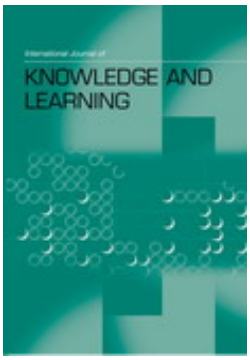


International Journal of Knowledge and Learning

ISSN online: 1741-1017 - ISSN print: 1741-1009
https://www.inderscience.com/ijkl

Teacher candidates' proficiency in utilising the REACT strategy through experimental activities

Harun Çelik, Hüseyin Miraç Pektaş, Abdulsamet Karaşahin, Orhan Karamustafaoğlu

DOI: 10.1504/IJKL.2022.10047592

Article History:
Received: 29 January 2022
Accepted: 04 April 2022
Published online: 30 November 2022

Teacher candidates' proficiency in utilising the REACT strategy through experimental activities

Harun Çelik* and Hüseyin Miraç Pektaş

Education Faculty,
Kırıkkale University, Turkey
Email: haruncelik@kku.edu.tr
Email: hmpektas@hotmail.com
*Corresponding author

Abdulsamet Karaşahin

Graduate School of Natural and Applied Sciences,
Kırıkkale University, Turkey
Email: sametcekerek@gmail.com

Orhan Karamustafaoğlu

Education Faculty,
Amasya University, Turkey
Email: orseka@yahoo.com

Abstract: It is known that the success of a science education reform depends considerably on science teachers' knowledge, skills and activities. In accordance with this, the aim of this study is to investigate the proficiency of science teacher candidates in the use of the REACT strategy through their experimental science activities within the scope of context-based learning approach. Within this context, this study was designed in the form of a longitudinal analysis, performances were analysed periodically, and the transformation was pursued. The data obtained from documents by means of a content analysis was presented via graphical instruments through converting it into quantitative data by means of the rubric which was developed by the researchers. According to the longitudinal analysis findings, it was observed that the teacher candidates' performance in utilising the REACT strategy is parallel to the ascending number of activities.

Keywords: react strategy; context-based learning; science teacher candidates; science activities.

Reference to this paper should be made as follows: Çelik, H., Pektaş, H.M., Karaşahin, A. and Karamustafaoğlu, O. (2023) 'Teacher candidates' proficiency in utilising the REACT strategy through experimental activities', *Int. J. Knowledge and Learning*, Vol. 16, No. 1, pp.1–16.

Biographical notes: Harun Çelik is an expert in science education. The researcher is engaged in metaphor and analogies in concept teaching, science learning environments enriched by technology, and science education and physics education in the areas of science laboratories.

Hüseyin Miraç Pektaş works as a Lecturer in the Department of Mathematics and Science Education. He is continuing his Doctorate in Science Education.

Abdulsamet Karaşahin is a Science Teacher at the Ministry of National Education. He is still continuing his postgraduate education in Science Education.

Orhan Karamustafaoğlu specialises on Physics Education, Science Teaching Practice, Teaching Methods and Teacher Education in Physics and Science. He has carried out many national scientific projects. He is an editor, vice editor, member of advisory board, member of scientific board and referee in many international and national scientific journals. He also has national and international papers and proceedings.

1 Introduction

Envisioning a learning environment within which learners could propose and develop solutions to probable problems they would encounter in their lives in a way that they could employ research and discovery strategies has a substantial role in the learning science notions. An interesting and life-related experimental process for students is seen as an important component of increasing their laboratory experience and gains (Buntine et al., 2020; Çelik et al., 2015). In recent years, various approaches which could allow learners to build transfer in terms of life have been developed so as to lead them to construct scientific concerns in a more comprehensible way in many countries. In terms of this, context-based learning approach encourages learning to be envisioned in a form that it could be related to real life on the basis of constructivism (Whitelegg and Parry, 1999; Broman et al., 2018). It is known that context-based learning approach is investigated in a great deal of countries such as Australia, New Zealand, England, Germany, Finland, Israel, the USA, the Netherlands and Turkey by means of major projects and scientific studies as well as it adopted within learning programs (Ayvacı, 2010; Ültay and Ültay, 2014). Correlatively, research findings from literature specify that context-based approaches are more motivating and intriguing than traditional alternatives with regard to both teachers and learners, and that they influence learners' thinking skills and academic achievement in the positive way (Dori and Sasson, 2008; Fensham, 2009; Schwartz, 2006; Yu et al., 2015). In contrast to this, negative criticism is made in terms of generating contexts related to daily life for scientific notions and specifying the phases of implementation (Ültay and Çalık, 2012). One of the methods which could be denoted as the execution of context-based learning approach within learning environments is the REACT strategy. The Center of Occupational Research and Development (CORD) is the first group to signify that the current problems corresponding with mathematics and science education could be resolved by means of context-based learning and propose REACT (Karamustafaoğlu and Tutar, 2018). In accordance with this, teacher candidates' competency in performing the REACT strategy within the scope of context-based learning approach was focused on.

According to Crawford (2001) and Navarra (2006), the contents comprising the implementation of the REACT strategy and the phases of REACT strategy where the activity types Karamustafaoğlu and Tutar (2018) proposed are presented together are specified below:

- Relating (R): The context where the previous knowledge and target achievements are related to daily life – stories, videos, reading passages, case study.
- Experiencing (E): Having experience through the phase of obtaining data and acquiring competencies – laboratory activities, worksheets, projects, problem-solving.
- Applying (A): Catching the opportunity to reach the target notions, have acquisition and perform experience – laboratory activities, projects, problem-solving, discussion, question and answer.
- Cooperating (C): Discussion on the acquired concerns with peers during the collaborative phase – a performance task as a group work, argumentation, projects.
- Transferring (T): Construction of knowledge, deepening it and relating it to daily life – discussion, projects, evaluation tasks, worksheets, question and answer.

It is specified that the REACT strategy influences learners' academic achievement and their attitudes in the positive way (Bennett et al., 2005; Demircioğlu et al., 2013; Jelatu et al., 2018; Karsli and Yigit, 2017; Ramsden, 1997; Saka, 2011; Sari, 2020), that it is the most significant part of the phase during which convenient contexts are signified (Tekbıyık and Akdeniz, 2010) and that the REACT strategy needs to be advanced (Coştu, 2009; Ültay and Alev, 2017; Ültay et al., 2015) within the studies in literature which comprise the evaluation of context-based learning and the implementation of the REACT strategy. When the approaches which are envisioned for learning environments or the approaches preferred are examined, notions such as the constructivist approach, context-based learning approach, questioning approach and STEM training approach encapsulate various common concerns such as requiring active learning, the need to relate to real life, the wish to construct the knowledge as student-centred. On the other hand, there still exist adversities through the implementation of each specified approach. The reason for this concern is that teachers play a crucial role in any educational reform and they need to readjust their pedagogical perceptions with regard to the updated curriculum and strategies so as to make achievement with a reform (Avargil et al., 2012).

Teachers are required to make substantial decisions in terms of the applicability of a new approach. At this point, the teachers who are experiencing an inner struggle are anxious about what kind of an effect the related innovation will lead to in terms of learners' academic success anxiety and their attitudes (Bennett et al., 2005). In this respect, this study will be influential on teachers' future decisions since it reflects their competency or performance in the application which they have recently experienced (Çelik et al., 2018). The reason for this concern is that the probability of teachers to make changes in their implementations would be higher as long as learning environments, meetings or workshops where new skills were introduced and designated, and where the teachers could have the opportunity to enhance and apply these skills according to studies by Joyce and Showers (1995). On account of this, teachers are required to be

knowledgeable about the philosophy underlying the approach they employ and should gain competencies in terms of their field of pedagogy (Ayvacı, 2010; Lancaster and Bain, 2019). Similarly, another concern which is considered today and whose analyses are still proceeding is the questioning of the results obtained from international tests such as PISA and TIMMS. At this juncture, the reasons for the failure are considered as the selection of the teaching activities which tend to keep learners passive and the teacher more active throughout the classes and that the teaching strategies which are foreseen within teaching programs have not become widespread yet. When it is regarded that teachers are the implementors of an approach, their perception and competencies should be evaluated, and their professional progress should be examined throughout this process. As a solution to these problems, teacher training is considered as a significant factor in enriching and making contribution to teaching programs (Çelik and Avcı, 2018).

In terms of the context-based learning notion as an actual approach, it is conceived as substantial to observe teacher candidates' competencies or problems which they encounter whilst the teaching experiments categorised systematically with regard to the REACT strategy from the aspect of teacher training phase and the questioning of the related teaching strategy. Within the scope of this study, it was aimed at exploring science teacher candidates' proficiency in harnessing the REACT strategy in their experimental science activities with reference to context-based learning approach.

2 Methodology

This study is a longitudinal research study which was generated with regards to developmental research approach. Throughout longitudinal studies, variables are investigated constantly or periodically with reference to the same people or units since the target in longitudinal studies are to designate the progress and transformation of variables to be researched within time (Özmen and Karamustafaoğlu, 2019). The number of people investigated in such studies is usually very few and additionally research in such contexts is generated so as to gather profound data (Keeves, 1987). Accordingly, this is a longitudinal study since it requires the periodical analysis of the change in science teacher candidates' performance which demonstrates their experience and competency corresponding to the REACT strategy within their experimental science activities. On the other hand, the experiment reports which reflect the teacher candidates' performance in group tasks were analysed by means of document analysis and through scoring by means of a rubric. Data obtained through document analysis is both more objective and could be employed in the same way as the data gathered with the aid of interviews and observation. In consequence, data obtained could provide descriptive information, prognosticate hypothesis and perform functions such as tracing transformation and progress (Merriam, 2009).

2.1 Participants

Participants in this study encapsulate third grade BA students at science teaching department at a state university throughout 2018–2019 academic years. They were selected as participants by means of easily accessible case sampling among purposive sampling methods. Easily accessible case sampling is a time saving and accelerating method for the researcher. The reason is that the researcher selects a close and accessible

state with this preference (Given, 2008). Since the teacher candidates' questioning skills were profoundly investigated, this study was restricted with the content analysis of 90 treatment reports (within three weeks) of 30 teacher candidates who participated in this research voluntarily.

2.2 Treatment

The treatment sessions were generated within a total of six weeks with regards to the 'Science Teaching Laboratory Implementations', which comprises a course of four hours a week. The experiments were applied within six sessions one of which incorporated a preparation week and each session was performed in its individual week. The treatment reports by participants were explored within the scope of the research during the second (when teacher candidates began writing their first treatment reports) and the sixth week (which was the last week of the treatment) of the study. It was decided by the researchers that the analyses of the treatment reports be comprised within the study since teacher candidates' performance should be analysed periodically in this research which was longitudinally envisioned. Treatment sessions were performed within the third and fifth week, as well, however, the evaluation of these weeks was merely inspection. At this juncture, the timeline for treatment and the activity names which were incorporated with the evaluation were specified in Table 1. During the treatment, the teacher candidates were primarily introduced the REACT strategy and the steps to be taken within the first week which was denoted as preparation. The teacher candidates were provided with the coursebook 'Science Teaching Laboratory Implementations I-II' (Dökme et al., 2010) prior to the five-week treatment and this allowed them to be aware of the contents and research the acquisition.

The requirements for the experiment reports expected from the teacher candidates were identified with regards to the performance aspects developed by the researchers. These performance dimensions were presented to the teacher candidates by the lecturer who taught during the preparation week by means of sample materials. By this means, teacher candidates contributed to the study being aware of what kind of a process they would encounter in the following treatment weeks. During the treatment in the laboratory, two instructors were in charge in addition to the associate. Accordingly, a team of three people dealt with all teacher candidates who participated in the study. It was endeavoured to contribute to teacher candidates' use of the REACT strategy through giving them constructive and critical feedback. Five groups each of which comprised six teacher candidates made five distinct experiments each week. Within this study which was enriched with the aid of 25 experiments (Table 1, column 2), 30 teacher candidates had face-to-face interaction. During the five treatment weeks, teacher candidates prepared and handed in a total of 150 experiment reports in terms of the performance aspects in REACT Strategy Evaluation Rubric (RSER) which was identified in Appendix 1. However, a total of 90 experiment reports which were handed in during the second, fourth and sixth weeks and which were generated with reference to the related week's experiment were analysed and utilised. The reason is that the teacher candidates' progress was traced and observed every two weeks based on the reports they prepared as a result of the experiments they performed collaboratively. By means of these reports, it was endeavoured to identify the change in teacher candidates' proficiency in utilising the REACT strategy through the rubric analysis.

Table 1 Treatment timeline and experimental activities

The process		*Experimental activities*
Preparation process	Week 1	Information in terms of the REACT strategy was given. The required contents within the experimental reports which would be performed beginning with the second week were denoted. This process was supported by means of sample materials.
Treatment process	Week 2*	→ The view on the intersecting mirrors → Sound amplitude and frequency → The existence of a view on mirrors → Making a solution from solid and liquid matters → The exploration of the structure of leaves
	Week 3	→ Does sound spread in space? → The conductive and insulative → Herbal tissues → Is cold water heavier than hot water? → The identification of blood type
	Week 4*	→ Let us learn acid and bases → Electricity motor model → Let us measure the compression of a balloon → Let us connect bulbs in series and in parallel → The exploration of chloroplasts
	Week 5	→ The existence of a view on lenses → The electromagnets model → The matchsticks existing in water → With which of their parts do plants breathe? → Does a compass deviate in a magnetic environment?
	Week 6*	→ The Dinamo model → Let us connect batteries in series and in parallel → Let us make an aerometer → The resistance of a conductive → The exploration of the heart of a mammal

Note: *The table specifies the experiments which were involved in the weeks of evaluation within the scope of the study.

2.3 Data collection and analysis

The reports of experiments which were performed by teacher candidates for five treatment weeks were analysed by the researchers with the help of RSER. By this means, the competency of teacher candidates in the use of the REACT strategy was identified. It is difficult to measure learning products through the laboratory. For the purposes of the experimental study; operational knowledge, conceptual understanding and process/inquiry skills must be measured together (Yeung et al., 2019). Therefore, the performance aspects which are required to exist in the rubric in terms of the REACT strategy was developed through exploring the studies in literature (Crawford, 2001; Navarra, 2006; Karamustafaoğlu and Tutar, 2018; Ültay and Çalık, 2011). Through performing the data over RSER, the mean value was obtained. An interval scale evaluation was generated so as to specify the sufficiency of each item. With reference to this, the distribution of scores in terms of options is given below: Proficient (3.00–2.25), basic (2.24–1.50), below basic (1.49–0.75) and deficient (0.74–0.00). Therefore, teacher candidates' proficiency in exerting the REACT strategy takes place in a score range of 0–3 points. The validity of the rubric was ensured through asking for the opinion of four instructors who proceeded laboratory studies actively and professionally in science education field. The reliability of the rubrics remarks the consistency in the scores reflected by two discrete scorers or their match (Moskal and Leydens, 2000; Tuncel, 2011). In correspondence to this, two distinct researchers scored the same experimental reports separately and the reliability of the scale was provided by means of

a Cohen Kappa test. The average coefficient value of each 21 items in the rubric was calculated as .78. Therefore, according to the data obtained from the Kappa coefficient, the reliability of the rubric was found at a well-matching level (Landis and Koch, 1977; Şencan, 2005).

3 Findings

In this section, teacher candidates' experiment reports which reflected their performance were evaluated by means of RSER considering the REACT strategy on a basis of context-based learning approach. The quantitative data in Tables 2–6, as required in longitudinal studies, in order reflect the average of performance scores which were obtained in the second, fourth and sixth weeks by the voluntary teacher candidates. The teacher candidates received these scores over the experiment reports with regards to each item within the rubric. With reference to this, the tables provide the opportunity to explore the teacher candidates' proficiency and progress in terms of each item which was classified considering the performance dimensions related to the REACT strategy.

According to the M3 ($\overline{X}_p = 2.84$) item, in which teacher candidates have been the most competent, a connection could be made between the notions and real life throughout teacher candidates' performance in terms of the REACT strategy relating phase whilst their experimental activities. In addition to this, according to Table 2, the average of the six items with regards to the relating phase demonstrates that teacher candidates could establish a connection with the science notions involved in the teaching programs and real life ($\overline{X}_p = 2.53$).

Table 2 Teacher candidates' performance competencies and transformation in terms of the relating phase (see online version for colours)

Dimension	*Matte*	*P2*	*P4*	*P6*	X_p	*Change*
(R) Relating	M1	1.80	2.23	2.87	2.30	
	M2	2.47	2.77	3.00	2.74	
	M3	2.57	2.97	3.00	2.84	
	M4	2.17	2.70	2.97	2.61	
	M5	1.87	2.47	2.83	2.39	
	M6	1.80	2.30	2.83	2.31	
	Total	2.11	2.57	2.92	2.53	

As Table 3 is explored, it is observed that teacher candidates' performance is lower than the first phase corresponding to this phase during which experience acquisition for learners was aimed. It is clearly observed that the most salient item for this phase is M9. Specifying the hypothesis and variables is a substantial concern for science teaching in terms of both scientific process skills and the questioning approach which was adopted by the teaching program. It could be identified that teacher candidates were not attentive and sufficient in performing this task.

Concerning the acquisition of the teaching program, data within Table 4 designates the performance competencies of the use of experience within activities corresponding to a content related to real life with regards to the expected phase. Similar to the state

existing in Table 3, performances in scientific process skills such as identifying hypothesis and variables, making inferences were discerned at a low level. As item 14 is explored, it is noticed that teacher candidates received a zero score which was interpreted as 'deficient' since they did not involve the experimental activities they performed in their REACT strategy reports. The activity envisioning competency, on the other hand, could be in general identified as positive.

Table 3 Teacher candidates' performance competencies and transformation in terms of the experiencing phase (see online version for colours)

Dimension	*Matte*	*P2*	*P4*	*P6*	X_p	*Change*
(E) Experiencing	M7	1.90	2.50	2.70	2.37	
	M8	1.73	2.10	2.10	1.98	
	M9	0.23	0.30	0.50	0.34	
	M10	1.60	2.10	2.53	2.08	
	M11	0.70	1.40	1.80	1.30	
	Total	1.23	1.68	1.93	1.61	

Table 4 Teacher candidates' performance competencies and transformation in terms of the applying phase (see online version for colours)

Dimension	*Matte*	*P2*	*P4*	*P6*	X_p	*Change*
(A) Applying	M12	2.37	2.57	2.80	2.58	
	M13	2.70	2.80	2.93	2.81	
	M14	0.00	0.20	0.00	0.07	
	M15	1.67	1.97	2.27	1.97	
	Total	1.68	1.88	2.00	1.86	

The cooperating phase is the period during which the learner who is predicted to reach a notional competency is expected to produce arguments and harness these arguments within a collaborative context. With respect to this, the employment of methods and techniques convenient to the greater utilisation of critical thinking is expected to be performed. As the data within Table 5 is analysed, it is found that this type of pedagogical competency is at a basic level.

Table 5 Teacher candidates' performance competencies and transformation in terms of the cooperating phase (see online version for colours)

Dimension	*Matte*	*P2*	*P4*	*P6*	X_p	*Change*
(C) Cooperating	M16	1.20	1.80	1.87	1.62	
	M17	1.30	1.57	1.80	1.56	
	M18	0.47	1.13	1.40	1.00	
	Total	0.99	1.50	1.69	1.39	

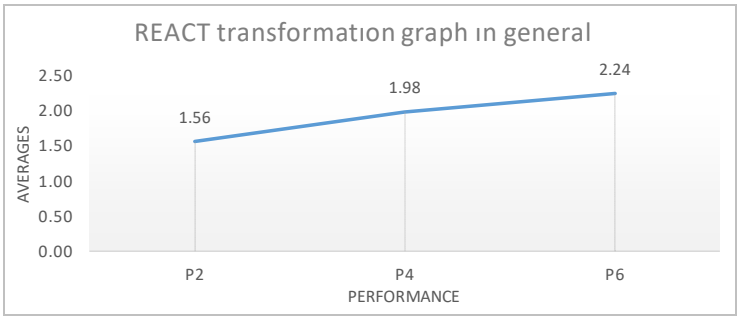
Transferring is the phase during which how productive the process is or how it is constructed is pointed at as in most pedagogical teaching activities. When it is considered that the quantitative data for Table 6 could be at 3.00 level at most, the performances with regards to this dimension could be specified as at a convenient level.

Table 6 Teacher candidates' performance competencies and transformation in terms of the transferring phase (see online version for colours)

Dimension	*Matte*	*P2*	*P4*	*P6*	X_p	*Change*
(T) Transferring	M19	1.13	1.77	2.20	1.70	
	M20	1.33	1.83	2.27	1.81	
	M21	1.77	2.20	2.40	2.12	
	Total	1.41	1.93	2.29	1.88	

Teacher candidates' experimental activities throughout science teaching and their competencies in adapting them corresponding to the REACT strategy could be discovered on Figure 1 concerning their three performances. The general transformation demonstrates that teacher candidates' competency in implementing activities in terms of the REACT strategy performed an increasing positive change.

Figure 1 Teacher candidates' longitudinal transformation in their performance in terms of the REACT strategy (see online version for colours)



4 Results and discussion

It could be denoted that the teacher candidates displayed a proficient performance with respect to the integration of experimental activities in science teaching into the REACT strategy. According to the longitudinal analysis findings, the 2.24 points obtained as a result of the three performances which were investigated periodically endorses this state. It is at the same time noticed in the related literature that teacher candidates' active implementation of the REACT strategy influences their academic proficiency and pedagodical competency in the positive way (Gilbert et al., 2011). Identically, in a similar sampling by Ültay and Alev (2017), teacher candidates remarked that the model had sustained the participants' attention alive and that the treatment sessions generated positive views in terms of their feedback on the REACT strategy. The longitudinal analysis throughout the treatment process displays an enhancement on performance. Accordingly, this circumstance could point to a notion that the more the REACT strategy is employed within learning environments, the more longitudinal teaching could be (Coştu, 2009). Likewise, the encouraging concerns of the applicable professional development and mentoring service own a substantial role in the spread of new educational reform application (Avargil et al., 2012; Dori and Herscovitz, 2005).

Therefore, it could be foreseen that this study has provided teacher candidates with professional development prior to professional service, and that it has supplied a mentoring service for future to those who do not professionalise actively at the moment.

It was observed that the teacher candidates were able to progress mostly at the relating level ($\overline{X}_p = 2.53$) depending on the average performances with regards to each dimension of the REACT strategy. On the other hand, the lowest performance was noticed within the cooperating phase ($\overline{X}_p = 1.39$). When these two circumstances are explored, it could be remarked that the essential science notions as the primary requirement of student-centred education intellect could be fluently attributed to real life. Concerning the student-centred teaching program intellect, it is also probable to denote that both the constructivist and the questioning approaches led to positive outcomes for teacher candidates who were trained. The reason for this notion is that the constructivist approach has existed within the teaching programs of principles since the early 2000s. One of the findings which have proceeded since those years is that learners experience adversities in adapting scientific knowledge into discrete real life contexts (Gilbert, 2006). And this instance points that context-based approach was established on constructivist approach (Berns and Erickson, 2001; Crawford, 2001).

Corresponding to the dimensions of the REACT strategy, with reference to the cooperating phase, it was discovered that the proficiency in preparing teaching activities which encourage critical thinking skills and require a questioning discussion environment was not at a high level. On the other hand, the findings obtained from the longitudinal analysis display that the performance progressed within time. This situation was profoundly explored by Osborne et al. (2004) so as to advance the argumentation method in science classes. Concerning the increasing number of research studies and experiments, it was accordingly observed that science teachers adapted their in-class activities into a form that their learners could generate more arguments.

Within the transferring phase which exists as the outcome of the REACT strategy, it could be specified that the performance level at item M21 which was expected to evaluate the notions directly was high, the items M19 and M20 which require reflective questioning could be denoted as the items in need of progress. Yurdabakan (2011) denoted that learners were in need of activities which could encourage questioning such as 'what I learned, what I did well, why I selected this product, what I need to develop' with reference to the acquisition they had throughout the learning process. When the linear or cyclic structure of teaching strategies is taken into consideration, evaluation/transferring phases should be regarded as reflective questioning concerns. While Lyons (2010) remarks that reflective questioning needs to be considered as a new approach for every professional development, he additionally specifies that it should be indirectly progressed. Accordingly, as a result of the treatment throughout this study, the increase in this proficiency which is additionally viewed as a metacognitive skill (Gezer and Şahin, 2017) could be identified as a positive outcome.

When the performance items with regards to the REACT strategy are explored, the highest performance was discovered in their competency in relating the concerns to real life ($\overline{X}_p = 2.84$). On the other hand, the lowest performance existed in items M9 and M14 which could be remarked as teacher candidates' low performance in displaying the sufficient attention to identifying the hypotheses and variables prior to the experimental – observatory activity. Therefore, it could be denoted that they did not employ much sensitivity towards developing their scientific process skills throughout the activities.

Additionally, it could be discovered that teachers are not so clear and intellectual about how to advance thinking skills in their classes (Barak and Shakhman, 2008). Similarly, it was stated that the in-class activities were not envisioned with regards to learners' acquisition of scientific process skills (Downing and Filer, 1999; Türkmen and Kandemir, 2018). For this reason, it was reflected among these studies, which investigated teachers' perception of scientific process skills, that these skills could be acquired indirectly since insufficient awareness is provided on them. In contrast to this, teaching models and methods should be envisioned in alignment with scientific process skills especially today during which questioning approaches are leading (Cairns and Areepattamannil, 2019; van Uum et al., 2016). In the same way, it is known that the REACT strategy is an outcome of the context-based learning approach and that for this reason it is in alignment with questioning laboratory activities (Schwartz, 2006). Especially when the aim is to supply the acquisition of skills and knowledge which do not directly correspond to learning objectives, greater guidance by teachers should be supplied (Hmelo-Silver, 2006). And this still exists as a problem which needs to be solved and developed whilst the teacher training process.

5 Suggestions

This study reflects the progress in performances by teacher candidates who were restricted in number for participation. It could be enlarged by means of distinct teacher training programs among discrete institutions. Additionally, this study is limited with laboratory activities. Therefore, the findings of this study could be encouraged by means of generalisations which could be employed as a result of studies performed within distinct disciplines and content. The resistance displayed by teacher candidates in terms of the use of questioning skills throughout the cooperating phase and experimental activities which demonstrated a lower progress than the other dimensions of the study could be interrogated. Within the scope of this study, the problems encountered whilst the use of the REACT strategy and their reasons could be investigated by means of qualitative data analysis.

Acknowledgements

Assoc. Prof. Dr. Harun Çelik is the coordinator of the project numbered 2020/21 financed by Kırıkkale University. This project is carried out with the ethics approval of Kırıkkale University Social and Human Sciences Research Ethics Committee, Decision Number: 24, dated 28.12.2020. We would like to thank Kırıkkale University for their support of this project work.

References

Avargil, S., Herscovitz, O. and Dori, Y.J. (2012) 'Teaching thinking skills in context-based learning: teachers' challenges and assessment knowledge', *J. Sci. Educ. Technol.*, Vol. 21, pp.207–225 [online] https://doi.org/10.1007/s10956-011-9302-7.

Ayvacı, H.Ş. (2010) 'Views of physics teachers about context based approach', *Dicle University Journal of Ziya Gokalp Education*, Vol. 15, pp.42–51 [online] https://dergipark.org.tr/en/pub/zgefd/issue/47950/606695.

Barak, M. and Shakhman, L. (2008) 'Fostering higher-order thinking in science class: teachers' reflections', *Teachers and Teaching: Theory and Practice*, Vol. 14, No. 3, pp.191–208 [online] https://doi.org/10.1080/13540600802006079.

Bennett, J., Gräsel, C., Parchmann, I. and Waddington, D. (2005) 'Context-based and conventional approaches to teaching chemistry: comparing teachers' views', *International Journal of Science Education*, Vol. 27, No. 13, pp.1521–1547 [online] https://doi.org/10.1080/09500690500153808.

Berns, R.G. and Erickson, P.M. (2001) 'Contextual teaching and learning: preparing students for the new economy', *The Highlight Zone Research Work*, Vol. 5, pp.1–8 [online] https://files.eric.ed.gov/fulltext/ED452376.pdf.

Broman, K., Bernholt, S. and Parchmann, I. (2018) 'Using model-based scaffolds to support students solving context-based chemistry problems', *International Journal of Science Education*, Vol. 40, No. 10, pp.1176–1197 [online] https://doi.org/10.1080/09500693.2018.1470350

Buntine, M.A., Burke da Silva, K., Kable, S.H., Lim, K.F., Pyke, S.M., Read, J.R., Sharma, M.D. and Yeung, A. (2020) 'Perceptions and misconceptions about the undergraduate laboratory from chemistry, physics and biology academics', *International Journal of Innovation in Science and Mathematics Education*, Vol. 28, No. 4, pp.1–15.

Cairns, D. and Areepattamannil, S. (2019) 'Exploring the relations of inquiry-based teaching to science achievement and dispositions in 54 countries', *Reserach Science Education*, Vol. 49, pp.1–23 [online] https://doi.org/10.1007/s11165-017-9639-x.

Çelik, H. and Avcı, Ö. (2018) 'The competence of pre-service science teachers' ability to use inquiry skills in experimental activities', *Fen Bilimleri Öğretimi Dergisi*, Vol. 6, No. 1, pp.37–59.

Çelik, H., Pektaş, H.M. and Karamustafaoğlu, O. (2018) 'Science teaching laboratory applications: common knowledge construction, learning cycle models and STEM approach', *International Journal on New Trends in Education and Their Implications*, Vol. 9, No. 3, pp.11–29.

Çelik, H., Sarı, U. and Harwanto, U.N. (2015) 'Developing and evaluating physics teaching material with Algodoo (Phun) in virtual environment: Archimedes' principle', *International Journal of Innovation in Science and Mathematics Education*, Vol. 23, No. 4, pp.40–50.

Coştu, S. (2009) *Teacher Experiences from a Learning Environment based on Contextual Teaching and Learning in Mathematics Teaching*, unpublished master thesis, Karadeniz Technical University, Trabzon.

Crawford, M.L. (2001) *Teaching Contextually: Research, Rationale, and Techniques for Improving Student Motivation and Achievement in Mathematics and Science*, CCI Publishing, Waco, Texas.

Demircioğlu, H., Dinç, M. and Çalık, M. (2013) 'The effect of storylines embedded within context-based learning approach on Grade 6 students' understanding of 'physical and chemical change' concepts', *Journal of Baltic Science Education*, Vol. 12, No. 5, pp.682–691.

Dökme, İ., Doğan, A. and Yılmaz, M. (2010) *Fen Öğretimi Laboratuvar Uygulamaları I-II (Science Teaching Laboratory Practices I-II)*, Vol. 2, Pegem Akademi, Baskı, Ankara.

Dori, Y.J. and Herscovitz, O. (2005) 'Case-based long-term professional development of science teachers', *International Journal of Science Education*, Vol. 27, No. 12, pp.1413–1446 [online] https://doi.org/10.1080/09500690500102946.

Dori, Y.J. and Sasson, I. (2008) 'Chemical understanding and graphing skills in an honors case-based computerized chemistry laboratory environment: the value of bidirectional visual and textual representations', *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, Vol. 45, No. 2, pp.219–250 [online] https://doi.org/10.1002/tea.20197.

Downing, J.E. and Filer, J.D. (1999) 'Science process skills and attitudes of preservice elementary teachers', *Journal of Elementary Science Education*, Vol. 11, No. 2, pp.57–64.

Fensham, P.J. (2009) 'Real world contexts in PISA science: Implications for context-based science education', *Journal of Research in Science Teaching*, Vol. 46, No. 8, pp.884–896 [online] https://doi.org/10.1002/tea.20334.

Gezer, S.U. and Şahin, F. (2017) 'Fen bilimleri öğretiminde yansıtıcı sorgulama (Reflective inquiry in science education)', in Akçay, B. (Ed.): *Fen Bilimleri Eğitimi Alanındaki Öğretme ve Öğrenme Yaklaşımları (Teaching and Learning Approaches in the Field of Science Education)*, ss.41–54, Pegem Akademi, Ankara.

Gilbert, J.K. (2006) 'On the nature of "context" in chemical education', *International Journal of Science Education*, Vol. 28, No. 9, pp.957–976 [online] https://doi.org/10.1080/09500690600702470.

Gilbert, J.K., Bulte, A.M.W. and Pilot, A. (2011) 'Concept development and transfer in context-based science education', *International Journal of Science Education*, Vol. 33, No. 6, pp.817–837 [online] https://doi.org/10.1080/09500693.2010.493185.

Given, L.M. (2008) *The SAGE Encyclopedia of Qualitative Research Methods*, Vols. 1-0, SAGE Publications, Inc., Thousand Oaks, CA, DOI: 10.4135/9781412963909.

Hmelo-Silver, C.E. (2006) 'Design principles for scaffolding technology-based inquiry', in O'Donnell, A.M., Hmelo-Silver, C.E. and Erkens, G. (Eds.): *Collaborative Learning, Reasoning, and Technology*, ss.147–170, Roudledge, NY.

Jelatu, S., Sariyasa and Ardana, I.M. (2018) 'Effect of GeoGebra-aided REACT strategy on understanding of geometry concepts', *International Journal of Instruction*, Vol. 11, No. 4, pp.325–336.

Joyce, B. and Showers, B. (1995) *Student Achievement through Staff Development*, Longman, White Plains, NY.

Karamustafaoğlu, O. and Tutar, M. (2018) 'REACT stratejisine dayalı bağlam temelli fen öğretimi (Context-based science teaching based on REACT strategy)', in Karamustafaoğlu, O., Tezel, Ö. and Sarı, U. (Eds.), *Güncel yaklaşım ve yöntemlerle etkinlik destekli fen öğretimi (Activity Supported Science Teaching with Current Approaches and Methods)*, ss.198–217, Pegem Akademi, Ankara.

Karsli, F. and Yigit, M. (2017) 'Effectiveness of the REACT strategy on 12th grade students' understanding of the alkenes concept', *Research in Science & Technological Education*, Vol. 35, No. 3, pp.274–291, DOI: 10.1080/02635143.2017.1295369.

Keeves, J.P. (1987) 'Longitudinal research methods', in *Economics of Education*, pp.369–382, Pergamon [online] https://doi.org/10.1016/C2013-0-03790-5.

Lancaster, J. and Bain, A. (2019) 'Designing university courses to improve pre-service teachers' pedagogical content knowledge of evidence-based inclusive practice', *Australian Journal of Teacher Education*, Vol. 44, No. 2 [online] http://dx.doi.org/10.14221/ajte.2018v44n2.4.

Landis, J.R. and Koch, G.G. (1977) 'The measurement of observer agreement for categorical data', *Biometrics*, Vol. 33, No. 1, pp.159–174.

Lyons, N. (2010) 'Reflective inquiry: foundational issues – "a deepening of conscious life"', in *Handbook of Reflection and Reflective Inquiry*, pp.25–44, Springer, USA.

Merriam, S.B. (2009) *Qualitative Research: A Guide to Design and Implementation*, John Wiley & Sons, San Francisco, CA.

Moskal, B.M. and Leydens, J.A. (2000) 'Scoring rubric development: validity and reliability', *Practical Assessment, Research & Evaluation*, Vol. 7, No. 10, pp.71–81 [online] https://doi.org/10.7275/q7rm-gg74.

Navarra, A. (2006) *Achieving Pedagogical Equity in the Classroom*, CORD Publishing, Waco, Texas, USA.

Osborne, J.F., Erduran, S. and Simon, S. (2004) 'Enhancing the quality of argument in school science', Journal of Research in Science Teaching, Vol. 41, No. 10, pp.994–1020 [online] https://pdfs.semanticscholar.org/634b/871cad6c5c8efc4c1f0df7ee0e02efdaf976.pdf.

Özmen, H. and Karamustafaoğlu, O. (Eds.) (2019) *Eğitimde Araştırma Yöntemleri (Research Methods in Education)*, Pegem Akademi, Ankara.

Ramsden, J. (1997) 'How does a context-based approach influence understanding of key chemical ideas at 16+?', *International Journal of Science Education*, Vol. 19, No. 6, pp.697–710 [online] https://doi.org/10.1080/0950069970190606.

Saka, A.Z. (2011) 'Investigation of student-centered teaching applications of physics student teachers', *Eurasian Journal of Physics and Chemistry Education*, January, pp.51–58, special issue [online] http://www.ijpce.org/index.php/IJPCE/article/view/122.

Sari, D.P. (2020) 'Implementation of REACT strategy to develop mathematical representation, reasoning, and disposition ability', *Journal on Mathematics Education*, Vol. 11, No. 1, pp.145–156 [online] https://files.eric.ed.gov/fulltext/EJ1241448.pdf.

Schwartz, A.T. (2006) 'Contextualized chemistry education: the American experience', *International Journal of Science Education*, Vol. 28, No. 9, pp.977–998 [online] https://doi.org/10.1080/09500690600702488.

Şencan, H. (2005) *Sosyal ve Davranışsal Ölçümlerde Güvenirlik ve Geçerlilik (Reliability and Validity in Social and Behavioral Measurements)*, Vol. 28, pp.977–998, 1. Baskı, Seçkin Yayınları, Ankara.

Tekbıyık, A. and Akdeniz, A.R. (2010) 'An investigation on the comparison of context based and traditional physics problems', *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education*, Vol. 4, No. 1, pp.123–140 [online] https://dergipark.org.tr/en/pub/balikesirnef/issue/3370/46522.

Tuncel, G. (2011) 'The effectiveness using of rubrics in social studies lessons', *Marmara Coğrafya Dergisi*, Vol. 23, pp.213–233 [online] http://hdl.handle.net/11424/2615.

Türkmen, H. and Kandemir, E. (2018) 'Öğretmenlerin Bilimsel Süreç Becerileri Öğrenme Alanı Algıları Üzerine Bir Durum Çalışması (A case study on teachers' perceptions of scientific process skills learning area', *Journal Of European Education*, Vol. 1, No. 1, pp.15–24 [online] http://eu-journal.org/index.php/JEE/article/view/171.

Ültay, E. and Alev, N. (2017) 'Teacher candidates' opinions about the explanation assisted REACT strategy', *Mersin University Journal of the Faculty of Education*, Vol. 13, No. 2, pp.803–820 [online] http://dx.doi.org/10.17860/mersinefd.336879.

Ültay, E. and Ültay, N. (2014) 'Context-based physics studies: a thematic review of the literature', *Hacettepe University Journal of Education*, Vol. 29, No. 3, pp.197–219 [online] http://www.efdergi.hacettepe.edu.tr/yonetim/icerik/makaleler/74-published.pdf.

Ültay, N. and Çalık, M. (2011) 'Distinguishing 5E model from REACT strategy: an example of 'acids and bases' topic', *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education*, Vol. 5, No. 2, pp.199–220 [online] https://dergipark.org.tr/en/pub/balikesirnef/issue/3373/46559.

Ültay, N. and Çalık, M. (2012) 'A thematic review of studies into the effectiveness of context-based chemistry curricula', *Journal of Science of Education and Technology*, Vol. 21, No. 6, pp.686–701, DOI: 10.1007/s10956-011-9357-5.

Ültay, N., Durukan, Ü.G. and Ültay, E. (2015) 'Evaluation of the effectiveness of conceptual change texts in the REACT strategy', *Chemistry Education Research and Practice*, Vol. 16, No. 1, pp.22–38, DOI: 10.1039/C4RP00182F.

van Uum, M.S.J., Verhoeff, R.P. and Peeters, M. (2016) 'Inquiry-based science education: towards a pedagogical framework for primary school teachers', *International Journal of Science Education*, Vol. 38, No. 3, pp.450–469 [online] https://doi.org/10.1080/09500693.2016.1147660.

Whitelegg, E. and Parry, M. (1999) 'Real-life contexts for learning physics: meanings, issues and practice', *Physics Education*, Vol. 34, No. 2, pp.68–72 [online] https://doi.org/10.1080/09500693.2016.1147660.

Yeung, A., Cornish, S., Kable, S. and Sharma, M.D. (2019) 'What can instructors focus on when improving undergraduate science experiments? Supporting a cross-disciplinary approach', *International Journal of Innovation in Science and Mathematics Education*, Vol. 27, No. 3, pp.25–40.

Yu, K., Fan, S. and Lin, K. (2015) 'Enhancing students' problem-solving skills through context-based learning', *International Journal of Science and Mathematics Education*, Vol. 13, pp.1377–1401 [online] https://doi.org/10.1007/s10763-014-9567-4.

Yurdabakan, İ. (2011) 'The view of constructivist theory on assessment: alternative assessment methods in education', *Journal of Faculty of Educational Sciences*, Vol. 44, No. 1, pp.51–77, Ankara University [online] https://www.acarindex.com/dosyalar/makale/acarindex-1423869893.pdf.

Appendix

Table A1 REACT strategy evaluation rubric

REACT strategy steps		*Performance dimensions*	*Deficient (0)*	*Below basic (1)*	*Basic (2)*	*Proficient (3)*
Relating	1	The convenience of the concerns within the activity to acquisition				
	2	The encouragement learners get from the contents so as to relate concerns to real life				
	3	The introduction of notions by relating them to real life				
	4	The introduction of the contents in a way that it could direct learners to the upcoming notions to learn				
	5	Asking questions about the contents which could form a problem-solving task				
	6	Testing learners' state of readiness				
Experiencing	7	Providing instructions which could encourage learners to gain experience about the sub-notions for the applying phase				
	8	Problem generation for experimental activities in the form of a preparation for the applying phase				
	9	The identification of the hypothesis and variables prior to the activity to experience				

Table A1 REACT strategy evaluation rubric (continued)

REACT strategy steps		*Performance dimensions*	*Deficient (0)*	*Below basic (1)*	*Basic (2)*	*Proficient (3)*
Experiencing	10	The envisioning of the experimental activities for learners to absorb the sub-notions				
	11	The relating of activity outcomes and inferences to the applying phase.				
Applying	12	Providing instructions or explanations in terms of the relating of the experience gained within the sub-notions to the applying phase				
	13	The envisioning of experimental or observatory applicable activities corresponding to the problem statement				
	14	The identification of the hypothesis and variables with regards to the activity to be organised				
	15	The specification of the activity outcomes and inferences				
Cooperating	16	The generation of arguments concerning the group discussion context where learners could utilise the knowledge, they have acquired				
	17	The employment of a learning activity related to a problem on which learners could make discussion within group tasks				
	18	Performing the evaluation in terms of cooperating learning activities				
Transferring	19	Asking questions which could supply the opportunity to relate the acquired knowledge to real life				
	20	The organisation of the questions related to the previous notions by the learners				
	21	Asking convenient questions which could evaluate the acquisition concerning the teaching program				