MIER Journal of Educational Studies Trends & Practices
May 2021, Vol. 11, No. 1, pp. 15 - 29
DOI: 10.52634/mier/2021/v11/i1/1751

Effect Of Inquiry-Based Biology Laboratory Applications On Scientific Process Skills, Attitude, Self-Efficacy And Self-Confidence

Dilek Sultan Acarli and Sevilay Dervisoglu

This study examined the effects of inquiry-based biology laboratory applications on pre-service biology teachers' scientific process skills, attitudes, self-efficacy, and self-confidence in the laboratory. In this context, many related tests and scales were applied to first-year students of biology education (N=25). The research adopted the pre-test and post-test control group model. The results showed that laboratory practices based on both the corroborative and the guided inquiry approach increase the scientific process skills of the prospective teachers. Guided inquiry-based laboratory practices have increased the attitudes of pre-service biology teachers toward laboratory lessons. However, self-efficacy and self-confidence of the pre-service teachers taking part in corroborative laboratory practices increased, while guided inquiry methods did not have a significant effect on self-efficacy and self-confidence. The findings of the study highlighted the importance of a guided inquiry approach in the laboratory applications related training of pre-service biology teachers.

Keywords: Pre-Service Biology Teachers, Biology Laboratory, Scientific Process Skills, Guided Inquiry Based Instructions

Introduction

The inquiry/research-based teaching approach has a significant role in recent developments within the field of science education (National Research Council, 1996, 2000). Within the context of teaching, inquiry denotes "the activities

Dilek Sultan Acarli ✉
Associate Professor, Faculty of Education, Department of Mathematics and Science Education Biology Education Programmes, Hacettepe University Beytepe, Ankara, Turkey.
Email: dsultan@hacettepe.edu.tr

Sevilay Dervisoglu
Associate Professor, Faculty of Education, Department of Mathematics and Science Education Biology Education Programmes, Hacettepe University Beytepe, Ankara, Turkey.
Email: sevilayd@hacettepe.edu.tr

of students in which they develop knowledge and understanding of scientific ideas as well as an understanding of how scientists study the natural world" (National Research Council, 1996). According to this, inquiry can be defined as students' and scientists' processes of researching the natural world. In inquiry-based teaching, scientific research processes are used as the learning-teaching method. In this process, students deal with scientific questions and problems. They bring proof-based explanations to scientific questions, and they evaluate, present, and defend these explanations under the light of alternative scientific explanations National Research Council (2000). The inquiry method is classified in various forms (Colburn, 2000). For instance, in the constructed inquiry, students investigate a problem by following the methods given by the teacher. In a guided inquiry, the teacher gives the problem, and the student decides on the solution path. Here, the task of the teacher is to steer the students to think and design their own research processes. In an open inquiry, students decide on both the research question and the solution path (Colburn, 2000). When verifying laboratory practices, also known as traditional methods, the teacher defines the topics to be examined and presents the process to be followed by the students. Here, students try to prove the pre-defined results by following the given methods (Domin, 1999). Therefore, this method is known as the cookbook method (Colburn, 2000; Domin, 1999).

Reforms implemented in the field of science education in recent years have made inquiry/research-based teaching a basic proficiency field for teachers (Davis, Petish, & Smithey, 2006). In this respect, institutions that train biology teachers should also provide inquiry/research-based learning-teaching experiences (Windschitl, 2003). To this end, pre-service teachers should be provided with lab opportunities where they can develop their skills related to scientific research and inquiry. In this context, scientific process skills are quite important. Scientific process skills are thought skills that are used to formulize results, investigate problems, and form knowledge (Tan & Temiz, 2003). Among the scientific process skills are observation, classification, measurement, data recording, using data and constructing a model, interpretation of data, drawing conclusions, determining/changing/controlling variables, forming and testing a hypothesis, and performing experiments (Tan & Temiz, 2003). Moreover, Ekici (2002, 2009) has shown that self-efficacy beliefs and attitudes may be important factors in teachers' participation in biology-related applications. According to Bandura (1997), self-efficacy refers to a person's view of himself or herself concerning their capacity to successfully realize activities necessary for a certain performance (Ekici, 2005).

Biology self-efficacy is defined as "a person's judgment of himself/herself regarding his/her ability to learn biology" (Ekici, 2009, p.112). Attitudes, on the other hand, are important for use in biology labs because they play

an important role in guessing behavior (Ajzen, 2001). Attitudes represent a brief evaluation of objects that are expressed with such expressions as liked/disliked, sweet/unpleasant, useful/useless, and good/bad (Ajzen, 2001). There is evidence that inquiry-based biology laboratory courses provide better learning outcomes by students (Beck, Butler, & da Silva, 2014). So, this experimental study was realized during a general biology laboratory lesson. In the study, guided inquiry-approach-based lab activities were prepared and were presented to freshmen studying biology education. This study examined how guided inquiry-based lab applications affect pre-service biology teachers' attitudes, self-efficacy, and self-confidence toward the laboratory.

Review Of Literature

Studies have reported that the inquiry-based approach has a positive effect on students' learning (Akben, 2015; Akkus, Gunel, & Hand, 2007; Demircioglu & Ucar, 2015; Gangoli & Gurumurthy, 1995; Kaya & Yilmaz, 2016; Tatar & Kuru, 2006; Timur & Kincal, 2010). More importantly, there is evidence that inquiry-based learning provides a framework for understanding science, thus affecting science learning in the long term. For example, Derting and Ebert-May (2010) found indications that the intensive inquiry-based student-centered learning at the beginning of the curriculum influence further science learning of students. Gehring and Eastman (2008) reported that inquiry-based learning in biology courses contributed to improve students' ability to gain and apply information. More specifically, the studies show that a guided inquiry-based method applied in lab environments would be an effective method to improve pre-service teachers' scientific process skills, their attitudes on laboratory lessons, their self-efficacy, and their self-confidence (Akpinar & Yildiz, 2006; Blanchard et al., 2010; Gormally, Brickman, Hallar, & Armstrong, 2009; Kaya & Yilmaz, 2016; Krystyniak, 2001). On the other hand, the findings on this issue vary. For instance, Duru, Demir, Önen, and Benzer (2011) determined that while the inquiry-based laboratory applications increased the students' ability to use scientific processes, it did not cause a significant change in their attitudes towards the laboratory. Cairns and Areepattamannil (2019) found that inquiry-based science education was significantly negatively linked to science achievement, while it was positively linked to the dispositions toward science. According to the findings of Furtak, Seidel, Iverson, and Briggs (2012), these differences may link to the way the inquiry-based teaching was practiced.

Research Methodology

This study is based on experimental design. In experimental design, the aim is to determine whether or not there is an effect of the variable studied. In this study, researchers aimed to measure the effect of inquiry-based biology laboratory applications on scientific process skills, attitudes, self-efficacy, and self-confidence. Also, the study was realized according to the pre-test-post-test model with control group. To this end, experiment and control groups were formed with freshman pre-service biology teachers.

Sample For The Study

The study group consisted of 25 students (twenty-one female and four male) enrolled in the Biology Education Department at a university during the 2016–2017 academic year. In order to ensure homogeneous distribution of control and experiment groups in terms of knowledge of the biology laboratory, groups were formed by considering the examination scores of the pre-service teachers in the laboratory lesson at the end of the first semester.

Data Collection Tools

Before beginning the applications, pre-tests were conducted with both groups. The measurement scales used were Scientific Process Skills Test (Geban, Askar, & Özkan, 1992), Self-Confidence Test Regarding Laboratory (Krystyniak, 2001; Yurdatapan, 2013), Biology Self-Efficacy Scale (Ekici, 2009; Hsu, 2000), and Scale for the Attitude of Biology Teachers toward Laboratory Lesson (Ekici, 2002).

Scientific Process Skills Test:

Originally designed by Okey, Wise, and Burns (1982), the Scientific Process Skills Test was adapted to Turkish by Geban et al. (1992). The test consisted of thirty-six multiple-choice questions and covered five different scientific process skills: determining variables, determining and expressing hypotheses, operational definition, designing research, and transforming data to graphics and evaluating them (Geban et al., 1992). The reliability coefficient of the test was found to be 0.77.

Scale for the Attitude of Biology Teachers Toward Laboratory Lesson:

The Scale for the Attitude of Biology Teachers Toward Laboratory Lesson was developed by Ekici (2002). Consisting of a total of twenty-one items (eleven

positive, ten negative), the scale had five Likert-type answer options (Completely agree: 5 … Completely disagree: 1). The scale had three dimensions, namely, Pleasure, Trust, and Importance. In this study, a total of six items were left out as they decreased reliability (Items 5, 10, 12, 13, 14, and 21), and Cronbach Alpha coefficient was found to be 0.75 for the totality of the scale. Cronbach Alpha reliability coefficients were calculated to be 0.61 for the Pleasure dimension, 0.57 for Trust, and 0.72 for Importance.

Biology Self-Efficacy Scale:

Originally designed by Woo (1999), the Biology Self-Efficacy Scale was adapted to Turkish by Ekici (2009). Consisting of a total of forty items, the scale had five Likert-type answer options (Highly Frequently: 5, Frequently: 4, Sometimes: 3, Rarely: 2, and Almost Never: 1). The scale had three dimensions, namely, Lab Activities, Learning Level, and Problem Solving. Two items were left out as they decreased reliability (items 13 and 40), and the Cronbach Alpha coefficient was found to be 0.95. Cronbach Alpha reliability coefficients were calculated to be 0.86 for the Lab Activities dimension, 0.85 for Learning Level, and 0.91 for Problem Solving.

Self-Confidence Test Regarding Laboratory:

Originally designed by Krystyniak (2001), Self-Confidence Test Regarding Laboratory was adapted to Turkish by Yurdatapan (2013). The scale consisted of twenty items, and it was evaluated through seven Likert-type answer options from 0–7 (I have no trust: 0 … I trust completely: 7). The Cronbach Alpha coefficient of the scale was calculated to be 0.94.

Within the scope of this study, general biology lab activities based on guided inquiry were prepared, and appropriate lab study sheets were developed. Weekly activity topics were as follows:

1st Week: Organography (Root, Stem, Leave).

2nd Week: Organography (Flower, Fruit, Seed. Differences between Monocotyl and

Dicotyl Plants).

3rd Week: Bacteria, Yeast cells.

4th Week: Fungi, Protists.

5th Week: Passing through a Membrane through Diffusion.

6th Week: DNA Isolation.

7th Week: Enzyme Activity on Live Tissue.

8th Week: Fish Dissection.

9th Week: Eye Dissection.

The confirmatory method was applied to the control group (N=13), and guided inquiry-based activities were realized with the experiment group (N=12). Groups of three were formed within the experiment group, and they were asked to prepare an experiment report where they wrote down the hypothesis, variable, operation steps, and results related to the topic of the experiment for each experiment. At the end of the applications, post-tests were applied to the control and experiment groups.

Data Analysis

Quantitative data obtained from the scales were evaluated with the help of SPSS 17. The Wilcoxon Signed Rank Test, which is a non-parametric method, was used in the comparison between the pre-test and post-test scores of the experimental and control groups.

Results Of The Study

The average total scores of the pre-test and post-test of pre-service teachers in the control and experimental groups, received from the aforementioned measurement tools, are given in Table 1.

Table 1

Average Total Scores Received from Measurement Tools.

Scales	Control Group				Experimental Group			
	Pre-test		Post-test		Pre-test		Post-test	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Scientific Process Skills	23.46	4.37	25	3.83	22	5.58	24.83	3.56
Attitudes toward Laboratory Lesson	64.92	5.42	67.38	5.39	61.86	6.61	65.83	5.17
Self-Efficacy toward Biology	152.69	21.84	162.13	17.76	156.08	17.80	156.50	12.53
Self-Confidence Regarding Laboratory	103.54	19.56	111	21.97	98.58	19.68	104.25	13.09

The Wilcoxon Signed Rank Test was conducted to determine the signifi-

cance of the difference between the pre-test and post-test scores of the control and experiment groups for the Scientific Process Skills Test. Wilcoxon Sign Rank Test results are given in Table 2.

Table 2

Results of the Wilcoxon Signed Rank Test to Determine the Difference Between Pre-test-Post-test Scores of the Scientific Process Skills Test.

	Post-test-Pre-test	N	Mean Rank	Sum of Ranks	Z	p
Control Group	Negative Ranks	3	3.50	1.50	-2.04	.04
	Positive Ranks	8	6.94	55.50		
	Ties	2				
Experimental Group	Negative Ranks	2	2.50	5.00	-2.50	.01
	Positive Ranks	9	6.78	61.00		
	Ties	1				

According to Table 2, there is a significant difference between the pre-test-post-test results of both the control and the experiment groups ($Z_{control}$=-2.04, p<.05; $Z_{experiment}$=-2.50, p<.05). When the rank scores of difference points are taken into consideration, it can be observed that there is a difference in favor of the positive ranks, or in other words, the post-test scores in both groups. Therefore, it can be said that both methods had a positive effect by improving pre-service teachers' scientific process skills.

The Wilcoxon Signed Rank Test was conducted to determine the significance of the difference between the pre-test and post-test scores of the control and experiment groups for the Scale for the Attitude of Biology Teachers Toward Laboratory Lesson. The Wilcoxon Sign Rank Test results are given in Table 3.

According to Table 3, there is no significant difference between the attitude pre-test-post-test scores of pre-service teachers in the control group ($Z_{control}$=-1.34, p>.05). In other words, confirmatory laboratory activities had no effect on pre-service teachers' attitudes towards the laboratory lesson. There is a significant difference between the attitude pre-test-post-test results of the experiment group ($Z_{experiment}$=-2.09, p<.05). When the rank scores of the difference points of the experiment group are taken into consideration, it is seen that this difference favours the post-test scores. Based on this, the guided inquiry-based

Table 3

Results of the Wilcoxon Signed Rank Test to Determine the Difference Between the Pre-test-Post-test Scores of Attitudes.

	Post-test-Pre-test	N	Mean Rank	Sum of Ranks	Z	p
Control Group	Negative Ranks	6	3.67	22.00	-1.34	.18
	Positive Ranks	6	9.33	56.00		
	Ties	1				
Experimental Group	Negative Ranks	1	7.00	7.00	-2.09	.04
	Positive Ranks	9	5.33	48.00		
	Ties	2				

method can be said to have a positive effect on pre-service teachers' attitudes toward laboratory lessons.

The Wilcoxon Signed Rank Test was conducted to determine the significance of the difference between the pre-test and post-test scores of the control and experiment groups for the Biology Self-Efficacy Test. The Wilcoxon Sign Rank Test results are given in Table 4.

According to Table 4, there is a significant difference between the pre-service teachers' self-efficacy pre-test-post-test scores in the control group ($Z_{control}$=-2.27, p<.05). When the rank scores of the difference points of the control group are taken into consideration, it can be observed that this difference favours positive ranks, or in other words, post-test scores. According to this, confirmatory lab activities can be said to have a positive effect on the improvement of biology self-efficacy of pre-service teachers. There is no significant difference in the self-efficacy pre-test-post-test scores of pre-service teachers in the experiment group ($Z_{experiment}$=-.09, p>.05). In other words, the guided inquiry-based method had no effect on pre-service teachers' biology self-efficacy beliefs.

Results of the Wilcoxon Signed Rank Test to determine the difference between the Self-Confidence Test Regarding Laboratory pre-test-post-test scores of the control and experiment groups are given in Table 5.

According to Table 5, there is a significant difference in the self-confidence

Table 4

Results of the Wilcoxon Signed Rank Test to Determine the Difference Between Pre-test-Post-test Scores of the Biology Self-efficacy.

	Post-test-Pre-test	N	Mean Rank	Sum of Ranks	Z	p
Control Group	Negative Ranks	3	4.33	13.00	-2.27	.02
	Positive Ranks	10	7.80	78.00		
	Ties	0				
Experimental Group	Negative Ranks	6	5.33	32.00	-.09	.93
	Positive Ranks	5	6.80	34.00		
	Ties	1				

Table 5

Results of the Wilcoxon Signed Rank Test to Determine the Difference Between Pre-test-Post-test Scores of the Self-confidence Test Regarding Laboratory.

	Post-test-Pre-test	N	Mean Rank	Sum of Ranks	Z	p
Control Group	Negative Ranks	2	5.50	11.00	-2.21	.03
	Positive Ranks	10	6.70	67.00		
	Ties	1				
Experimental Group	Negative Ranks	5	6.30	31.50	-.59	.56
	Positive Ranks	7	6.64	46.50		
	Ties	0				

pre-test-post-test results of pre-service teachers in the control group ($Z_{control}$=-2,21, p<.05). When the rank scores of the difference points of the control group are taken into consideration, it can be seen that this difference favours post-test scores. According to this, confirmatory lab activities can be said to have a positive effect on the improvement of lab activity self-confidence of pre-service teachers. There is no significant difference in the self-confidence pre-test-post-test scores of pre-service teachers in the experiment group ($Z_{experiment}$=-.59, p>.05). In other words, the guided inquiry-based method had no effect on pre-service teachers' self-confidence towards the laboratory lesson.

As a result, the research findings showed that both confirmatory and guided inquiry-based laboratory applications had a positive effect on the development of pre-service teachers' scientific process skills. In addition, confirmatory laboratory applications were effective in increasing pre-service teachers 'biology self-efficacy beliefs and their self-confidence towards the laboratory, while guided inquiry-based laboratory applications positively affected pre-service teachers' attitudes towards laboratory lessons.

Discussion And Conclusions

The importance of scientific inquiry-based learning-teaching experiences in science education has been emphasized in recent years (Davis et al., 2006). Research on this issue has shown that inquiry-based teaching contributes to improving scientific process skills (Blanchard et al., 2010; Demircioglu & Ucar, 2015; Duru et al., 2011; Kaya & Yilmaz, 2016; Wu & Krajcik, 2006; Yurdatapan, 2013). Scientific process skills are the fundamental skills necessary for the realization of experimental activities. Scientific processes help the development of these skills. When these skills are developed, they help people relate experiments with the topic and contribute to the mental construction of concepts (Tan & Temiz, 2003). Studies showed that the inquiry-based approach has a positive effect on students' learning and comprehension (Akben, 2015; Akkus et al., 2007; Demircioglu & Ucar, 2015; Gangoli & Gurumurthy, 1995; Kaya & Yilmaz, 2016; Tatar & Kuru, 2006; Timur & Kincal, 2010). When the outcomes of confirmatory and inquiry-based lab applications are compared, the inquiry-based approach can be seen to be more effective in improving students' critical thinking and scientific process skills (Blanchard et al., 2010; Irwanto, Saputro, Rohaeti, & Prodjosantoso, 2019). Findings of this study partially support the literature. This study has shown that both confirmatory and inquiry-based biology lab applications improve pre-service teachers' scientific process skills. Pre-service teaches are required to employ scientific processes such as experimenting, analysing, and drawing conclusions in the lab in both methods. Thus, the fact that confirmatory lab applications also improve pre-service teachers' scientific process skills is an expected finding. Moreover, the findings from

the qualitative part of this study also indicate that the inquiry-based method increases the skills to research and interpret (Acarli & Dervisoglu, 2018).

Findings of this study show that inquiry-based lab applications do not have a significant effect on pre-service teachers' self-efficacy and self-confidence. However, pre-service teachers' self-efficacy and self-confidence increased in a significant manner at the end of the confirmatory lab applications. Similar to these findings, Gormally et al. (2009) also reported that self-efficacy of pre-service teachers who participated in traditional labs increased more compared to those who participated in inquiry-based labs. They contended that this was due to the fact that inquiry-based labs are more demanding compared to traditional labs. In the qualitative part of this study, pre-service teachers reported that this method positively influenced their self-confidence and self-efficacy. While they also indicated that they did not know how to perform research (what to do / how to do it), they specifically mentioned difficulties when accessing information (Acarli & Dervisoglu, 2018). This is thought to be due to the fact that the pre-service teachers were familiar with the confirmatory method and were pressured during the applications because they were encountering the inquiry method for the first time. When the effect of experience on self-efficacy and self-confidence is considered, it can be argued that pre-service teachers should be exposed to more inquiry-based lab activities. In this way, their prejudices as well as their fears may be overcome, and their fluency and self-efficacy may be increased. Studies show that teachers also find it difficult to apply the inquiry approach in their classes (Furtak, 2006; Kaya & Yilmaz, 2016; Yoon, Joung, & Kim, 2012; Zion, Schanin, & Shmueli, 2013). Windschitl (2003) showed that pre-service teachers who had participated in classes designed according to the inquiry-based approach also learned these methods better. In other words, it is important to provide opportunities for inquiry/research-based learning-teaching approaches in teacher training.

Inquiry-based lab applications were seen to be effective in the development of pre-service teachers' scientific process skills, especially their attitudes toward biology laboratory lessons. The qualitative research findings of the researchers are similar (Acarli & Dervisoglu, 2018; Hsu, 2000). Pre-service teachers found the inquiry method to be interesting and entertaining despite the difficulties they experienced. They stated that they enjoyed exploring during practices and, as a result, they expressed satisfaction with science, biology, and biology laboratory. Since attitude is an important predictor of behaviour, this positive change in attitude toward the laboratory is an important finding. Indeed, a pre-service teacher with a positive attitude will be more willing to perform lab applications during their education, as well as in their professional life. Based on these findings, it is suggested that teacher-training programs should put emphasis on implementing and teaching inquiry-based methods.

Acknowledgement

This research project numbered SHD-2016-13042 was supported by the Hacettepe University Scientific Research Projects Coordination Unit.

References

Acarli, D. S., & Dervisoglu, S. (2018). Pre-service biology teachers' views towards guided inquiry-based instructions in laboratory. *Science Education Art and Technology Journal*, *2*(1), 22-34.

Ajzen, I. (2001). Nature and Operation of Attitudes. *Annual Review of Psychology*, *52*(1), 27-58. https://doi.org/10.1146/annurev.psych.52.1.27

Akben, N. (2015). The Effect of Open Inquiry-Based Laboratory Activities on Prospective Teachers' Misconceptions about Matter. *International Online Journal of Educational Sciences*, *7*(3), 164-178. https://doi.org/10.15345/iojes.2015.03.003

Akkus, R., Gunel, M., & Hand, B. (2007). Comparing an Inquiry-based Approach known as the Science Writing Heuristic to Traditional Science Teaching Practices: Are there differences? *International Journal of Science Education*, *29*(14), 1745-1765. https://doi.org/10.1080/09500690601075629

Akpinar, E., & Yildiz, E. (2006). Investigation of the effect of open-ended experiment technique on the attitudes of students toward laboratory. *Journal of Buca Faculty of Education*, *20*, 69-76.

Beck, C., Butler, A., & da Silva, K. B. (2014). Promoting Inquiry-Based Teaching in Laboratory Courses: Are We Meeting the Grade? *CBE—Life Sciences Education*, *13*(3), 444-452. https://doi.org/10.1187/cbe.13-12-0245

Blanchard, M. R., Southerland, S. A., Osborne, J. W., Sampson, V. D., Annetta, L. A., & Granger, E. M. (2010). Is inquiry possible in light of accountability?: A quantitative comparison of the relative effectiveness of guided inquiry and verification laboratory instruction. *Science Education*, *94*(4), 577-616. https://doi.org/10.1002/sce.20390

Cairns, D., & Areepattamannil, S. (2019). Exploring the relations of inquiry-based teaching to science achievement and dispositions in 54 countries. *Research in Science Education*, *49*(1), 1-23.

Colburn, A. (2000). An inquiry primer. *Science Scope*, 42-44.

Davis, E. A., Petish, D., & Smithey, J. (2006). Challenges New Science Teachers Face. *Review of Educational Research*, *76*(4), 607-651. https://doi.org/10.3102/00346543076004607

Demircioglu, T., & Ucar, S. (2015). Investigating the effect of argument-driven inquiry in laboratory instruction. *Educational Sciences: Theory*

and Practice, *15*(1), 267-283.

Derting, T. L., & Ebert-May, D. (2010). Learner-Centered Inquiry in Undergraduate Biology: Positive Relationships with Long-Term Student Achievement. *CBE – Life Sciences Education*, *9*(4), 462-472. https://doi.org/10.1187/cbe.10-02-0011

Domin, D. S. (1999). A Review of Laboratory Instruction Styles. *Journal of Chemical Education*, *76*(4), 543-543. https://doi.org/10.1021/ed076p543

Duru, M. K., Demir, S., Önen, F., & Benzer, E. (2011). The effects of inquiry-based laboratory applications to preservice science teachers' laboratory environment perceptions, attitudes and scientific process skills. *Marmara University Atatürk Education Faculty Journal of Educational Sciences*, *33*, 25-44.

Ekici, G. (2002). The attitude scale of biology teachers toward laboratory lesson. *Hacettepe University Journal of Education*, *22*, 62-66.

Ekici, G. (2005). The validity and reliability of the biology self-efficacy instrument. *Hacettepe University Journal of Education*, *29*, 85-94.

Ekici, G. (2009). Adaptation of the Biology Self-Efficacy Scale to Turkish. *Kastamonu Education Journal*, *17*(1), 111-124.

Furtak, E. M. (2006). The problem with answers: An exploration of guided scientific inquiry teaching. *Science Education*, *90*(3), 453-467. https://doi.org/10.1002/sce.20130

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and Quasi-Experimental Studies of Inquiry-Based Science Teaching. *Review of Educational Research*, *82*(3), 300-329. https://doi.org/10.3102/0034654312457206

Gangoli, S. G., & Gurumurthy, C. (1995). A study of the effectiveness of a guided open-ended approach to physics experiments. *International Journal of Science Education*, *17*(2), 233-241. https://doi.org/10.1080/0950069950170207

Geban, Ö., Askar, P., & Özkan, İ. (1992). Effects of Computer Simulations and Problem-Solving Approaches on High School Students. *The Journal of Educational Research*, *86*(1), 5-10. https://doi.org/10.1080/00220671.1992.9941821

Gehring, K. M., & Eastman, D. A. (2008). Information Fluency for Undergraduate Biology Majors: Applications of Inquiry-based Learning in a Developmental Biology Course. *CBE – Life Sciences Education*, *7*(1), 54-63. https://doi.org/10.1187/cbe.07-10-0091

Gormally, C., Brickman, P., Hallar, B., & Armstrong, N. (2009). Effects of Inquiry-based Learning on Students' Science Literacy Skills and Confidence. *International Journal for the Scholarship of Teaching and Learning*, *3*(2). https://doi.org/10.20429/ijsotl.2009.030216

Hsu, M. T. (2000). *An exploratory study of the relationship between the attitude*

toward science self-efficacy in life science and representation of nutrition-health beliefs/ academic achievement of students at institute of technology. National Taiwan Normal University. (Unpublished Doctoral Thesis)

Irwanto, I., Saputro, A. D., Rohaeti, E., & Prodjosantoso, A. K. (2019). Using Inquiry-Based Laboratory Instruction to Improve Critical Thinking and Scientific Process Skills among Preservice Elementary Teachers. *Eurasian Journal of Educational Research*, *19*(80), 1-20. https://doi.org/10.14689/ejer.2019.80.8

Kaya, G., & Yilmaz, S. (2016). The impact of open inquiry-based learning on students' achievement and development of science process skills. *Hacettepe University Journal of Education*, *31*(2), 300-318.

Krystyniak, R. A. (2001). *The effect of participation in an extended inquiry project on general chemistry students' laboratory interactions, confidence and process skills.* University of Northern, Colorado. (Unpublished Doctoral Thesis)

National Research Council. (1996). *National science education standards*. Washington DC: National Academy Press.

National Research Council. (2000). *Inquiry and the national science education standards*. Washington DC: National Academy Press.

Okey, J. R., Wise, K. C., & Burns, J. C. (1982). *Integrated process skills test ii*. Athens: Department of Science Education, University of Georgia.

Tan, M., & Temiz, B. K. (2003). The importance and role of the science process skills in science teaching. *Pamukkale University Journal of Education*, *1*(13), 89-101.

Tatar, N., & Kuru, M. (2006). The effect of inquiry-based learning approach in science education on academic achievement. *Hacettepe University Journal of Education*, *31*, 147-158.

Timur, B., & Kincal, R. Y. (2010). The effect of inquiry teaching on student achievement in 7th grade science course. *Journal of Turkish Educational Sciences*, *8*(1), 41-65.

Windschitl, M. (2003). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education*, *87*(1), 112-143. https://doi.org/10.1002/sce.10044

Woo, T. N. (1999). *Relationship between self-efficacy in biology and academic achievement and its effects in parallel discussion.* National Taiwan Normal University. (Unpublished Masters Thesis)

Wu, H.-K., & Krajcik, J. S. (2006). Inscriptional practices in two inquiry-based classrooms: A case study of seventh graders' use of data tables and graphs. *Journal of Research in Science Teaching*, *43*(1), 63-95. https://doi.org/10.1002/tea.20092

Yoon, H. G., Joung, Y. J., & Kim, M. (2012). The challenges of science inquiry teaching for pre-service teachers in elementary classrooms:

Difficulties on and under the scene. *Research in Science Education*, *42*(3), 589-608.

Yurdatapan, M. (2013). The effect of problem based laboratory activities on self-confidence, self-efficacy and science process skills of students. *Hacettepe University Journal of Education, Special Issue*, *1*, 421-435.

Zion, M., Schanin, I., & Shmueli, E. R. (2013). *Teachers' performances during a practical dynamic open inquiry process* (Vol. 19). Informa UK Limited. https://doi.org/10.1080/13540602.2013.827457