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Comparison of inquiry-based instruction in real and virtual laboratory environments: Prospective science teachers' attitudes

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Abstract

The aim of this experimental study was to compare the attitudes of prospective Science teachers towards Chemistry Laboratory and Chemistry Lesson delivered via inquiry-based instruction method in real and virtual laboratories. The study was conducted in 2013-2014 academic year and adopted Mixed Methods design based on both quantitative and qualitative data. The participants of the study comprised 34 freshman student teachers of Science at a faculty of Education in a state university in Turkey. The purposefully selected participants were assigned as Group-1 (N=17) and Group-2 (N=17). While the Group-1 was instructed via inquiry-based instruction in a real laboratory, the Group-2 was taught utilizing the same instruction method in a virtual laboratory. In the study, 8 different experiments were conducted in the both real and virtual laboratories using some related software. As the data collection tools, the Attitude Towards Chemistry Lesson Scale; the Attitude Towards Chemistry Laboratory Scale, and a semi-structured interview form were used. The results revealed that although all the prospective Science Teachers' (PST) attitudes toward Chemistry Lesson and Chemistry Laboratory improved significantly in both real and virtual laboratory environments, the improvement in their scores in a real laboratory environment was significantly higher than that in the virtual laboratory. The semi-structured interview results were coherent with the results of the scales.

Keywords: Attitude towards chemistry lesson; attitude towards chemistry laboratory; inquiry-based learning; virtual laboratory

1. Introduction

In today's developing world, promoting favorable attitudes has been a principal issue of science instruction (Osborne, Simon & Collins, 2003) and providing new learning

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experiences to students is very important for promoting their attitudes from elementary to undergraduate levels. One of these learning experiences is inquiry-based activities.

1.1. Inquiry-Based Learning

Inquiring is a multifaceted concept, and it is difficult to define (Kidman & Casinader, 2017). However, inquiring concepts are used for understanding theories, improving skills, answering questions, inquiring into the universe and promoting attitudes towards science in learning environments (Chippetta & Adams, 2004). Inquiry-based learning can be explained as the activities that improve students' knowledge, teach them scientific thinking and the working ways of scientists (NRC, 2000).

The inquiry-based learning approach has different levels according to the extent of student-centered and teacher-centered. One of the student-centered levels is guided inquiry. Students discuss and define the problem presented by the teacher, write their hypothesis, design and make an investigation to test the hypothesis, examine their findings, evaluate their hypothesis based on the findings and then share the findings of the investigation with other students (Colburn, 2000). In this method, teachers play a crucial role in designing a learning environment, developing a research problem, providing materials and asking questions. Because students need support for the beginning of inquiry (Alfieri et al., 2011) and guided inquiry allows students to remove the difficulties of designing their inquiry processes. The use of the guided-inquiry method makes it possible to connect lecturing and active methods (Bilgin, 2009).

Inquiry-based activities also have very beneficial effects on laboratory instruction. When inquiry-based learning used manner appropriately, it has very useful to widen the horizon of education and to ensure more active in the learning process (Blessinger & Carfora, 2014). Inquiry-based activities have also very beneficial effects on promoting attitudes towards chemistry and laboratories (Acar-Şeşen & Tarhan, 2013; Bozkurt, 2015; Chase, Pakhira & Stains, 2013; Cheung, 2008; Hofstein & Lunetta, 2004; Widowati, Nurohman & Anjarsari, 2017; Winkelmann et al., 2014; Wolf & Fraser, 2008).

1.2. Virtual Laboratories

In the 21st century, it becomes a necessity to move of a learning environment beyond traditional boundaries of school walls for providing informational, technological and communication skills to students (Shapley, Sheehan, Maloney & Caranikas-Walker, 2011). In our global world today, technology has also significant role for meaningful teaching and learning (Abubakar & Salmanu, 2018). Therefore, educational technologies have gained importance in designing productive learning environments during the last decades. One of these technologies is a virtual laboratory and many educators have discussed whether it is an alternative to the real laboratory environment.

Laboratory instruction is essential in science education (Singer, Hilton & Schweingruber, 2006), and it improves students' attitudes gradually (Hofstein & Mamlok-Naaman, 2007). However, it has some limitations. For example, chemical events cannot observe at the molecular level in a real laboratory. Besides, a significant part of teachers hesitates to use the laboratories because of their limitations, such as having to work with dangerous and expensive chemicals, having to give lengthy and time-consuming instructions about how to use these chemicals and safety rules in the laboratory, crowded classrooms. Additionally, other effective factors on this hesitation are teachers' negative attitudes toward using the laboratory, and teachers' being less self-confident about laboratory management. In this case, online learning environments gain importance in the last decades. Virtual laboratories are online learning environments and they are effective in overcoming real laboratories' limitations as mentioned above. Virtual laboratories provide integration of laboratory and computer simulations (Ratamun & Osman, 2018). They are handy to help students understanding complex science topics (Chiu & Linn, 2014; Honey & Hilton, 2011). This integration also provides some opportunities to learn not only in classrooms but also in all other environments where there are computers (Yang & Heh, 2007). Also, students can pause, proceed and repeat to an experiment many times. Furthermore, virtual laboratories provide a safe instructional environment, in which there is no waste of time or chemicals, for the students. They have great advantages to observe and interact with unobservable events (Honey & Hilton, 2011).

Virtual laboratories have taken advantage of students to accomplish experiments out of the classroom. On the other hand, virtual laboratories are criticized from various aspects such as students cannot use authentic materials, cannot feel a laboratory environment, so they cannot develop their laboratory skills (Bilek & Skalická, 2010). For this reason, many comparative researches have mainly addressed to examine the advantages and disadvantages of virtual laboratory (traditional cook-book design or supported by an active learning approach) and a hands-on verification experiment in a real laboratory with/without a comparative group in different level of the education (Bilek & Skalická, 2010; Hensen, Barbera, 2019; Pyatt & Sims, 2012; Ratamun & Osman, 2018; Shegog et al., 2012; Tuysuz, 2010; Winkelmann, Keeney-Kennicutt, Fowler & Macik, 2017).

1.3. Importance of the Research

Inquiry-based experiments were preferred to compare real and virtual laboratories in the present study. This aspect is a different and innovative aspect of the study from the other comparative researches about virtual laboratories. Using the inquiry-based experiments provided to take opportunities of the possible positive effects of inquiry on attitude. Prospective science teachers (PSTs) participated more actively in the experimental process and they had some opportunities using inquiry-based experiments. The study aimed to give a different perspective to compare real and virtual environments to the literature from this aspect and it focused on importance of inquiry-based learning.

1.4. Research Questions

The main research question of the study is "Is there a significant difference between the attitude of prospective Science teachers (PST) toward Chemistry Laboratory and Chemistry Lesson delivered via the inquiry-based instruction method in real and virtual laboratory environments?" Based on this main research question, the sub-research questions of the study can be sated as follows:

1. What are the effects of inquiry-based instruction method in the real and the virtual laboratory environments on PSTs' attitude toward Chemistry lesson?
2. What are the effects of inquiry-based instruction method in the real and the virtual laboratory environments on PSTs' attitude towards Chemistry laboratory?
3. What are the opinions of PSTs about their learning process, and their own attitude toward Chemistry Laboratory and Chemistry Lesson in real and virtual laboratory settings?

2. Method

The research adopted an experimental study design based on Mixed Methods with quantitative and qualitative data collected in both real and virtual Chemistry Laboratory environments.

2.1. Participants

The participants were 34 freshman student teachers of Science in the same class of a Faculty of Education in a state university in Turkey. Their ages ranged from 19 to 22 years. The study was conducted in the Spring Semester of 2013-2014 academic year. The participants were selected among those who were successful in the General Chemistry course and had learned the basic Chemistry concepts as well as the safety rules of working in the laboratory.

The prospective Science teachers (N=34) were assigned in to two experimental groups in accordance with their gender, age, and their scores obtained from pre-tests of attitude scales and the distribution of the PSTs was exhibited in Table 1.

Table 1. The distribution of PSTs to groups

		Group-1	Group-2
Attitude toward Chemistry Lesson Scale	Low	5	6
Mean Score	Medium	6	6
	High	6	5
Attitude toward Chemistry Laboratory Scale	Low	5	6
Mean Score	Medium	6	5
	High	6	6
Gender	Girl	14	14
	Boy	3	3
Age	19	14	13
	19+	3	4

The sample size constitutes a limitation of the research. Random sampling and large sample size are wished in the research but this is often not the case in real-life research (Pallant, 2015). Primarily comparative investigations are conducted in actual classes and they had unalterably limited populations. Alpha level was adjusted to compensate for this limitation (Stevens, 1996).

2.2. Data Sources

2.2.1. Attitude towards chemistry lesson scale

The five-point Likert type Attitude towards Chemistry Lesson Scale (ATCS) developed by Acar (2008) was used before and after the instructions. To enhance content validity, five science and chemistry educators, one assessment and evaluation expert, and one philology expert examined the scale. Then, the scale was administrated to 195 undergraduates. The final scale consists of 25 items ($\alpha = 0.82$) and four dimensions.

Dimensions of the scale were the importance of chemistry in real life (five items, $\alpha = 0.83$), the interest of chemistry lesson (six items, $\alpha = 0.78$), understanding and learning chemistry (10 items, $\alpha = 0.84$), chemistry and choice of profession (four items, $\alpha = 0.87$). The highest point was 125, and it takes about 20 min to complete the scale.

2.2.2. Attitude towards chemistry laboratory scale

The five-point Likert type Attitude towards Chemistry Laboratory Scale (ATCLS) developed by Tarhan (2008) was used to compare the PSTs' attitudes towards the chemistry laboratory before and after the instructions. To enhance content validity, five science and chemistry educators, one assessment and evaluation expert, and one philology expert examined the scale. Then, the scale was administrated to 283 undergraduates. The final scale consists of 27 items and four dimensions ($\alpha = 0.87$).

Dimensions of the scale were laboratory environment and using equipment (four items, $\alpha = 0.82$), experimental process in the laboratory (10 items, $\alpha = 0.90$), assessment in the laboratory (nine items, $\alpha = 0.85$), cooperative learning in the laboratory (four items, $\alpha = 0.87$). The highest point was 135, and students completed the instrument about 20 min.

2.2.3. *Semi-structured interview form*

A semi-structured interview was administered to all participants after the instructions to evaluate how PSTs' attitudes toward chemistry lesson and chemistry laboratory changed genuinely. For this purpose, a semi-structured interview form was used. This form consisted of four questions and follow-up questions were asked to participants according to the nature of the interview. Some example questions are, "You conducted an instruction in General Chemistry Laboratory during a semester. What do you think about this instruction?" "What is the contribution of this instruction to you?". The interview took ten minutes for each participant and it was conducted in a silent room.

2.3. Instructions

Before the treatment, pre-tests were given to all PSTs, and they were divided in to Group-1 and Group-2. PSTs did not have past experience of inquiry-based learning and virtual laboratory; they had no experience of inquiry-based learning or virtual laboratory. For these reasons, a brief orientation was conducted about the learning process. This orientation included the purpose of the study, rules of the learning process, their roles in the inquiry-based learning environment and doing an experiment in the virtual laboratory (only Group-2).

Eight inquiry-based chemistry experiments carried out in the real and virtual laboratories by Group-1 and Group-2, respectively. A semi-structured interview was conducted to all participants after the instructions to evaluate how to change PSTs' attitude. (Table 2).

Table 2. The research design used in the study

	Group-1	Group-2
Pre-test	ATCS	ATCS
	ATCLS	ATCLS
Treatments	Inquiry-Based Chemistry Experiments in Real Laboratory	Inquiry-Based Chemistry Experiments in Virtual Laboratory
Post-test	ATCS	ATCS
	ATCLS	ATCLS
	Semi-structured interview	Semi-structured interview

2.3.1. Inquiry-Based Instruction

Eight inquiry-based chemistry experiments were developed in the research. These experiments were related to effective factors on reaction rate (two different experiments), Le Chatelier's Principle, the heat of the neutralization, titration, buffers, effective factors on cell potential, corrosion. They were carried out in both groups according to the step of the inquiry-type experiment (Hofstein, Shore & Kipnis, 2004), as exhibited in Figure 1.

In an example activity about acids-bases, the reason for taste differences between different types of olive oil mentioned in the story was inquired. In the first step of this task, PSTs tried to define and answer the research problem given in the reading part. After the instructor confirmed their problem, they wrote their hypothesis based on their problem, and they designed an experiment related to acid-base titration using NaOH, two different types of olive oils, phenolphthalein indicator, burette and Erlenmeyer flask. They can also use other chemicals, laboratory materials, and equipment that they wanted. After the instructor had confirmed their experimental design, they carried out the two titrations. The acidities of two different types of olive oil were calculated and compared. Then, they wrote their observations and findings to their worksheets during the experiment. In the last stage of the experiment, they discussed their findings and reconciled any conflict between their hypothesis and results. Finally, the results and findings of all groups were shared with the other groups.

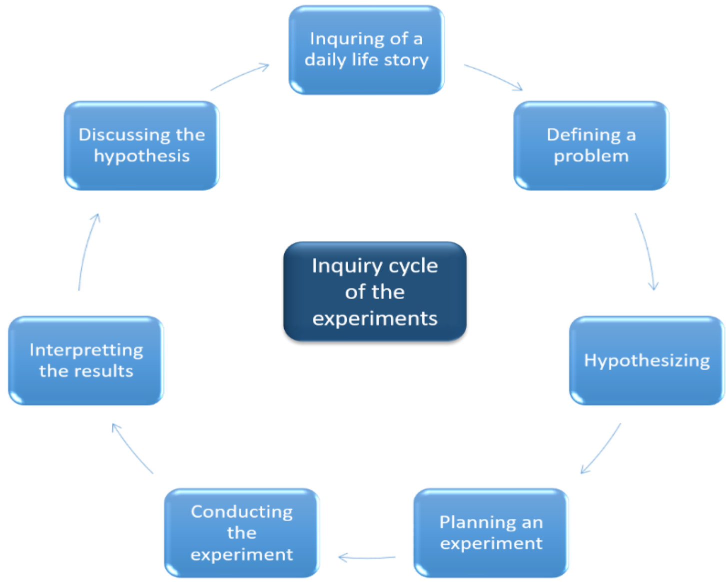

Figure 1. Inquiry cycle of the experiments in this study (adopted from Hofstein, Shore & Kipnis, 2004)

2.3.2. Treatment in Group-1

In Group-1, PSTs carried out eight inquiry-based chemistry experiments in a real laboratory environment. For this treatment, hands-on laboratory worksheets based on inquiry phases adopted from Hofstein, Shore, and Kipnis (2004) were prepared. Four experts in chemistry education reviewed to all worksheets and pre-implementation was conducted with five PSTs. PSTs in Group-1 (N=17) assigned four cooperative sub-groups.

During the hands-on inquiry-based experiments, while PSTs were working in their groups, the instructor had a guiding role in the learning process. They were also charged to assign their tasks in the experiment for effective group dynamics. They conducted group discussions for inquiry steps such as identifying the problem, forming hypotheses, etc. The group's speaker presented their predictions in all steps to the instructor. They could pass the next stage of the inquiry phase if the instructor confirmed their predictions. All PSTs in the subgroups were not only cognitive but also physically active during the experiment; for example, while one of them was conducting titration, one of the other measured changing volume of the titrant. On the other hand, they had opportunities to work with real materials, chemicals, and equipment; in other words, they learned by doing. Also, some PSTs had anxiety for using equipment or chemicals; controlled experiences were provided to using these to overcome their fear.

2.3.3. Treatment in Group-2

PSTs in Group-2 (N = 17) engaged in the same inquiry-based chemistry experiments that the Group-1 carried out; however, they used virtual chemistry laboratory software.

Two different software tools were used in the treatment in Group-2. PSTs used virtual chemistry laboratory software (Figure-2) and it included inquiry-based chemistry experiments that had a real experimental step and data, and this software was designed including implication steps of the inquiry-based experiment (Hofstein, Shore & Kipnis, 2004). The other software was intended to allow the instructor to connect an interaction with PSTs. This software also allowed the instructor to check and revise groups' problems, hypotheses, experimental design, findings, and interpretations.

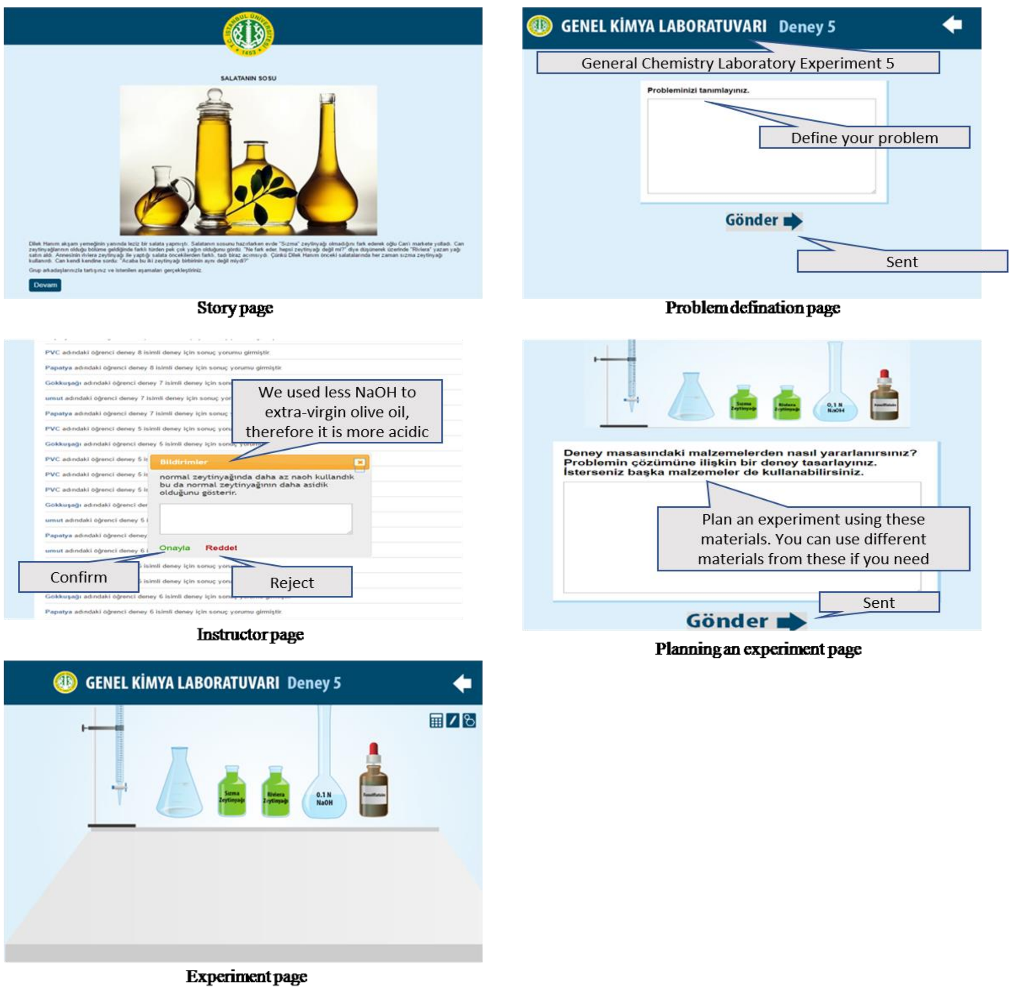

Figure 2. The interface of GIBVL (Language of the software is Turkish)

PSTs in Group-2 were assigned four cooperative sub-groups like Group-1. Computers and internet connections were prepared by the instructor before the experiments to overcome technological problems. PSTs assigned a person to use the group's computer before each experiment and they were attentive to charge for using the computer from different group members in the next experiment. They conducted practical discussion sessions in each step of the inquiry-based experiment. After the discussion, they wrote and sent their problem, hypothesis, etc. for checking by the instructor. The instructor could confirm or refuse (with her justification and suggestion) PSTs' writings using the instructor software. PSTs only communicated with the instructor using their software and they could pass the next stage of the experiment after the instructor's confirmation. Virtual chemistry laboratory software also allowed to PSTs to repeat steps of experiments if they want.

3. Results

Nonparametric statistical methods, which are the Mann-Whitney U test and Wilcoxon Signed Ranks, were preferred to investigate research problems because of small size participants in each group. Alpha level was set a cut-off 0.10 rather than the traditional 0.05 level to prevent the negative effect of small sample size on the power of the tests as suggested by Stevens (1996).

The following formula was also carried out to identify the effect size of significance (Pallant, 2015):

$$r = z/\sqrt{N}$$

3.1. Attitude towards Chemistry Lesson

The first research question, which is "What are the effects of inquiry-based instructions in the real and the virtual laboratory environments on PSTs' attitudes towards chemistry lesson?" was answered using ATCS as a pre-test and post-test. Descriptive statistics for ATCS were calculated and presented in Table 3.

Table 3. Descriptive Statistics for ATCS

Group	Test	Mean	Standard Deviation	Minimum Score	Maximum Score
Group-1	Pre-Test	85.06	12.13	49.00	104.00
	Post Test	115.88	7.29	92.00	123.00
Group-2	Pre-Test	84.65	8.67	68.00	98.00
	Post Test	102.06	12.71	83.00	121.00

Considering the values in Table 3, while it could be observed that pre-test scores of the groups were approximate values, Group-1 had a higher mean score than Group-2 in the post-test. The Mann Whitney U test was used to compare groups' pre- and post-test scores (Table 4).

Table 4. Comparative Results of ATCS obtained from Mann Whitney U Test

Test	Group	N	Mean Rank	Sum of Rank	U	p
Pre-Test	Group-1	17	18.35	312.00	130.000	0.617
	Group-2	17	16.65	283.00		
Post-Test	Group-1	17	22.38	380.50	61.500	0.004
	Group-2	17	12.62	214.50		

The analysis of Mann Whitney U test on the ATCS pre-test showed no significant difference ($U = 130.00$, $p > 0.10$) between Group-1 ($M = 85.06$, $SD = 12.13$) and Group-2 ($M = 84.65$, $SD = 8.67$). Results of Mann Whitney U test on the ATCS post-test highlighted that there was significant difference ($U= 61.500$, $z = -2.866$, $p< 0.10$, $r = 0.49$) between Group-1 ($M = 115.88$, $SD = 7.29$) and Group-2 ($M = 102.06$, $SD = 12.71$) in favour of Group-1.

The Mann Whitney U test was conducted for each sub-dimension to evaluate which sub-dimensions of ATCS had a significant difference in the post-test (Table 5).

Table 5. Mann Whitney U Test Results for sub-dimensions of ATCS

Sub-dimensions	Group	N	Mean	Mean Rank	Sum of Rank	U	p
Interest of chemistry lesson	Group-1	17	27.29	22.79	387.50	54.500	0.002
	Group-2	17	23.23	12.21	207.50		
Understanding and learning chemistry	Group-1	17	46.00	21.50	365.50	76.500	0.018
	Group-2	17	41.41	13.50	229.50		
Importance of chemistry in real life	Group-1	17	24.29	23.18	394.00	48.000	0.001
	Group-2	17	21.94	11.82	201,00		
Chemistry and choice of profession	Group-1	17	18.29	21.74	369.50	72.500	0.011
	Group-2	17	15.53	13.26	225.50		

As seen that Table 5, findings indicated that there was significant difference between Group-1 and Group-2 on all sub-dimensions which were interest of chemistry lesson ($U = 54.500$, $z = -3.148$, $p< 0.10$, $r = 0.54$), understanding and learning chemistry ($U= 76.500$, $z = -2.361$, $p< 0.10$, $r = 0.40$), importance of chemistry in real life ($U= 48.000$, $z = -3{,}474$, $p< 0.10$, $r = 0.60$) and chemistry and choice of profession ($U= 72.500$, $z = -2.530$, $p< 0.10$, $r = 0.43$) in favor of Group-1.

The Wilcoxon Signed Ranks Test was conducted to investigate the changing of groups' scores across the instruction (Table 6).

Table 6. Wilcoxon Signed Ranks Test Results of ATCS

Group	Post-test-Pre test	N	Mean Rank	Sum of Rank	Z	p
	Negative Rank	0	0.00	0.00	-3.623*	0.000
Group-1	Positive Rank	17	9.00	153.00		
	Ties	0	-	-		
	Negative Rank	1	1.00	1.00	-3.577*	0.000
Group-2	Positive Rank	16	9.50	152.00		
	Ties	0	-	-		

*Based on the negative rank

Considering the findings in Table-6, both scores of Group-1 ($z=3.623$, $p<0.10$, $r=0.62$) and scores of Group-2 ($z=3.577$, $p<0.10$, $r=0.61$) showed significant increasing before and after the instructions.

3.2. Attitude towards Chemistry Laboratory

The second research problem is "What are the effects of inquiry-based instructions in the real and the virtual laboratory environments on PSTs' attitudes towards chemistry laboratory?" and ATCLS was applied as pre-and post-test and evaluated to answer this problem. Descriptive statistics for data set obtained from ATCLS before and after the treatments are exhibited in Table 7.

Table 7. Descriptive Statistics for ATCLS

Group	Test	Mean	Standard Deviation	Minimum Score	Maximum Score
Group-1	Pre-Test	96.82	13.24	70.00	114.00
	Post Test	116.76	8.68	102.00	130.00
Group-2	Pre-Test	96.41	15.03	73.00	123.00
	Post Test	109.53	9.07	89.00	130.00

In a similar manner to ATCS results, the post-test mean score of Group-1 ($M = 116.76$) was higher than Group-2 ($M = 109.53$). Mann Whitney U test was used to examine whether the differences between groups' pre- and post-test scores were significant (Table 8).

Table 8. Comparative Results of ATCLS obtained from Mann Whitney U Test

Test	Group	N	Mean Rank	Sum of Rank	U	p
Pre-Test	Group-1	17	17.62	299.50	142.500	0.945
	Group-2	17	17.38	295.50		
Post-Test	Group-1	17	21.06	358.00	84.000	0.037
	Group-2	17	13.94	237.00		

As seen in Table 8, there was no significant difference (U = 142.500, p > 0.10) between pre-test scores of Group-1 (M = 96.82, SD = 13.24) and Group-2 (M = 96.41, SD = 15.03); statistically significant difference was found (U = 84.000, z = -2.088, p < 0.10, r = 0.36) on post-test scores of Group-1 (M = 116.76, SD = 8.68) and Group-2 (M = 109.53, SD = 9.07) in favour of Group-1.

Mann Whitney U test was also conducted to investigate which sub-dimensions of ATCLS had a significant difference in post-test (Table 9).

Table 9. Mann Whitney U Test Results for sub-dimensions of ATCLS

Sub-dimensions	Group	N	Mean	Mean Rank	Sum of Rank	U	p
Laboratory environment and using equipment	Group-1	17	17.58	19.74	335.50	106.500	0.185
	Group-2	17	16.53	15.26	259.50		
Experimental process in the laboratory	Group-1	17	46.35	18.85	320.50	121.500	0.427
	Group-2	17	45.18	16.15	274.50		
Assessment in the laboratory	Group-1	17	38.88	21.53	366.00	76.000	0.018
	Group-2	17	35.52	13.47	229.00		
Cooperative learning in the laboratory	Group-1	17	18.82	21.09	358.50	83.500	0.032
	Group-2	17	17.06	13.91	236.50		

Findings in Table 9 showed that while there was significant difference on two sub-dimensions which were assessment in the laboratory (U = 76.000, z = -2,370, p< 0.10, r = 0.41), cooperative learning in the laboratory (U= 83.500, z = -2.145, p< 0.10, r = 0.37) in favor of Group-1, there was no significant difference on two sub-dimensions which were laboratory environment and using equipment (U= 48.000, p> 0.10) and experimental process in the laboratory (U= 72.500, p> 0.10).

In addition to these, groups' ATCLS scores before and after the treatment were compared with the Wilcoxon Signed Ranks Test (Table10).

Table 10. Wilcoxon Signed Ranks Test Results of ATCLS

Group	Post-test-Pre test	N	Mean Rank	Sum of Rank	Z	p
	Negative Rank	1	1.50	1.50	-3.554*	0.000
Group-1	Positive Rank	16	9.47	151.50		
	Ties	0				
	Negative Rank	4	5.38	21.50	-2.407*	0.016
Group-2	Positive Rank	12	9.54	114.50		
	Ties	1				

*Based on the negative rank

Data in Table 10 indicated that scores of Group-1 (z=3.554, p<0.10, r=0.61) and Group-2 (z=2.407, p<0.10, r=0.41) significantly improved after the instruction.

3.3. Semi-Structured Interviews

The last research question, which is "What are the opinions of PSTs about their learning process, and their own attitude toward Chemistry Laboratory and Chemistry Lesson in real and virtual laboratory settings?" was answered by conducting semi-structured interviews after the treatment by the participation of all PSTs in both groups. Themes were assigned as the attitude toward chemistry lesson and attitude toward chemistry laboratory. Codes related to these themes and their frequencies obtained from the interview were exhibited in Table 11.

Table 11. Content analysis results about PSTs' attitude toward chemistry laboratory

	Codes Instructions provide to/have/are…	Group-1 (f)	Group-2 (f)
Attitude toward chemistry laboratory	Learn by doing	17	-
	Beneficial if they carried out in a real laboratory	-	10
	Learn laboratory safety rules	17	-
	Solve laboratory problem	12	-
	Save time	-	17
	Decrease anxiety of chemical using	-	17
	Some technological problems	-	17
	A learning environment that could be work without needing to learn laboratory safety rules	-	17
	The different and exciting experience	-	12
	A less enjoyable experiment in comparison to real laboratory	-	5
	Experiments that I want to carry out them in a real laboratory	-	17
Attitude toward chemistry lesson	More improving discussions	17	10
	More in-depth thinking	15	15
	Increase to want to work	17	17
	Beneficial	17	17
	More participation	8	7
	Helpful for chemistry lesson and its exam	15	10
	Intriguing	15	15
	Funny	17	16
	Related to daily life	15	14
	Increase interest in the chemistry lesson	17	15

Content analysis results showed that although PSTs in Group-2 had a favourable opinion about their instruction like in Group-1, they preferred to carry out their experiments in real environments. However, they underlined that the virtual laboratory environment provided some advantages such as different experiences, decreasing anxiety of chemical use, saving time. PSTs in Group-1 and Group-2 had similar positive opinions under the heading of attitude toward chemistry lesson. However, PSTs in Group-1 differentiate into Group-2 in terms of some codes such as more improving discussion, helpful for chemistry lesson and its exam etc.

4. Discussion

In the present study, it was compared to the PSTs' attitude toward chemistry laboratory and chemistry lesson in real and virtual laboratories using inquiry-based experiments. Considering the findings obtained from Wilcoxon Signed Ranks Test results, it was found that both scores of Group-1 ($z=3.623$, $p<0.10$, $r=0.62$) and Group-2 ($z=3.577$, $p<0.10$, $r=0.61$) obtained from ATCS significantly increased following the completion of the treatments. Similar significant improvement found for ATCLS for scores of Group-1 ($z=3.554$, $p<0.10$, $r=0.61$) and Group-2 ($z=2.407$, $p<0.10$, $r=0.41$). These results emphasized that both real and virtual laboratories were effective in promoting PSTs' attitudes toward both the chemistry laboratory and chemistry lesson. Inquiry-based learning was used in both groups' instructions and it is interpreted that these findings underlined that the inquiry-based learning approach was an effective learning approach to promote students' attitudes. While they were conducting inquiry-based experiments, they had opportunities to solve a daily life problem and continuous feedback were given to them during the learning process by the instructor. Moreover, these instructions were quite a change and they were allowed to use different cognitive and affective skills and they learned by doing. Therefore, their attitudes improved in both laboratories and these results reemphasized that the inquiry-based learning approach was an effective learning approach to promote students' attitudes (Akben, 2011; Author, 2013; Berg et al., 2003; Bozkurt, 2015; Chase, Pakhira & Stains, 2013; DiBiase & McDonald, 2015; Silm et al., 2017; Taitelbaum et al., 2008; Timmermans & Geerdink, 2016; Widowati, Nurohman & Anjarsari, 2017; Wolf & Fraser, 2008). Moreover, the prospective science teachers in real and virtual laboratories defined the problem in a reading part related to the learning issue derived from daily life. This instruction showed that they learned places of learning issues in their daily life and they had opportunities to solve a daily life problem by carrying out laboratory activities based on inquiry-based learning in this study. Therefore, their attitudes might have been affected positively by this instruction. As mentioned by Hofstein and Mamlok-Naaman (2011), if the students associate the science topics with everyday life and use this association for social and environmental problems, this situation has a positive effect on students' attitude, as in our research. Another effective factor in the changing of the prospective teachers' attitude is continuous feedback given during the learning process by the instructor in both real laboratory and virtual software. This feedback provides prospective teachers to focus on the learning process and to motivate learning. Additionally, an instructor has a chance for a formative assessment about the process and she gave elaborated feedback to the prospective teachers. Therefore, their attitudes toward both the chemistry lesson and chemistry laboratory are promoted.

When post-test scores were compared, it was found a significant difference between scores of Group-1 and Group-2 obtained from both ATCS ($U= 61.500$, $z = -2.866$, $p< 0.10$, $r = 0.49$) and ATCLS ($U = 84.000$, $z = -2.088$, $p< 0.10$, $r = 0.36$) in favour of Group-1. These findings showed that the PSTs had a better attitude toward both the chemistry laboratory and chemistry lesson in the real laboratory than in a virtual laboratory with accomplishing the instructions. In addition to these, Group-1 had a more positive opinion about the instruction than Group-2 as shown in the content analysis of the interview. Although Group-2 emphasized the advantages of virtual laboratories such as time management, safety laboratory environment, less chemical anxiety, they would have rather done their experiment in a real laboratory environment. Most of all, while Group-1 highlighted the importance of learning by doing, Group-2 did not. It was thought that this was the most effective factor for the difference in attitudes. These results were in accord with results obtained from the scales. In the literature, a comparison of virtual and real laboratory environments showed different results such as a virtual laboratory did not give them the same sense of a real laboratory (Mercer-Chalmers et al., 2004), students would have rather done the experiment using real materials in a real laboratory environment (Bilek & Skalická, 2010). On the other hand, several kinds of research (Tuysuz, 2010; Winkelmann, Keeney-Kennicutt, Fowler & Macik, 2017) compared a virtual laboratory with a real laboratory and they found that the virtual laboratory had promoted students' attitudes towards chemistry lesson and students had a better opinion about the virtual environment.

In addition to these, all sub-dimensions of ATCS had significantly higher post-test scores in Group-1. However, there was a significant difference between groups' post-test scores of ATCLS on two sub-dimensions, which were the assessment in the laboratory and cooperative learning in the laboratory, in favour of Group-1. It was thought that this finding might be a result of working in a real environment and well-planned group dynamics. On the other hand, there was no significant difference between groups' post-test scores on two sub-dimensions which were laboratory environment and using the equipment and experimental process in the laboratory, although Group-1 had higher mean scores on post-test than Group-2. According to results, it is wondered that PSTs might need more time and further experiments to assigned a difference in their attitude in these sub-dimensions.

5. Conclusions

It can safely be concluded that the teaching/learning environments in Science teacher education programs should be supported through offering an inquiry-based learning method to promote PSTs' attitudes towards Chemistry Laboratory and Chemistry Lesson. Although a real laboratory may have the best effects, the virtual laboratory also has potential to contribute to improving students' attitudes. A real laboratory environment can be preferable in many contexts but it should also be remembered that virtual laboratory environment can also be functional to conduct experiments in certain circumstances. Further researches can also be designed to introduce various real laboratory activities and virtual software programs as beneficial sources to open new horizons in the field of Science teacher education.

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