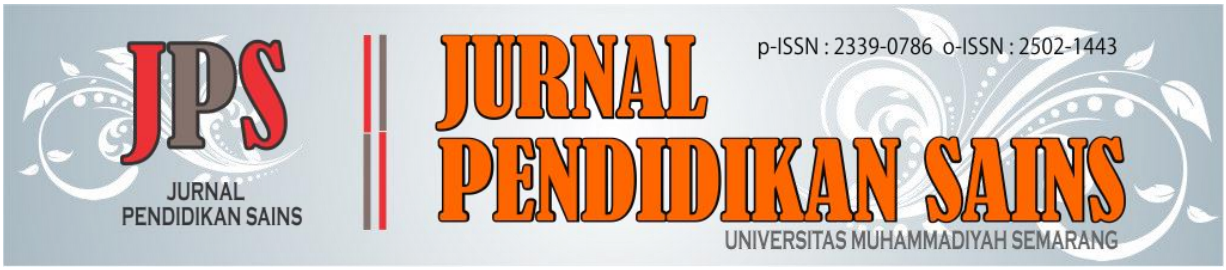
Jurnal Pendidikan Sains Universitas Muhammadiyah Semarang
October Vol. 10(2) pp 72-79 ISSN:2339-0786
DOI: https://doi.org/10.26714/jps.9.1.2021.72-79



The trend of Virtual Laboratory Apps: Ontology, Epistemology, and Axiology Perspectives to Support Contextualized Knowledge to Develop Learning Resource in Chemistry Education

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Article history
Submission : 2022-11-23
Revised : 2023-01-02
Accepted : 2023-01-02

Abstract
There were difficulties with the pandemic-related chemistry practicum learning. Therefore, a study of these issues is required. A virtual laboratory is one existing solution. This research seeks to identify the current Android VL trend. How does Android VL support chemistry education's scientific method? Do pupils now possess any new skills due to utilizing VL Android? This study is a case study. 237 Android Apps were found in the search results and categorized as Apps Virtual Laboratory (VL). The results of the selection produced 118 Apps. The study's findings indicate that chemical reactions are generally the focus of the VL, primarily created by the British state. It would be ideal to combine VL and lab practicum learning, as this would enable students to be better prepared for fieldwork in the real world and boost student self-efficacy and instructor teaching motivation.

Keyword
Virtual Laboratory
Trend
Learning Resource
Chemistry Education

1. INTRODUCTION

The student learning process in chemistry includes practical experience. Both students and instructors can do a practicum in the lab. Students can practice the concepts they learn in class in the lab. The Committee on Professional Training (CPT) of the American Chemical Society (ACS) defines laboratory functions as follows:

> *The American Chemical Society Committee on Professional Training (CPT) explains that laboratory experiences provide "a beautiful opportunity for inquiry-driven and open-ended investigations that promote independent thinking, critical thinking and reasoning, and a perspective of chemistry as a scientific process of discovery* (Bretz, 2019).

This demonstrates the precision with which laboratory procedures are performed as part of instructing students in scientific discovery. A balance between theory and practice in learning chemistry must first exist before the theory can be applied to practical actions in science. The lab can also be utilized as a location for conducting research. Enhancing practical abilities is the most crucial aspect of laboratory use. Consequently, the laboratory is also a practical chemical exercise. The lab is where students learn how to perform chemistry (Reid & Shah, 2007).

In the laboratory, a variety of talents can be cultivated. Skills that students acquire during practical laboratory sessions (1) skills related to learning chemistry, (2) practical skills, (3) scientific skills, and (4)general skills (Reid & Shah, 2007). The laboratory is "the place to learn how to do chemistry." However, physical laboratory sessions are labor and time-intensive for the personnel involved, and the laboratory infrastructure is costly (Jones, 2018). However, lab exercises for practicum in chemistry education are expensive. This agrees with Bretz's viewpoint.

> *Teaching laboratories are labor intensive (prep staff, instructional faculty, graduate teaching assistants) and costly (specialized classroom space, breakable equipment, instrumentation, consumable chemicals that cannot be reused each semester, waste disposal costs, salaries, and tuition of graduate student instructors)*(Bretz, 2019)

The majority of the time is spent on practicum tasks in the lab. As a result, time and equipment are the two things that restrict freedom in practicum. These two issues hamper the provision of a chemical lab at numerous schools. Limited numbers of sufficient learning laboratories are made available due to this circumstance. In the field of education, this is a problem.

Educational facilities are impacted by current technological advancements as well. The process of actual implementation is one of them. We, therefore, require a fix for this scenario. Technology, namely a virtual laboratory, offers one option (VL). One of the digital resources that can be used to deliver laboratory sessions over distance learning is virtual laboratories.

These virtual labs are computer-simulated learning environments ranging from simple 2D visualizations of laboratory experiments to advanced 3D simulations that try to replicate natural laboratory environments (Ali & Ullah, 2020). Traditional laboratories have issues that the virtual laboratory attempts to solve. Therefore both have benefits and drawbacks. The two types of laboratories are contrasted in the following paragraphs (Figure 1).

Classical experimental work	Virtual laboratory
+ training manual skills	+ learning about the scientific approach to work
+ learning about the scientific approach to work	+ the results are always the same
+ following instructions	+ a large range of chemicals and accessories
- preliminary preparation	+ an easy implementation of dangerous, expensive, harmful to health experiments or experiments in specific conditions
- dangerous or harmful to health chemicals	+ inexpensive
- difficult, too long or too expensive experiments	+ visualization features are included
- there are variations	- alienation from nature and from reality
	- it can be only a supplement and not a replacement of practical work

Figure 1. Advantages and disadvantages of classical and virtual laboratory Classical (Dinevski & Herga, 2012)

Currently, VL is undergoing rapid development. Numerous platforms, including websites and Android, have seen the development of VL. One of them uses Android software and is called VL. Since so many different kinds of Android VL have been created, research on this current trend in Android VL is essential. Therefore, this study aims to determine how the current Android VL trend is doing. How does Android VL support chemistry learning's scientific method? After using VL Android, do kids get any new skills?

2. METHOD

By searching for "chemical virtual lab" in the Google Play Store, researchers could find the Apps data they were interested in. Google Play Store shows connections to products for Android: 237 Android Apps were found in the search results, and they were categorized as Apps Virtual Laboratory (VL).
https://play.google.com/store/search?q=chemist%20virtual%20lab&c=apps.

Data

The following information is displayed in the Google Play Store search results for applications: app name, logo shape, language, rating (Scale 5), subscription costs, What is a new, most recent update, current version, developer, file size (MB), a summary of virtual lab contents, and the total number of downloads. Excel spreadsheets are used to record and analyze app data.

Data Analyst

Following data collection, analysis is done. Data analysis was carried out in 3 stages: data reduction, data display, and concluding/verification (Rahmawati, Taylor, Taylor, Ridwan, & Mardiah, 2022). Analisis dilakukan secara kuantitatif dan kualitatif. Tahapan yang dilakukan sebagai berikut:

1. Google Play Store's VL Data Recap
   The collected VL data is then chosen based on the chemical domain. 118 Apps were found in the chosen results. The number of downloads then sorts the data for the 118 Apps. This quantity of downloads reflects the user's enthusiasm for the apps.
2. Application selection that addresses chemical material
   Ten of the best apps were chosen for the discipline of chemistry based on how well the topic fit the app.
3. After that, by utilizing them and studying their material, the 10 Apps are examined for VL content and the benefits of their products.
4. We conclude the trend of VL Apps found in this research case based on the qualitative data analysis.

October Vol. 10(2) pp 72-79 ISSN:2339-0786
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3. RESULTS AND DISCUSSION

The trend of Virtual Laboratory Apps at the Play Store

Table 1.10 lists the outcomes of the top 10 Apps selection. Along with the content displayed in the Application, information about VL Apps is presented in this table.

Table 1 lists the top 10 applications (Chemical field)

No	Name	Language	Rating	Number of Downloads	Material
1.	Virtual Science Lab-Premium	Indonesia	3+	5,000,000	The software simulates chemical reactions and includes a periodic chart and a molar mass calculator.
2.	Periodic Table 2021 - Chemistry	Indonesia	3+	5,000,000	The program shows the whole set of tables for the periodic table that has been accepted by the International Union of Pure and Applied Chemistry (IUPAC)
3.	BEAKER-Mix Chemicals	Inggris	3+	1,000,000	Using up to 150 substances, chemical experiments
4.	Science Lab!	Inggris	3+	1,000,000	Complete experiments and discover new elements in this addictive and super-satisfying science lab simulation.
5.	Complete Chemistry - Periodic Table 2020	Inggris	3+	1,000,000	Applications to practice chemistry problems include periodic tables, chemical calculators, and virtual laboratories.
6.	Chemical Substances: Organic & Inorganic Chemistry	Inggris	3+	1,000,000	The program lists 200 chemical substances (100 simple and 100 complexes), along with their standardized names, structures, and formulas.
7.	Periodic Table 2021. Chemistry in your pocket	Inggris	3+	1,000,000	Mendeleev's periodic table
8.	Chemistry X10 - problems and reactions	Inggris	3+	1,000,000	Chemical Reaction
9.	Periodic Table Quiz	Inggris	3+	1,000,000	The software offers a quick-memorization chemistry quiz that helps users learn the symbols for chemical elements, groups, periods, blocks, and atomic numbers.
10.	Formulia	Inggris	3+	1,000,000	The Application provides math, physics, and chemical content (Tools, Periodic table)

As a result of the analysis, ten Android applications are available for free download for every user. The majority of developers who create Android-compatible apps are from the UK. Applications typically feature Android specs of 4.1 or higher, and their download sizes range from 12-133 MB. 1–5 million users have downloaded the ten programs, according to the analysis findings. More notable is that people have downloaded two programs called "Virtual Science Lab-Premium" up to 5 million times.

Ontology, Epistemology, and Axiology Perspectives to Support Contextualized Knowledge to Develop Learning Resources in Chemistry Education

Due to numerous issues, science will continue to advance. Problems now will only get worse. Different issues will now be processed through philosophical thought. During the Covid-19 epidemic, dealing with a practical issue was one of the difficulties in chemistry education. The pandemic hampers learning activities, so a fix is required. You can apply a philosophical approach to know and comprehend the issue holistically to discover a solution. Ontology, epistemology, and axiology are the three dimensions that must always be present in philosophical operations.

Ontology practical learning will be studied in the initial phases. The nature of learning and practicum is called into question by the ontology dimension, consequently, through understanding how learning and practicum work. You can explore alternatives to distant practical learning when the Covid-19 pandemic strikes. What follows is the implementation procedure and what is required.

Epistemology also asks how to discover the process of doing a practicum remotely in order to prove that the approach is just as successful as doing one in a lab. Of course, an experimental investigation is necessary to find conclusive procedural evidence. However, at the time, references to the findings of studies such as literature reviews and meta-analyses were used to uncover the proof.

Toward the end of the axiological dimension. What good is studying in an online lab? The role of the Virtual Laboratory as a method of remote practicum learning, if circumstances prevent direct practicum learning from taking place, has been highlighted from the beginning. On the other hand, VL is not only an option but also possible to improve the preparation of laboratory activities for chemical practicum. Student self-efficacy, teacher motivation, and students' abilities to recognize different needs in practical situations in the lab are a few factors that might be improved.

Android VL Support for Chemistry Learning of Scientific Processes

Chemical reaction simulations and completeness were two standouts in the VL search results on the Android Application. 40% of apps offer facilities exclusively for chemical chemistry simulations, whereas other applications offer supporting infrastructure. Periodic tables, chemical calculators, chemical substance identities, systematic names, structures, and formulas are supporting tools for simulating chemical reactions. Furthermore, details on organic, inorganic, and organometallic compounds are offered. The availability of a virtual lab as a substitute for assisting students in practicum (Warning & Kobylianskii, 2021). They still need help mastering hands-on laboratory techniques in the virtual practicum (Kelley, 2021; Mistry & Shahid, 2021; Serafin & Chabra, 2020). This is because pupils use different chemical equipment to move the mouse.

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Before comparing them, it is vital first to study the skills that may be mastered in a practicum in the lab and a virtual laboratory. In the laboratory, a variety of talents can be cultivated. Skills that students acquire during practical laboratory sessions (1) skills related to learning chemistry, (2) practical skills, (3) scientific skills, and (4)general skills (Reid & Shah, 2007).

The laboratory is "the place to learn how to do chemistry". Berdasarkan pernyataan tersebut, maka keduanya memiliki peran yang sama dalam membelajarakan bagaimana melakukan praktikum. Studi sebelumnya telah ada beberapa pembelajaran kimia menggunakan virtual laboratory (Hamed & Aljanazrah, 2020; Heras et al., 2021; Thi Vu Hoai & Thao, 2021; Winkelmann, Scott, & Wong, 2014). Namun, secara umum ada perbedaan dalam ketrampilan praktik. Riset sebelumnya juga telah mengkaji terkait virtual laboratory.

The scientists (Chan, Gerven, Dubois, & Bernaerts, 2021) The literature review findings demonstrate that virtual laboratories are superior to passive learning (lectures, books, or videos) and may even be comparable to or superior to hands-on laboratory learning. Additionally, it was discovered that virtual laboratories would benefit from being integrated with in-person laboratory instruction (Aliyu & Talib, 2019; Chan et al., 2021; Dinevski & Herga, 2012; Nais, Sugiyarto & Ikhsan, 2019).

On the other hand, the virtual laboratory's flaw, which is not genuine, may be used to assist students in feeling less anxious during practicums. Students encountered several negative situations, including failure to understand the subject, physical injuries, equipment damage, and expensive material and tool costs. Many students are concerned about this. Therefore this VL can help them become more self-sufficient and prepared for their laboratory practicum (Kolil, Muthupalani, & Achuthan, 2020). Students gain from VL, which also helps teachers feel more motivated to use the instructional materials (Rahmadani, Retno, Ariani, Mulyani, & Yunita, 2020).

Learning about chemistry has benefited through the development of several designed VLs. However, VL faces several learning challenges, including user cognitive load, supervision, and instructions in the user's native tongue. As a result, VL must be developed following the user's language, or even better, if possible, students should be reinforced using VL as the primary language of education.

After utilizing VL Android, did pupils learn any new skills?

Several skills can be mastered in the offline practicum. Skills that students acquire during practical laboratory sessions (1) skills related to learning chemistry, (2) practical skills, (3) scientific skills, and (4)general skills (Reid & Shah, 2007). The ability to use existing tools is one area where the virtual practicum differs significantly from the laboratory practicum. However, VL has several benefits, including enhancing kids' cognitive preparedness and self-efficacy. In addition to offering a different educational option and assisting with creating laboratory learning experiences (Ali & Ullah, 2020).

According to (Ali & Ullah, 2020), the 2D, 3D, and metaphor-based virtual chemistry laboratories are only a few of the several types. A combination of virtual learning and laboratory practice will improve chemistry learning. VL improves learner readiness for practical Application (Ullah, Ali, & Rahman, 2016). The emphasis of this study on Android applications is VL. In general, employing VL Android enables students to prepare for a practicum before engaging in the real-time practice in the lab.

4. CONCLUSION

The study found that the British state focused primarily on chemical interactions when developing the VL. However, the Indonesian government creates the most well-liked software. Additionally, combining VL learning with practical laboratory learning would be preferable because both are equally effective. In addition to offering an alternative to distant practicum learning, virtual learning (VL) can boost student self-efficacy and teacher teaching motivation while also preparing students for practicum in the real world.

ACKNOWLEDGMENT

We appreciate my student Rizki Permata Sari for coming up with the concept for this study. We also thank Ms. Adhel, who assisted in gathering information about VL applications in the App Store. We also thank Prof. Siti Masitoh, my lecturer, whom Dr. Mochamad Nursalim encouraged to write this research.

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