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Teaching Internet of Things on 3D Virtual Environment - Platform VRIOT

Ali GERIS
Manisa Celal Bayar University

Nesrin OZDENER
Marmara University

Osman Gazi YILDIRIM
National Defence University

Abstract: In recent years, a considerable amount of research has been conducted on the theme of Internet of Things (IoT). Evidence suggests that IoT is among the most important factors in smart technologies and near future. However, understanding IoT concepts is technically not easy. This paper reports on a study in which a three-dimensional (3D) virtual environment was designed and utilized for teaching IoT (http://www.virtualiot.net/). The main purpose of this research is to investigate the change in students' knowledge about IoT after using the VRIOT platform. To reach its goals, this study was designed as action research and participants comprised twenty-four university students studying in the Department of Information and Communication Technology at a public university in Turkey. A questionnaire consisting of open-ended questions was developed and used as data collection tool. The first step in this study was to determine students' knowledge level of IoT with the questionnaire. Then, students took a course related to IoT concepts on VRIOT platform. The platform was designed using Unity Technologies as a 3D virtual environment for teaching IoT as part of an Erasmus+ KA2 project. After completion of the course, post-test was administrated. The results of the study showed that although the majority of the participants stated that they heard the concept before using the VRIOT platform, they had misconceptions about IoT. Correlatively, the students also had problems in giving correct examples about IoT. On the other hand, almost all students were able to give correct definitions and examples about IoT after the training on VRIOT platform. Taken together, these results provided important insights into students' perception of IoT. Further research needs to examine different methods and tools to teach IoT concepts more effectively.

Keywords: Internet of Things, virtual environments, teaching IoT, ideography, VRIOT.

Introduction

Considering the Internet of Things (IoT) in its most general sense, it defines a phenomenon in which all existing objects can be managed over a network, any desired data can be collected, objects can interact with each other or with users regardless of whether it is industrial or in daily use (Jankowski, Covello, Bellini, Ritchie, & Costa, 2014). Although different names such as Internet of Everything, Network of Things, Machine to Machine have been used for this connection situation between machines, the title Internet of Things, which was first used by Kevin Ashton in 1999, is the most widely used definition (Gözüaçık, 2015). While IoT was considered as one of the promising and most invested technologies in 2015 (Akkuş, 2016), Gartner (2017) stated that 8.4 billion objects could be connected to the internet in the next two years. By 2020, it is estimated that the number of objects that can is connected to the internet will be 20.5 billion (Kassab, DeFranco, & Laplante, 2020).

The number of objects that can interact with each other and with people increases day by day and while it is a part of daily life, it did not take long for educators to show interest in this field. With the introduction of the education world to the IoT, there has been a great increase in the use of development cards and sensors for

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teaching purposes. As a result of many studies in the field of IoT, it has been stated that IoT education can contribute to students in different aspacts. Contributions in the literature can be summarized as follows:

a. Improved creative thinking skills have been observed in students (Osipov & Riliskis, 2013),
b. Students' skills of learning by doing and experiencing have increased (Yaren, Süel, Yeniaydın, Sakacı, & Kizir, 2014),
c. IoT education has enabled positive results in project-based and problem-solving activities (Charlton & Avramides, 2016),
d. IoT education has enabled collaborative and interdisciplinary work (Zhong & Liang, 2016),
e. It has been made possible to enrich the education life with the applications developed(Uskov et al., 2016),
f. IoT has the potential to contribute to open and distance education (Altınpulluk, 2018).
g. IoT education increases motivation of students and teachers (Callaghan, 2012).

As the studies in the literature show, the issue of the IoT can have positive effects on both learners and teachers. When we analyze the researches in general, it can be seen that almost all of the studies are carried out face-to-face due to the nature of the IoT subject, and the process of teaching the subject through distance education is not focused enough. In a limited number of studies, it has been determined that the internet technologies of objects used in distance education processes affect the academic performance of students (Yang & Yu, 2016). In addition, Bao (2016), who brought a new approach to evaluation processes in distance education, took an important step towards using IoT technologies in this field. Despite the aforementioned researches, Fırat (2016) showed the IoT as one of the subjects that must be researched in distance education. On the other hand, using the great potential of IoT technologies can only be possible with well-equipped and knowledgeable teachers. Because the proficiency of teachers on the internet of objects that increase their influence day by day will play a key role in informing and guiding the learners on this issue. At this point, the perceptions of pre-service teachers, who will be new generation trainers, about the concept of the IoT emerges as an important issue that needs to be investigated. It should be noted that the concept of the IoT is an interdisciplinary subject that brings together complex systems such as electronics, hardware and programming. It will be possible for teacher candidates to comprehend the IoT by bringing different disciplines together. However, IoT technology should be one of the most important issues to be covered in distance education processes, which is an indispensable part of society. Students will be able to increase their knowledge of the concept by experiencing the IoT education that they could not catch in face-to-face environment in virtual environments. Based on these points, the main purpose of this study is to determine what pre-service teachers know about the concept of the IoT and to examine the effect of education given in a three-dimensional virtual environment on pre-service teachers' conceptual understanding of the internet of things.

Method

Research Model

This research was planned as an action research and the participants were considered as a single group. The study was carried out within the scope of the Information Learning and Teaching Approaches course taught in the Faculty of Education in the spring semester of the 2019-2020 academic year. The students were introduced to the VRIOT Platform developed and after they were registered, they were asked to complete the IoT education on this platform as part of the course. After all the participants completed the training the "Conceptual Understanding Test" used as a pre-test was presented to the students again. The obtained data was qualified as post-test. The post-test was administered after a period of approximately thirty days after the pre-test.

Research Group

The participants comprise 24 university students in a state university in Turkey studying at the Department of Computer Education and Instructional Technology Department.

Data Collection Tools

Platform VRIOT

The Platform VRIOT used in the research was developed within the scope of the Erasmus + KA203 project conducted between 2017 and 2019 under the coordination of Marmara University. The Platform VRIOT was developed by a team including the authors of the study and created as a three-dimensional learning environment using Unity 3D (Figure 1a). The system has been developed to support four different languages. The platform contains comprehensive information on IoT education and a content of nine projects in total. The projects included in the content were created, recorded and integrated into the system by the research team. At the same time, there is a three-dimensional object collection laboratory on the system to control the information that users have learned in the training content (Figure 1b). The platform has a chat screen and a question - answer section that also supports student - teacher interaction (Figure 1c). In addition, an administrator panel for teachers was created as web-based, allowing the follow-up of learners' processes (Figure 1d). Participants' follow-up and completion status of the training was examined through the admin panel developed for teachers on the VRIOT Platform and used in data analysis.

Figure 1a

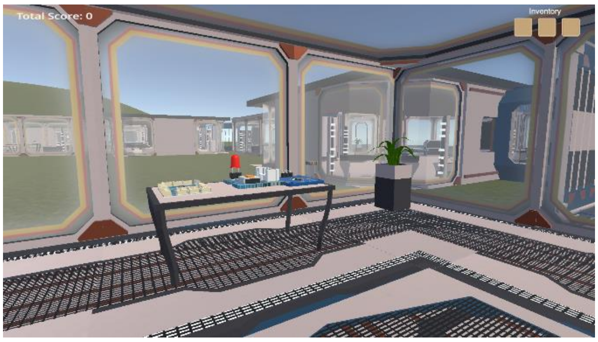

Figure 1b

Figure 1c

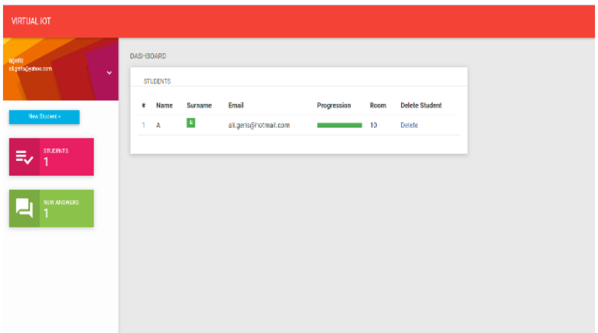

Figure 1d

Figure 1. Platform VRIOT screenshots

Conceptual Understanding Test

The test developed within the scope of the study was created to determine what the participants know about the concept of IoT and how they form the concept in their minds. In order to determine the effect of the training carried out on the VRIOT platform on the participants 'understanding of the IoT and to examine the changes in students' minds, the test was used twice as pre-test and post-test before and after the application. A total of six open-ended questions were included in the Conceptual Understanding Test, and these questions are given below:

1. Have you ever heard of the concept of the Internet of Things (IoT)? If so, where did you hear it first?
2. What comes to mind when you say the IoT? Explain in a sentence.
3. Can you explain what the concept of IoT means by giving an example?

Findings

In order to determine whether students have heard of the concept of IoT before and after the training held on the VRIOT platform, "Have you ever heard of the concept of the Internet of Things (IoT)? If so, where did you hear it first?" question has been posed. Their answers to this question have been analysed and the results are presented in the ideographic in Figure 2.

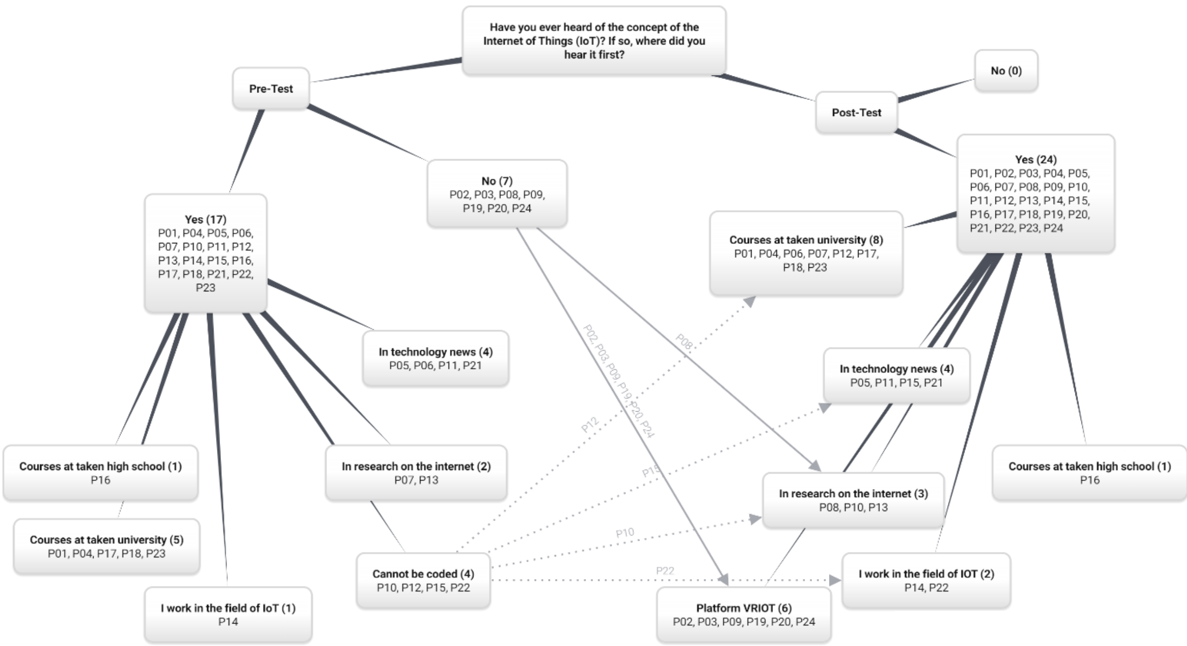

Figure 2. Ideographic analysis of the first question

As seen in Figure 2, the rate of the participants who stated that they heard the IoT concept before the training on the VRIOT platform was 70.8% (17). 7 (29.2%) participants stated that they had not heard the concept before. The sources of the participants, who stated that they have heard the IoT concept before, varied. While 5 participants stated what they heard about the concept in the courses they took at the university, there are also differences in these courses. For example, while the participant with the code P01 used the expressions " *Yes I heard. I heard about it in our current practices in education course last semester*", the participant P17 stated that he heard the concept of the internet of objects in the "*Programming course of 2020*". On the other hand, four participants stated that they heard the concept of the IoT while following technology news. P06, one of these participants, informed that "*Yes, I first heard it on a technology channel I followed".* While two of the participants reported that they saw the concept of IoT while they were doing research on the internet, one participant said that they heard it in a class in high school. On the other hand, the participant coded P14 stated, "*I heard, I have been working with Arduino and Raspberry Pi for 3 years*". Since four participants only answered "*Yes*" to this question, their information on where they heard the concept could not be coded.

All of the participants stated that they heard the concept after the training held on the VRIOT Platform. When the answers of the people who stated that they heard the concept were analysed, the rate of those who stated that they heard in the lesson in the university increased compared to the pre-test stage. However, the situation of first hearing about the concept in the class in high school, encountering the concept in technology news or obtaining information about IoT in the internet environment found its place in the post-test phase. On the other hand, six of the seven participants (P02, P03, P09, P19, P20, P24) who answered "No" to the question "Have you ever heard of the IoT concept" in the pre-test phase stated that they got acquainted with the training made on the VRIOT Platform in the post-test; It was observed that the P08 coded student met the concept during the research on the internet.

In order to determine how students can explain the concept of the IoT before and after the training held on the VRIOT platform, their answers to the question "What comes to mind when you say IoT, explain it with a sentence" were analysed. During this analysis, whether the components of the IoT, the connection of the objects to the internet and the ability to interact with each other or with users, are included in the explanation. The results obtained are presented in the ideographs in Figure 3.

The reason why the responses of the participants are partially coded as correct descriptions is that they leave some of the IoT components missing in their explanations. For example, while explaining the P24 coded internet of objects, he/she used the expressions "*Each object has its own electronic software and objects can control each other*". In this explanation, the participant P24 ignored the situation that objects need to be connected to the internet. For this reason, he/she has made a partially correct definition, but the internet component is missing. Similarly, the participant coded P18 ignored that the objects should be in communication while using the expressions "*Connecting two objects to each other over the same network*". When the answers given by the participants were analysed according to their codes, it was seen that there were also people whose answers were completely wrong. Seven people in the study could not find a correct definition of IoT in the pre-test phase. For example, one of these answers, "*Connecting many tasks to faster and more practical automation*", was used by the participant P14. At this stage, it was observed that a participant could not answer the question at all. When the answers of 17 participants who stated that they heard the IoT concept in the pre-test phase of the first question of the study were examined, it was determined that 6 participants made correct definitions, 9 participants made partially correct definitions, and 2 participants made incorrect definitions. While 1 of the 7 participants who stated that they had not heard of the concept before was partially correct, 1 could not make any definitions, and 5 of them had incorrect definitions.

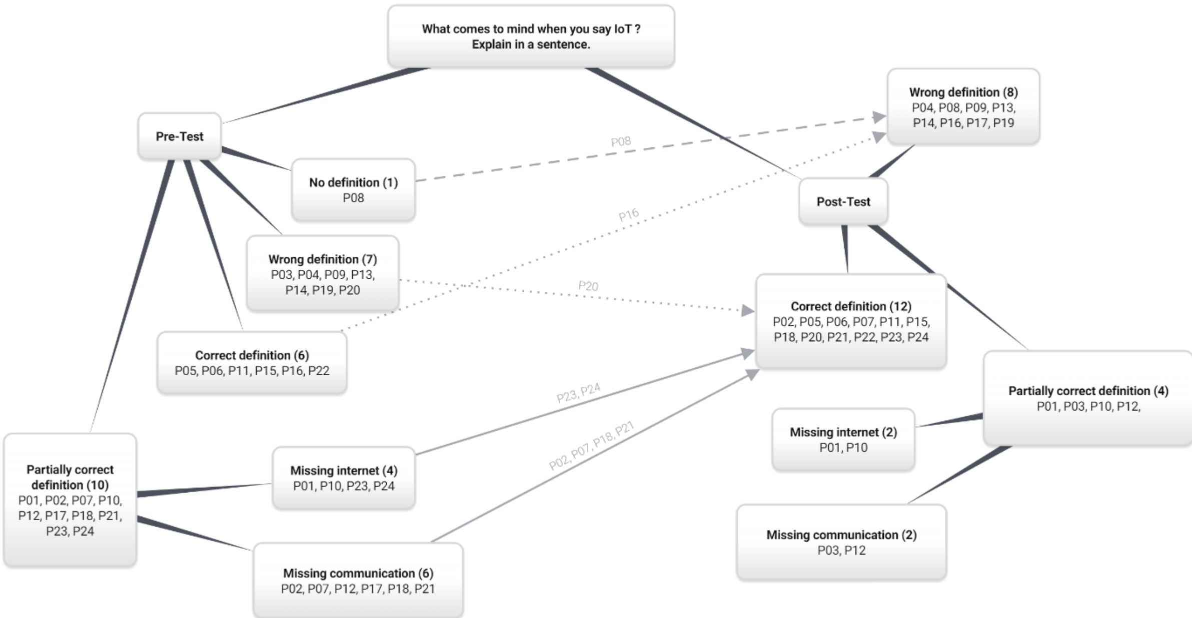

Figure 3. Ideographic analysis of the second question

When Figure 3 is examined, it is seen that the rate of participants who correctly define the concept after the training on the VRIOT Platform increased from 25.0% to 50.0%. However, it was observed that the participant P08, who did not answer the question at the pre-test stage, tried to make a statement about IoT in the post-test stage and his/her explanation was wrong. Another striking situation is the lack of a desired level of positive development in the participants who answered incorrectly. In the post-test phase, 33.3% of the participants made a false statement about IoT. In the post-test phase, it was observed that one of the seven people who gave the wrong answer in the pre-test made the correct definition, and the one who gave the correct definition partially. The definitions made by six people, who made a partially correct definition in the pre-test stage, developed in the post-test stage and made correct explanations. After the training on the VRIOT platform, it was observed that the participants who had deficiencies in the communication component of the IoT concept made a great improvement and made correct definitions. It was observed that the participants who had deficiencies in the internet component of the concept experienced an average improvement. For example, in the "*Interaction of physical objects with the Internet*" statements, which is the answer given by one of these participants, P02 coded pre-service teacher, in the pre-test phase, the communication component between objects is missing. On the other hand, in the post-test phase, he/she made a correct statement with the words "*Electronic devices make our life easier by communicating with each other via the internet*". However, after the training, third of the six participants (P02, P20, P24) who said that they heard the concept of IoT on the VRIOT platform for the first time, made correct definitions, while one (P03) made partially correct definitions, and the participant coded P09 and P19 also made a wrong definition. In order to see what examples students can give about the IoT before and after the training carried out on the VRIOT platform, "Can you explain what the concept of IoT means by giving an example?" The answers they gave to the question were analysed and the results are presented in the ideographs in Figure 4.

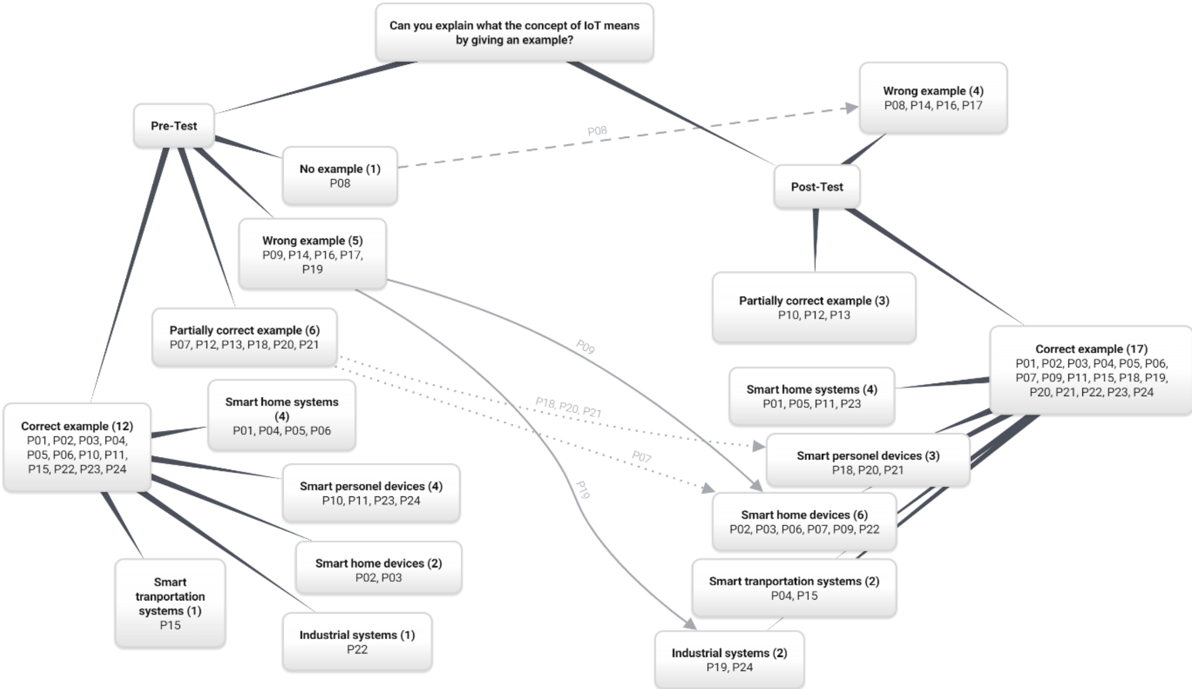

Figure 4. Ideographic analysis of the third question

As can be seen in Figure 4, it was determined that the rate of participants who could give correct examples about IoT before the training on the VRIOT platform was 50.0%. It was seen that the examples mostly given by these participants were on smart home systems and smart personal devices. For example, the participant with the code P05 stated that "*It is possible to adjust the temperature of our house beforehand by means of the phone while away from home with IoT*". The participant P10, who gave an example on personal devices, said, "*The smart toothbrush connects with our phone and reminds us when to brush our teeth*". Four people who gave partially correct examples have component deficiencies in their answers as in the IoT definition. For example, when he/she said P12 "Smart watch" could be an example, he/she did not elaborate in what extent he/she gave this example. On the other hand, the answers of seven participants who made similar statements to the participant number P14, who gave the example of "pulse detector", were coded incorrectly. One of these participants, P16, could correctly explain IoT in the previous question in the pre-test phase, but could not give a correct example on the subject. On the other hand, other participants who could define correctly were able to give correct examples.

When Figure 4 is examined, the ratio of the participants who can give correct examples about IoT after the training on the VRIOT Platform rose to 70.8%. When the given examples were examined, it was seen that examples were given mainly on smart home systems and smart devices in the post-test phase as well as in the pre-test phase. A person who did not give an example during the pre-test phase answered this question in the post-test phase, but the answer given was wrong. The user with the P08 code replied "Internet networks" to the example question about IoT. On the other hand, two people who gave wrong examples in the pre-test phase gave correct examples in the post-test phase. Similarly, the examples given by four people who gave partially correct answers after the training were coded correctly. One of these participants, P21, responded in the pre-test stage as "*Smart watches record the number of steps taken*", while in the post-test stage, "*Smart watches record the number of steps, count the heart rhythm, and give us information by calculating the calories burned*". After the training on the VRIOT platform, it is possible to say that the rate of participants who can give correct examples has increased by almost half and the rate of participants who give wrong answers has decreased.

Conclusion

The main purpose of this study was to determine the current knowledge of pre-service teachers about the concept of the IoT and to examine the effect of IoT education given in a three-dimensional virtual environment on pre-service teachers' conceptual understanding of IoT. Studying is important as prospective teachers will train and guide future generations. The results obtained from the study have been comprehensively discussed through ideographies. With the Conceptual Understanding Test, which was developed within the scope of the study and used in the pre-test post-test phase, the students' knowledge about the IoT concept was examined. The first question of the six-question test focused on whether the participants had heard of the concept of IoT before, and if they heard, its source. It is a very important result that 29.2% of the students have never heard of the IoT concept, although it is one of the most invested technologies before the education given, and it shows that the education curriculum in pre-university education should be updated on this subject. In addition, it was observed that the system, which was developed as a three-dimensional virtual education platform and enables distance education, created an awareness of IoT in participants. After the training held on the platform, all participants stated that they heard the concept of the internet of things, while the VRIOT platform made it possible for many participants to hear the concept for the first time.

Secondly, the participants were asked to define the concept of IoT. Although the number of people who could explain the concept correctly in the pre-test phase was insufficient (25.0%), this situation showed a positive change in the post-test phase (41.7%). Despite this, it is not possible to say that the rate of this change is high. It was determined that the participants ignored some components of IoT in their explanations. It can be thought that this is due to the fact that IoT consists of multiple components. IoT has a structure that requires objects to be connected to the internet and allows them to interact with each other and users. It is one of the striking results of the study that there are deficiencies in these three basic components, especially in the communication between objects and communication with the user. However, after the training on the VRIOT platform, it was observed that the deficiencies in the internet component of the concept were largely eliminated, while the participants increased if they made correct definitions. The content used in the training carried out on the platform enabled the participants to complete the shortcomings they experienced on these issues. On the other hand, in the third question asked related to this question, the participants were asked to give an example about IoT. While many users could not give a correct answer to this question during the pre-test phase, it was determined that they wrote more correct examples after the training on the VRIOT platform. It has been observed that the training carried out on the platform has a positive effect on reaching the right examples for teacher candidates. This situation supports the results of Osipov and Riliskis (2013) which stated that IoT contributes to students' thinking skills. At this point, the striking point was that the answers given by the participants both in the pre-test and post-test stages were mainly focused on smart home systems and smart personal devices. It is thought that smart home technologies and personal smart devices, which are becoming widespread every day, may be one of the main reasons for this situation. Another reason is thought to be that the examples and projects used in the VRIOT platform related to IoT are developed on the smart campus theme.

The most basic result that can be expressed after this study is that pre-service teachers have conceptual deficiencies about IoT. Although it looks like a practical education (Charlton & Avramides, 2016; Uskov et al., 2016), IoT takes place in all areas of life and increases its prevalence day by day (Kassab et al., 2020). At this point, especially the pre-service teachers' level of knowledge about the concept should be increased. The VRIOT platform is an important step towards serving this purpose. It was observed that the education provided through the platform positively affected the pre-service teachers' comprehension of IoT. Another important point is that the platform enables IoT education to be carried out in a three-dimensional virtual environment with the method of distance learning. As a basis for the suggestions of researchers such as Bao (2016), Fırat (2016), and Altınpulluk (2018) in the literature, it was seen in this study that the realization of the internet education of objects by distance learning method can produce positive results. On the other hand, with the results obtained from the study, it was determined in which aspects there were problems in comprehending IoT. It was concluded that the participants had problems because IoT is from different components.

Recommendations

Some suggestions for future research have been made. The first of these suggestions is to take steps towards more comprehensive implementation of IoT subject with the method of distance education. This training was carried out on a conceptual level and supported by the ability to interact with objects. In addition, more contributions can be made to prospective teachers and students on IoT with purely practical and experience-based trainings. On the other hand, it has been observed that the platform developed in this study is effective in introducing the Internet of Things, especially the interaction / communication component to students as a concept. With new activities to be added to the platform or new software to be developed, steps can be taken to bring the concept to students by focusing more on the internet component of the concept. Thus, educational content can be shaped more accurately in terms of facilitating the comprehension of IoT. Finally, in the studies to be carried out on IoT, different perspectives can be given to prospective teachers by conducting research on other areas related to the concept, except smart home systems and smart personal technologies. This situation is an issue that can be a solution to the lack of producing new and original project ideas experienced by teacher candidates.

Acknowledgements or Notes

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Author Information

Ali GERİŞ
Manisa Celal Bayar University
Manisa Celal Bayar University, Manisa, Turkey
Contact e-mail: *ali.geris@cbu.edu.tr*

Nesrin ÖZDENER
Marmara University
Marmara University, İstanbul, Turkey

Osman Gazi YILDIRIM
National Defence University
National Defence University, Balıkesir, Turkey