

Virtual Laboratories in Science Lessons

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Introduction

Science is an important discipline that is intertwined with every aspect of our daily lives. For this reason, the science course, which ensures that the information learned can be applied in real life, is considered very important (Ergün, 2018). This course is considered to be a course in which students often have difficulty due to both the wide range of concepts it contains and the intensity of abstract subjects (Subaşı, 2012).

The information presented in lessons using traditional teaching methods causes students to memorize information (Biçer, 2011). However, using students' mental and physical abilities to perform activities related to the visible and invisible universe encourages permanent and meaningful learning (Çeken & Tezcan, 2006). Therefore, students should be offered effective learning opportunities by going beyond traditional teaching methods.

Laboratories are one of the places where science courses can be taught effectively and students' interest in the course can be attracted (Alkan et al., 1991). Laboratories allow science subjects to be associated with the real world and abstract concepts to be made more understandable (Fidan, 2018). The use of laboratories in science



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lessons not only increases students' interest in the lessons, but also has a positive effect on reducing conceptual misconceptions (Koç-Ünal, 2019). Along with these contributions, problems are sometimes encountered in the use of laboratories. These problems can be listed as missing or insufficient laboratory materials, the number of students in the classrooms being too high, teachers seeing the use of laboratories as unnecessary, and the experiments being only on display (Bilir, 2019).

The rapid advancement of technology has led to major transformations in many fields, including education. In today's "information age", the use of technology has become an inevitable necessity. The science course also has a strong relationship with technology. The Science Curriculum emphasizes the integration of the content taught with technology in order to provide students with perspectives appropriate to the needs of the age (Ministry of National Education [MoNE], 2018). This is because the use of technology in science courses provides students with creative thinking skills and increases time efficiency in the course, enabling faster achievement of course objectives (Koç-Şenol, 2012). This situation reveals the importance of virtual laboratory applications.

For this purpose, this section will provide information about laboratory and virtual laboratory applications within the scope of science course.

Using Laboratory and Technology in Science Lessons

Science is a subject that allows students to discover what happens in nature through experiments and observations. Science topics are often complex and involve abstract concepts. In order for students, especially at the primary school level, to understand these abstract topics, concrete materials should be used (Çepni & Ayvaci, 2016). For this reason, laboratory environments are considered the cornerstone of science education (Hofstein & Lunetta, 2007).

Laboratories are one of the most important learning environments where students can observe events in nature, make sense of the scientific method and develop their field-specific skills (İlhan, 2013). In general, laboratories, which are defined as well-

equipped environments where observations are made while performing experiments, are an important part of science (Anılan, 2016). As a matter of fact, it is known that laboratories, which are the key to scientific progress, provide students with many positive characteristics. Laboratory practices provide students with a unique learning space where they can collaborate and work in small groups to examine scientific hypotheses (Hofstein & Lunetta, 2004). It also stimulates students' curiosity and contributes to the development of problem solving, idea generation and creative thinking skills (Yenice, 2005). In addition, it increases students' reasoning skills and provides them with the opportunity to understand scientific knowledge (Yılmaz, 2017). Laboratory practices during science teaching help students to concretize abstract concepts (Baltürk, 2006). Many studies emphasize that meaningful learning of science courses depends on the presence of a science laboratory (Hofstein & Lunetta, 2004; Hofstein & Mamlok-Naaman, 2007; Tobin, 1990).

Batır (2018) summarized the purposes of using laboratories in science courses as follows: Laboratories aim to better explain the content to students with visual materials to make abstract concepts concrete. At the same time, it increases students' motivation for the science course. By providing students with the experience of learning by doing and experimenting, it contributes to the development of a positive attitude towards nature, living things and the environment. It helps students understand the subjects better by ensuring that the theoretical knowledge is associated with daily life through experiments conducted in the lessons. It also increases students' self-confidence and encourages their interest in science and scientific knowledge by applying the working principles of scientists. Topsakal (2005) stated that the use of laboratories in science courses aims to develop students' mental abilities to gain a scientific approach; to become science literate who can question unknown questions, investigate, observe and interpret the results instead of only answering known questions.

In addition to these benefits of laboratory practices, it is known that some difficulties and problems are encountered while performing laboratory practices. For example, when the class size is high, it may be difficult to perform laboratory applications

effectively. In addition, experiments that should be done individually may be done in groups or as demonstrations or even not done at all. The high cost of laboratory materials may cause inadequate equipment. At the same time, the coexistence of many chemicals may cause safety problems and the lack of laboratories in some schools may constitute obstacles to qualified laboratory practices (Anılan, 2016; Günlü, 2019).

Therefore, the use of technology in science laboratories can help solve these problems by providing students with the opportunity to perform costly, dangerous or highly complex experiments outside the laboratory.

Today, technological developments have led to radical changes in many areas from business to education, from health services to communication. The role of technology, which is an integral part of daily life, especially in the field of education, is becoming more and more important every day. It is inevitable to integrate technology into education in order to carry out a qualified education and training process and to train students competently (Barut, 2015). When the literature is examined, it is seen that the use of technology in education has many benefits. The first of these is that it improves the quality of the learning process. Technology provides students with a more effective and interactive learning experience, allowing them to penetrate knowledge more deeply. In addition, technology saves time for teachers and students. Teachers can convey information to students more quickly and effectively and increase learning time. Another important contribution of technology in education is to maintain the quality of education while reducing costs. It can offer a more economical learning experience than traditional education methods. Finally, technology makes students more active in the learning environment. Interactive educational tools and resources provide students with more participation and contribution to learning (Akkoyunlu, 1998). In parallel with these benefits, İşman (2005) listed the advantages of using technology in education as follows:

- The use of educational technology gives both students and teachers more freedom in terms of time and space. It offers a more flexible learning experience compared to traditional teaching methods.

- In traditional teaching, information usually comes from second- or third-hand sources, whereas with educational technologies, information can be obtained directly from first-hand sources.
- Educational technology has enhanced and enriched education and has the potential to provide equal educational opportunities to people in every corner of the country and even around the world.
- By using educational technologies, teachers can create learning environments that match students' abilities. This supports each student to learn at their own pace.
- Educational technology improves students' productivity and accelerates the pace of learning by developing new learning environments and methods.
- The use of educational technologies offers students and teachers multiple and diverse teaching and learning options.
- Educational technologies offer students the opportunity to maintain continuous learning throughout their lives.

The use of technological tools in science education and their integration into educational processes are of great importance in ensuring effective and continuous learning. With the use of technology in science education, students have easier and faster access to science activities. Technology makes it easier to record findings, consolidate experiences, and transform ideas, observations and concepts into results and process reports more easily. It also contributes to improved teaching and learning communication. Finally, it enables the creation of a broad learning community through the Internet (Bell & Fenton, 2006).

Technology is now widely used in science laboratories as well as traditional classrooms (Chiu et al., 2015). The use of technology in science laboratories provides an important advantage by giving students the opportunity to try costly, dangerous or complex experiments outside the laboratory. The literature shows that the use of technology has positive results in science laboratories (Olympiou et al.,

2013; Trundle & Bell, 2010). Technological materials are widely used in learning environments, especially in science education. These materials include various instructional technologies such as simulations, augmented reality applications, digital storytelling, 3D printing technology, digital games, QR codes, social media-based learning, and mobile applications (Johnson et al., 2015).

Using Virtual Laboratory in Science Course

Virtual Laboratory

With the changes brought about by the 21st century, the concept of “virtual laboratory”, which combines experiments with scientific process skills, has been developed in order to improve students’ scientific thinking skills (Dana et al., 2001; Bruder, 1993; Keller & Keller, 2005). There are many definitions of this concept in the literature. Virtual laboratories are learning tools that allow students to reinforce their theoretical knowledge with hands-on experiments and provide a virtual simulation of physical laboratory experiments (GroB, 2002). These laboratories are a type of technology that simulates a real laboratory using three-dimensional visuals and animations created with computer-based technologies, allowing users to interact with objects in this environment (Tatlı & Ayas, 2011). Prieto-Blázquez et al. (2009) defined virtual laboratories as virtual learning spaces that can be customized in accordance with student and teacher needs and used for conducting experiments.

Two- or three-dimensional technologies are used to create virtual laboratories. With this method, the real laboratory environment can be modeled virtually. In this way, students have the opportunity to perform experiments that can be performed a limited number of times in traditional laboratories. Students gain experience by interactively using virtual equipment using tools such as keyboards or hand controllers. These experiences can be presented through desktop or laptop computers using two-dimensional technologies or through augmented reality glasses using three-dimensional technologies (Cummings & Bailenson, 2016). The virtual laboratory is

modeled with software tools such as Java, Flash, XML and LabVIEW (Chen et al., 2010).

Advantages of Virtual Laboratory Applications

Virtual laboratories are one of the technological innovations that represent a significant shift in education and research in science and other laboratory-based disciplines. They are tools that bring some or all of the traditional physical laboratory experiments to online and simulation-based platforms. This approach has a number of important advantages. First of all, the use of these laboratories is highly economically advantageous. They require a much lower budget than traditional laboratories (Abulrub et al., 2011). In addition, science experiments that students find difficult to observe directly, such as some chemical reactions, radiology, electricity and thermodynamics, can be examined in detail through virtual laboratories (Çavaş et al., 2021).

Virtual laboratories also provide access to students at any time, eliminating space and time constraints (Abulrub et al., 2011). Through simulations, students can investigate science topics in depth and access important information about the results of experiments. These laboratories provide students with the opportunity to change variables in experiments, adjust the speed of the experiment and perform experiments repeatedly. This encourages students to actively participate in the experimental process (Moshell & Hughes, 2002)

Virtual laboratories can also be adapted for students with special needs, which provides equal opportunities (Wang et. al., 2009). In addition, these laboratories provide the opportunity to perform dangerous experiments safely (Abulrub et al., 2011). Finally, students who gain experience in virtual laboratories are better prepared for the problems they may encounter in real laboratories. Therefore, virtual laboratories play an important role in science education (Çavaş et al., 2021).

Disadvantages of Virtual Laboratory Applications

Virtual laboratories offer great opportunities in science and other laboratory-based disciplines, but they also bring some disadvantages. These digital tools, which are used as an alternative to traditional physical laboratory experiments, have some limitations and challenges. Çavaş et al. (2021) expressed these limitations and challenges as follows:

Students may feel that virtual experiments do not have the same impact as real-world experiments. In addition, the use of virtual laboratories can be a challenge for students who do not have internet access, computers or tablet computers. Preparing educational materials and creating simulations of virtual experiments may require time and effort. In addition, inadequate or poor-quality design of virtual laboratories may cause attention deficit in students. Finally, virtual laboratories cannot offer students sensory experiences such as smelling, touching and feeling (Çavaş et al., 2021).

While some studies support the view that virtual laboratories are less costly than traditional physical laboratories, some studies suggest that virtual laboratory setup can be more costly (Şardağ & Tüysüz, 2020). In addition, older teachers with professional seniority may be less enthusiastic about new educational methods. This may cause them to have difficulty in adopting virtual laboratories and show resistance to these practices (Velev & Zlateva, 2017).

Virtual Laboratory Applications Used in Science Teaching

Stellarium: It is a publicly available, education-oriented three-dimensional software. With this software, different features in the sky can be explored in detail and the sky can be observed live.

Accessed from: <https://stellarium.org/>



Figure 1. Stellarium software (URL-1)

Celestia: This laboratory contains many celestial objects such as the solar system, the Milky Way galaxy and thousands of stars. This software allows you to navigate the Solar System at any time and at any speed, giving you the opportunity to observe with spacecraft.

Accessed from: <https://celestia.space/>

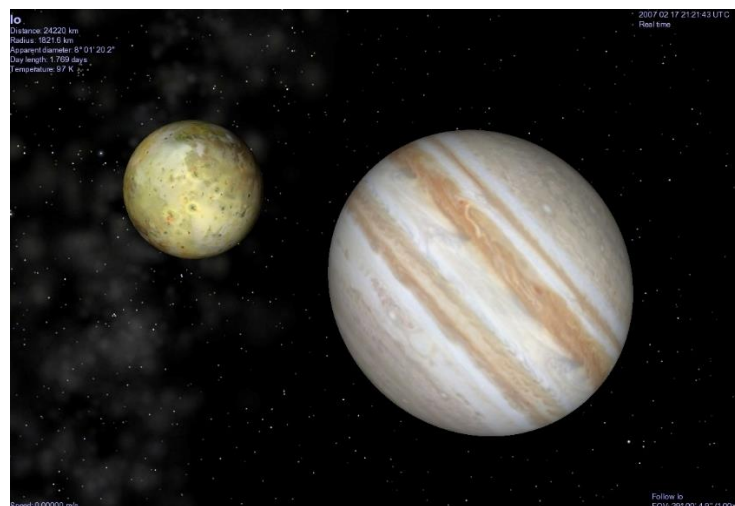


Figure 2. Celestia software (URL-2)

Yenka: With this software, science experiments can be carried out and math-based models can be created.

Accessed from: <https://yenka.com/>

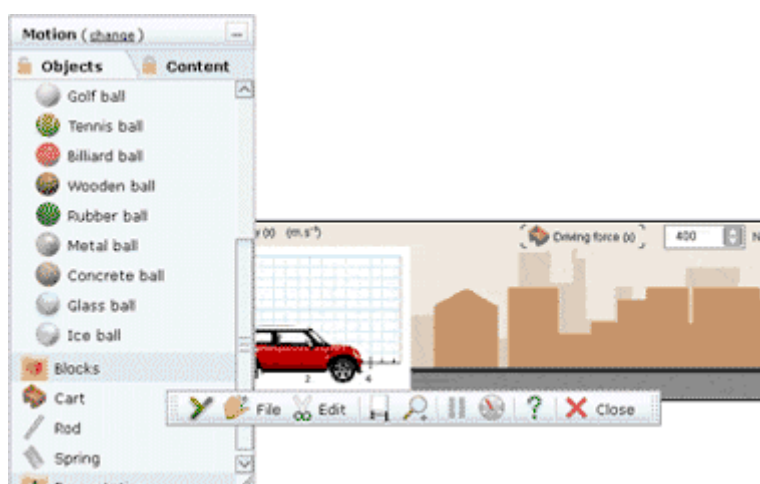


Figure 3. Yenka software (URL-3)

Phet Colarado: This virtual laboratory offers the opportunity to explore science topics interactively.

Accessed from: <https://phet.colorado.edu/>

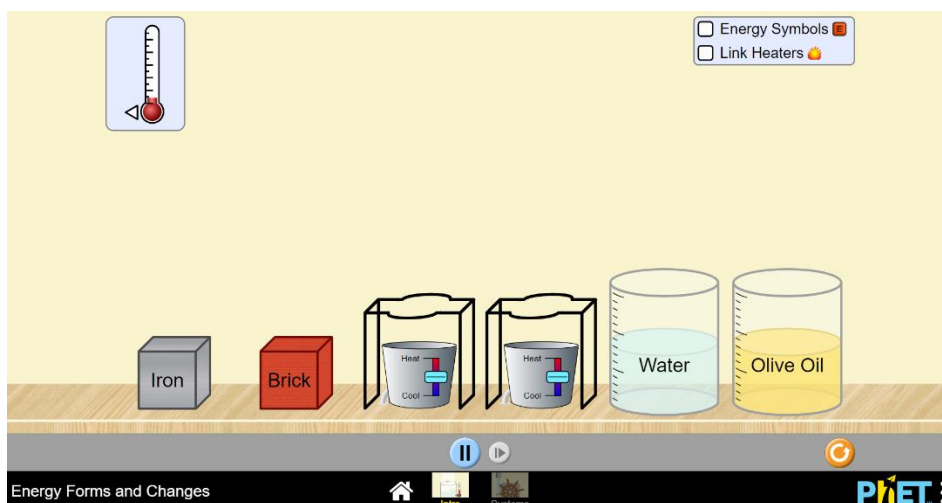


Figure 4. Phet Colarado software (URL-4)

Virtual Labs: This project includes more than 100 virtual laboratories and more than 700 web-based experiments developed for remote operation and viewing.

Accessed from: <https://www.vlab.co.in/>

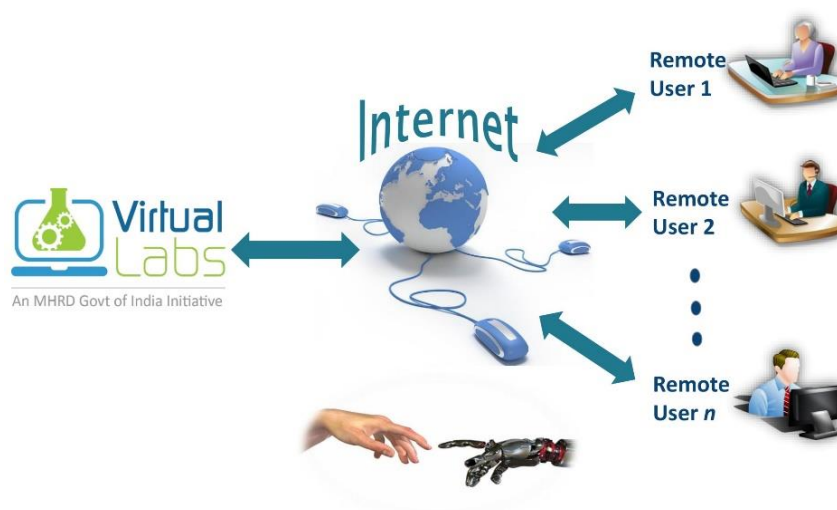


Figure 5. Virtual labs software (URL-5)

PrimalPictures: It is an online lab that presents human anatomy in three dimensions with real body scans and imaging data.

Accessed from: <https://primalpictures.com/>



Figure 6. PrimalPictures software (URL-6)

Go-Lab: This simulator supports the use of learning technologies in online laboratories.

Accessed from: <https://chemcollective.org/>

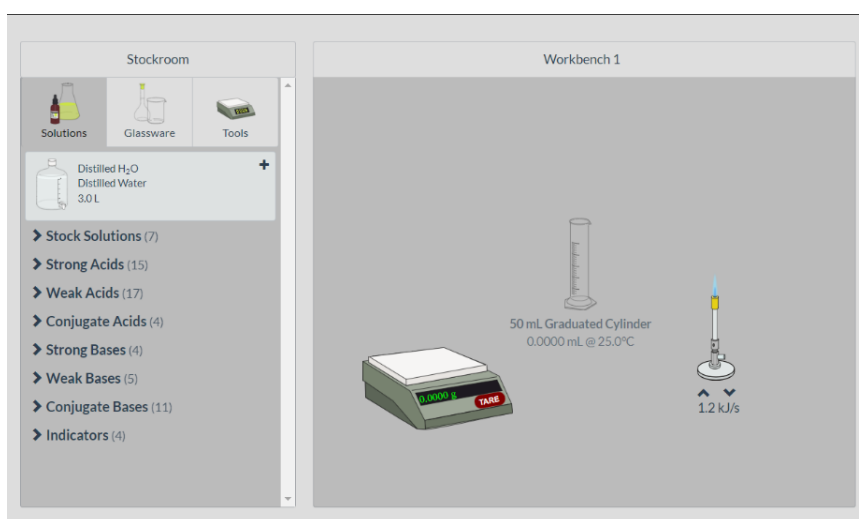


Figure 8. ChemCollective software (URL-8)

Conclusion

Laboratories offer students the opportunity to concretize science, develop scientific skills, test hypotheses, collaborate and think creatively. However, laboratory practices also have some challenges. These challenges include inadequate equipment, high costs and safety issues. Technology can help overcome these challenges in science laboratories. Indeed, technology can make science education more accessible, safe and affordable. Virtual laboratories are one of these technologies. The advantages of virtual laboratories include low cost, accessibility at any time, customization according to student needs, and security. However, there are also some disadvantages. These include; not creating the same effect as real-world experiments, access problems, lack of attention and lack of sensory experience.

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