

The qualitative and quantitative conclusions of the study indicated that there were significant differences in the logical and intuitive thinking skills of student teachers in the experimental group, where the Process-based Teaching Model was applied. The application phases of the Process-based Teaching Model highlight teaching individuals the thinking strategies (Vermut, 1995), guiding them to think for discovering the process awareness (Duman, 2008) and thinking loudly on the cognitive process (Wong, 1992). Additionally, it is known that individuals have different logical and intuitive thinking systems, which enabled them to grow up as unique individuals. For instance, studies have shown that logical thinking skills of males were more improved than that of females, while the intuitive thinking skills of females were more improved than that of the males (Epstein, Pacini, Denes-Raj & Heier, 1996; Sladek, Bond & Phillips, 2010). Individuals with improved logical thinking skills require less effort as they need less cognitive resources to judge or make decisions (Epstein, 1998). Individuals interpret the events they experience in terms of their logical thinking skills (Piaget, 1966). This study concluded that the students in the experimental group had improved logical thinking levels at the end of the application than that of the control group, which could be interpreted as a result of student teachers' efforts to construct new knowledge using their own cognitive awareness within the systematic of Process-based Teaching plans (Duman, 2008). In evaluating opinions, knowledge and experiences, logical thinking is used more intensively (Soylu, 2004). The existing knowledge of individuals set a platform to support

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their future learning (Alexander, 1996). The existing knowledge of student teachers before the application were determined through the Acid and Bases Achievement Test. Findings obtained indicated significant differences in the average scores of students before and after the application in both groups. However, after the application is completed, students in the experimental group experienced significant improvements in their logical and intuitive thinking skills in addition to their achievement. Findings of the studies in the literature on Process-based Teaching have displayed the increase in the achievement levels of the students (Rosenbluth, 1990; Schatteman, Carette, Couder & Eisendrath, 1997; Walraven & Reitsma, 1992). For instance, Walraven & Reitsma (1992) applied Process-based Teaching Model on students as an alternative to the traditional model to activate the existing knowledge in students. The study concluded with an important increase in students' achievement levels. Another study by Stavy (1991) on Process-based Teaching concluded that it was more effective than the traditional teaching model. Duran (2008) found that the achievement levels of students at the experimental group improved significantly and positively when they are exposed to learning environments, which enable them to develop their scientific process skills as well as resenting them. These findings indicate that there is a positive relationship between students' logical thinking skills and their abilities to understand science classes and the achievement level increased significantly (Lawson, Banks & Logvin, 2007).

Cook-Sather (2006) reported that students in the learning process not only constructed knowledge but also transformed themselves with the help of mental models (Gordon, 2008). According to Johnson-Laird (1983) the mental models of individuals are in fact the structures in their minds and they function to integrate new knowledge into the existing knowledge in mind to construct meaning (Stefani & Tsaparlis, 2009). In this respect, learning environment and learning situations should be designed and evaluated within a process-based approach, learning activities should be planned, managed and applied accordingly as significant characteristics of the Process-based Teaching Model (Duman, 2008). The literature contains various studies concluding that Process-based Teaching is an effective model in providing permanent learning with higher achievement (Ashman & Conway, 1993; Birmingham & Garnick, 1994; Duman, 2008; Gerard & Junhkala, 1980; Rosenbluth, 1990; Schatteman, et al, 1997; Shaw, 1983; Volet, 1991). The increase in the achievement levels of participating student teachers in experimental group, who were taught according to the Process-based Teaching Model, was quite apparent in the qualitative findings and alternative assessment results. The experimental group students obtained the highest scores in the Structured Grids as they questioned the functions of acids and bases in their daily lives. This comes from the fact that the Process-based Teaching Model is a learning technique that allows students to construct their own knowledge, problems and behaviors by relating them to daily life situations in terms of their own thinking and perceptions (Duman, 2008). Driscoll (2005) supports that for the constructive learning to occur, multiple presentations and social interactions that require effort shall be embraced in teaching. In this respect Process-based Teaching is observed to enable more constructive and permanent learning. Increase in achievement level, which is defined as the progress towards a targeted conclusion (Wolman, 1973), and the positive improvement in student teachers' thinking competences have been the most important conclusions of this study.

Conclusions

Many studies have been done to open the doors of people's worlds of thoughts and to obtain concrete data about the mysteries hidden behind. In the light of this opinion, it is very important to question the scientific process skills of student teachers as the teachers of the future as well as the potential significant differences in these skills due to logical and intuitive thinking characteristics. However, this opinion restrains the analysis on changing student profile, which should be taken into consideration in teaching and learning. It is very important in active learning to determine students' ways of processing and developing their thinking systems. The student teachers shall experience new and different thinking processes for solving the problems they face individually. Therefore, this study focused on the theory that laboratory environments, where Process-based Teaching applications are done, could be effective on achievement as well as thinking systems as the most important affective variables. The importance of this study in the literature comes from its emphasis on how the logical and intuitive thinking skills of individuals are affected in laboratory environments supported with Process-based Teaching applications. The findings of the study indicated the effects of Process-based Teaching Model on thinking and achievement. The people's worlds of though are quite important in affecting individuals' worlds of thoughts and motivating their functionalities in their lives. Therefore, it is very important to increase the number of studies in this field as well as contributing to the literature with new resources.

References

Alexander, P. A. (1996). The past, present and future of knowledge research: A Reexamination of the role of knowledge in learning and instruction. *Educational Psychologist*, *31* (2), 89-92.

Ashman, A. F., & Conway, R. N. F. (1993). *Using cognitive methods ın the classroom*. London: Routledge.

Ashman, A. F., Wright, S. K., & Conway, R. F. (1994). Developing the metecognitive skills of academically gifted students in mainstream classrooms. *Roeper Review, 16* (3), 198.

Appleton, K. (1997). Analysis and description of students' learning during science classes using a constructivist-based model. *Journal of Research In Science Teaching*, *34* (3), 303–318.

Baram-Tsabari, A., Sethi, R., Bry, L., & Yarden, A. (2006). Using questions sent to an ask-a-scientist site to identify children's interests in science. *Science Education*, *90* (6), 1050–1072.

Baram-Tsabari, A., & Yarden, A. (2009). Identifying meta-clusters of students' interest in science and their change with age. *Journal of Research in Science Teaching*, *46* (9), 999–1022.

Berg, L. B. (1998). *Qualitative research methods for social sciences*. Boston: Allyn & Bacon.

Birminghman, N., & Garnick, S. (1994). Teacher's voice: Reflections on the Boston University/Chelsea Public Partnership and its effect on the literacy initiatives. *Journal of Education*, *176* (1), 127-135.

Bogdan, R. C., & Biklen, S. K. (1998). *Qualitative research for education: An introduction to theory and methods*. Boston: Allyn & Bacon.

Bolhuis, S. (2000). *Toward self-directed learning. What do teachers do and think*. Leuven/Apeldoorn: Garant.

Bonwell, C., & Eison, J. (1991). *Active learning: creating excitement in the classroom*. Washington: Jossey-Bass.

Chiu, M. H., Chou, C. C., & Liu, C. J. (2002). Dynamic processes of conceptual change: analysis of constructing mental models of chemical equilibrium. *Journal of Research in Science Teaching*, *39* (8), 688-712.

Cook-Sather, A. (2006). Change based on what students say: Preparing teachers for a more paradoxical model of leadership. *International Journal of Leadership in Education*, *9* (4), 345–358.

Cronholm, T., Höög, J., & Martenson, D. (2000). Student attitudes towards laboratory exercises in medical biochemistry. *Medical Teacher*, *22* (1), 30-33.

De Jong, F. P. C. M. (1995). Process-oriented instruction: some consideration. *European Journal of Psychology of Education*, *10* (4), 317-323.

Denes-Raj, V., & Epstein, S. (1994). Conflict between intuitive and rational processing: when people behave against their better judgement. *Journal of Personality and Social Psychology, 66* (5), 819-829.

Driscoll, M. P. (2005). *Psychology of learning for instruction*. Boston: Pearson Allyn & Bacon.

Duman, B. (2008). *Öğrenme- öğretim kuramları ve süreç temelli öğretim*. Ankara: Anı Yayıncılık.

Duran, M. (2008). *Fen öğretiminde bilimsel süreç becerilerine dayalı öğrenme yaklaşımının öğrencilerin bilime karşı tutumlarına etkisi*. Yüksek Lisans Tezi, Muğla Üniversitesi Fen Bilimleri Enstitüsü, Muğla.

Ekmekçioğlu, E. (2007). *Ortaöğretim kimya dersinde asit baz konusunun anlamlı öğrenme kuramı ve kavram haritası ile öğretiminin başarıya etkisi*. Yüksek Lisans Tezi, Selçuk Üniversitesi Fen Bilimleri Enstitüsü, Konya.

Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist, 49* (8), 709-724.

Epstein, S. (1998). *Cognitive-experiential self-theory: A dual-process personality theory with implications for diagnosis and psychotherapy*. In R. F. Bornstein and J. M. Masling (Eds.), *Empirical Research on the Pschoanalytic Unconcious* (Vol 7, p. 99-140). Washington D.C: American Psychological Association.

Epstein, S., Pacini, R., Denes-Raj, V., & Heier, H. (1996). Individual differences in intuitive-experiential and analytical-rational thinking styles. *Journal of Personality and Social Psychology, 71 (2)*, 390-405.

Gay, L., Mills, G., & Airasian, P. (2006). *Educational research competence for analysis and applications (8th Ed.)*. New Jersey: Pearson Prentice Hall.

Gerard, J. A., & Junkala, J. (1980). Task analysis, handwriting and process-based instruction. *Journal of Learning Disabilities*, *13* (1), 54-58.

Gordon, M. (2008). Between constructivism and connectedness. *Journal of Teacher Education*, *59* (4), 322-331.

Hofstein, A., Ben-Zvi, R., & Samuel, D. (1976). The measurement of the interest in, and attitudes to, laboratory work amongst Israeli high school chemistry students. *Science Education*, *60* (3), 401–411.

Houck, C. K. (1993). Ellis's potential integrative strategy instruction model: an applealing extension of previous efforts. *Journal of learning Disabilities, 26* (6), 399-403.

Johnstone, A. H., Bahar, M., & Hansell, M.H. (2000). Structural communication grids: a valuable assessment and diagnostic tool for science teachers. *Journal of Biological Education*, *34* (2), 87-89.

ISSN 1648–3898

Johnson-Laird, P. N. (1983). *Mental models: towards a cognitive science of languages, inference and consciousness.* Cambridge: Cambridge University Press.

Kirkpatrick, L. A., & Epstein, S. (1992). Cognitive experiential self theory and subjective probability: further evidence for two conceptual systems. *Journal of Personality and Social Psychology, 63* (4), 534-544.

Klaczynsky, P. (2001). Analytic and heuristic processing influences on adolescent reasoning and decision making. *Child Development*, *72* (3), 844–861.

Klaczynski, P., & Cottrell, J. M. (2004). A dual process approach to cognitive development: the case of children's understanding of sunk cost decisions. *Thinking & Reasoning, 10* (2), 147-174.

Kolb, D. A. (1985). *LSI learning style inventory*. Boston: McBer.

Lang, Q. C., Wong, A. F. L., & Fraser, B. J. (2005). Student perceptions of chemistry laboratory learning environments, student-teacher interactions and attitudes in secondary school gifted education classes in Singapore. *Research in Science Education*, *35*, 299–321.

Lawson, A. E., Banks, D. L., & Logvin, M. (2007). Self-efficacy, reasoning ability and achievement in college biology. *Journal of Research in Science Teaching*, *44* (5), 706-724.

Lowenthal, B. (1986). Planning abilities to aid metacognition. *Academic Therapy, 22* (2), 199-203.

Lucas, A. M. (1971). Creativity, discovery and inquiry in science education. *The Australian Journal of Education*, *15* (2), 185-196.

Lunetta, V. N. (1998). *The school science laboratory: historical perspectives and centers for contemporary teaching*. In B. J. Fraser & K. G. Tobin (Eds.), *International handbook of science education*. Dordrecht: Kluwer

Moersch, C. (1997). Computer efficiency : Measuring the instructional use of technology. *Learning and Leading with Technology, 23* (3), 40-42.

Naglieri, J. A., & Johnson, D. (2000). Effectiveness of a cognitive strategy intervention in improving arithmetic computation based on the PASS Theory. *Journal Learning of Disabilities, 33* (6), 591.

Nancy, H. K. (1997). Education over the web: distance learning and the information professional. *Online, 21* (5), 63-72.

Okebukola, P. A. (1986). An investigation of some factors affecting students, attitudes toward laboratory chemistry. *Journal of Chemical Education*, *63* (6), 531-542.

Pacini, R., & Epstein, S. (1999). The relation of rational and experiential information processing styles to personality, basic beliefs, and the ratio-bias phenomenon. *Journal of Personality and Social Psychology*, *76* (6), 972-987.

Piaget, J. (1966). The psychology of intelligence and education. *Childhood Education*, *42*, 528.

Richardson, J. T., & Ginsburg, G. P. (1999). *A judge's deskbook on the basic philosophies and methods of science.* Reno, Nevada: University of Nevada, State Justice Institute.

Rosenbult, G. S. (1990). *The effects of writing process-based instruction and word processing on remedial and accelerated 11th graders*. Doctoral Thesis, West Virginia University.

Sanger, M. J., Phelps, A. J., & Fienhold, J. (2000). Using a computer animation to improve students' conceptual understanding of a can-crushing demonstration. *Journal of Chemical Education*, *77* (11), 1517-1520.

Schatteman, A., Carette, E., Couder, J., & Eisendrath, H. (1997). Understanding the effects of a process-oriented instruction in the first year of university by investigating learning style characteristics. *Educational Psychology, 17* (1-2), 111-125.

Scherz, Z., & Oren, M. (2006). How to change students' images of science and technology. *Science Education*, *90* (6), 965–985.

Shaw, T. J. (1983). The effect of a process-orienten science curriculum upon problem-solving ability. *Science Education*, *67* (5), 615-623.

Sladek, R. M., Bond, M. J., & Phillips, P. A. (2010). Age and gender differences in preferences for rational and experiential thinking. *Personality and Individual Differences, 49,* 907-911.

Soylu, H. (2004). *Fen öğretimde yeni yaklaşımlar.* Ankara: Nobel Yayın Dağıtım.

Sprent, P., & N. C. Smeeton (2007). *Applied nonparametric statistical methods* (4th Ed.). Boca Raton: Chapman & Hall.

Stavy, R. A. (1991). *Students' problem solving in mechanics: preference of a process- based instruction*. Clearinghouse: SE052946, Geographic Source: Israel 8p.

Stefani, C., & Tsaparlis, G. (2009). Students' levels of explanations, models, and misconceptions in basic quantum chemistry: a phenomenographic study. *Journal of Research in Science Teaching*, *46* (5), 520–536.

Taitelbaum, D., Mamlok-Naaman, R., Carmeli, M., & Hofstein, A. (2008). Evidence for teachers' change while participating in a continuous professional development programme and ımplementing the inquiry a professional development programme and implementing the inquiry approach in the chemistry laboratory. *International Journal of Science Education*, *30* (5), 593-617.

Teglasi, H., & Eptein, S. (1998). Temperament and personality theory: the perspective of cognitive-experiential self theory. *School Psychology Review, 27* (4), 534–548.

Townsend, L. A. (2012). *The effects of laboratory-based activities on student attitudes toward science*. Dissertation Thesis, Intercollege Programs for Science Education, Montana State University.

Turk, E. G. (2011). *Ergenlerin düşünme biçemlerini yordayan faktörler: anne baba, üstbiliş ve epistemolojik inançlar.*

Doktora Tezi, Ankara Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Vermut, J. D. (1995). Process-oriented instruction in learning and thinking strategies. *European Journal of Psychology of Education*, *10* (4), 325-349.

Volet, S. (1995). Process-oriented instruction: a discussion. *European Journal of Psychology of Education, 10* (4), 449-459.

Vygotsky, L. (1978). *Interaction between learning and development. In mind in society*. Cambridge: Harvard University Press.

Walraven, M., & Reitsma, P. (1992). *Activating prior knowledge as a process-oriented strategy*. Paper presented at the Annual Meeting of the National Reading Conference (42nd, San Antonio, TX, December 2-5, 1992). Eric: ED354498.Clearninghouse: CS011207.

Witteman, C., Bercken, J., Claes, L., & Godoy, A. (2009). Assessing rational and intuitive thinking styles. *European Journal of Psychological Assessment, 25* (1), 39-47.

Wolf ,S. J., & Fraser, B. J. (2008). Learning environment, attitudes and achievement among middle school science students using inquiry-based laboratory activities. *Research in Science Education*, *38* (3), 321-341.

Wolman, B. B. (1973). *Dictionary of behavioural science*. New York: Van Nostrand Reinhold Co.

Wong, S. L. (1992). Approaches to study of distance education students. *Research In Distance Education*, *4* (3), 11-17.

Wong, A. F. L., & Fraser, B. J. (1996). Environment-attitude association in the chemistry laboratory classroom. *Research in Science and Technological Education*, *14* (1), 91-102.

Wong, K. F. E., Kwong, J. Y. Y., & Ng, C. K. (2008). When thinking rationally increases biases: the role of rational thinking style in escalation of commitment. *Applied Psychology: An Internationasl Review, 52* (2), 246-271.

Zhang, D. & Campbell, T. (2011). The psychometric evaluation of a three-dimension elementary science attitude survey. *Journal of Science Teacher Education*, *22* (7), 595–612.

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