Innovation of Project Based Learning Material and Virtual Laboratory to Improve High Order Thinking Skill (HOTS) in Teaching Electrophoresis at Universitas Negeri Medan

Lanita Bernadetta Munthe[1], Manihar Situmorang[2] , Zainuddin M[3]

{gibrejo@gmail.com, msitumorang@lycos.com, z_muchtar@yahoo.com}

Department of Chemistry Education, Universitas Negeri Medan, Jl. Williem Iskandar Pasar V Medan Estate, Medan, Indonesia, 20221

Abstract. The purpose of this research is to improve students' capacity for high order thinking skills (HOTS) by developing instructional materials for teaching electrophoresis using a virtual project-based laboratory. Purposive sampling is used in the research design, and 20 students are included in the sample for the experiment and control classes. Experts in the field of chemistry and the media completed the validation instrument. The experimental class's average student learning results were 85.8, while the control group's average was 61.7. A sig value of = 0.000<0.05 is shown by the one sample independent t-test, indicating that Ha is accepted and H0 is rejected. As a result, compared to students who do not use virtual lab-based practicums with project-based learning, learning results for those who do.

Keywords: project based learning material, HOTS, virtual lab.

1 Introduction

Every year, education undergoes a fast transformation, particularly in the 4.0 age. The development of technology has the largest influence on schooling in the fourth industrial revolution. Students need to adjust to the demands of the twenty-first century, which include critical thinking, creativity, collaboration, problem solving, and effective public speaking [1,2]. It is necessary to update the innovation learning materials with collaborative learning so that students have access to them. In the realm of education, particularly separation chemistry, the materials, when paired with virtual learning and a project-based approach, are creative approaches to support independent learning and enhance students' knowledge and higher order thinking abilities [3].

ICoSTA 2023, November 02, Medan, Indonesia

DOI 10.4108/eai.2-11-2023.2343253

Students are challenged by the Indonesian National Qualification Framework (KKNI) to develop their higher order thinking abilities and learn how to solve problems [4]. This difficulty has resulted in an upgrade to the teaching and learning model, which has changed learning methodologies. Various approaches have been devised to help students get closer to applying theory to real-world problem solving. Students' ability to solve difficulties in everyday life has improved when project-based learning was implemented [5]. The pupils might search for the answer and write a report on it. The most effective method for assisting students in maximizing their competency objective is through innovative learning materials [5].

One of the most crucial aspects of studying chemistry is experimentation. Due to its greater conceptual foundation, chemistry is widely seen as one of the more difficult topics [6]. Students gain a better understanding of chemistry through this experiment, particularly when it comes to practical applications. The problem at Universitas Negeri Medan (UNIMED) is that certain experiments—specifically those involving electrophoresis—cannot be completed due to a shortage of supplies and equipment [7, 8]. One of the topics covered in the separation chemistry course is this one. For UNIMED second-year students, this course is required. This subject is beneficial and enhances their ability to do studies. Thus, the greatest substitute for conducting experiments is a virtual laboratory; yet, this won't entirely provide students with a concept of conducting experiments, but rather help them on understanding the procedure in electrophoresis topic..

A virtual laboratory program and an effective learning methodology should enable students to overcome any challenges they may have when studying electrophoresis [9, 10]. This learning resource bundle provides a virtual laboratory to help prevent misunderstandings and challenges in comprehending the electrophoresis process. This aids students in pushing themselves to finish study cases based on real-world events, like figuring out who is the cat's father in a paternity case. There are five study cases available in the virtual laboratory, this being one of them. Thus, the purpose of this research is to provide cutting-edge project-based learning materials that are combined with online laboratories to teach electrophoresis and can be used to help students achieve higher learning objectives in separation chemistry.

2 Method

2.1. Population and Sample

Students in their second year at Universitas Negeri Medan's FMIPA Department of Chemistry made up the research population. The samples were separated into an experimental group and a control group using purposive sampling. Different learning treatments are applied for each of the two sample groups in the design investigation. Students in the control group received a textbook and traditional teaching methods, whereas the experimental group received a package of project-based learning materials including a virtual lab.

2.2. Research Procedure

In order to find the initial need analysis and determine the urgency of this research, the study begins with conducting interviews. The development of project-based learning materials using a virtual laboratory to teach electrophoresis was the next step in the research process. Updating the study case into the virtual laboratory and adding the instructions for conducting the experiment completes the construction of educational content. The course curriculum concentrated on DNA gel electrophoresis and its practical applications. The learning material package's content was standardized by analytical chemistry teaching experts. They had access to the rubrics and were free to offer ideas and criticism on how to make the package of instructional materials better. Additionally, a media specialist contributed to standardizing the look, accuracy, and the virtual laboratory's viability. The Network Learning System (SIPDA) provided assignments for students to finish, including writing proposals, applying projects, and turning in project reports. The study design is depicted in Figure 1.

.

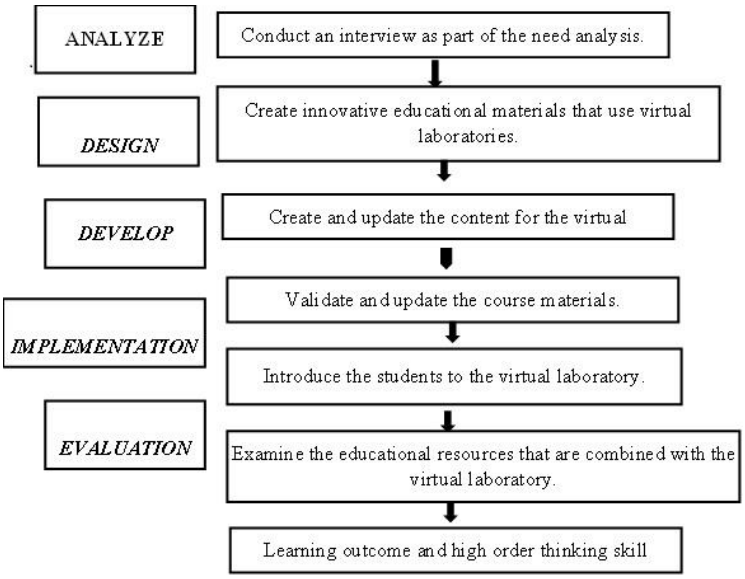

Fig 1. The Research Procedure of Innovation Project-Based Learning Material Integrate with Laboratory Virtual on Teaching Electrophoresis

3 Result and Discussion

3.1. Standarization of Innovative Learning Material Electrophoresis with Virtual Laboratory in Teaching Electrophoresis

The learning resource bundle was standardized through the use of BSNP rubrics. The purpose of this expert standardization survey is to ensure that project-based learning materials are feasible. Based on the findings, a virtual laboratory and learning material package are assessed as very good (average 3.75±0.42), and Table 1 summarizes the standardization results. Every element in the row table for language and chemical symbol accuracy (average = 3.9), content coverage (average = 3.9), and virtual laboratory presentation feasibility (average = 3.6) is in the very good category and valid

Table 1. The Respondend Respond V_1 (Validator 1), V_2 (Validator 2), And V_3 (Validator 3) Toward the Component Learning Material Package With Project- Based Integrate with

Rubrics	Description	V_1	V_2	V_3	Aver	Description
Content	Content coverage, correctness, currentness, and arouse curiosity	3.85	3.9	3,85	3,9	Very Good
Language	Chemical symbol that is accurate, communicative, interactive, clear, and easy to grasp	3.85	3.85	3,85	3.9	Very Good
Presentation	Excellent media and design, with simple media operation	3.6	3.55	3.55	3.6	Good

The outcome showed that using a virtual laboratory and project-based learning package in the teaching and learning process for the Electrophoreis topic is viable.

3.2. The Implementation of Project-Based Learning Material with Virtual Laboratory

A project-based learning approach was implemented in both classrooms, with the control group using a handbook and the experimental group using a learning package with a virtual laboratory. Table 2 displays the learning outcomes data for both classes. The learning package with a virtual laboratory enhances the learning outcome by examining the outcome. The pretest results for the experimental group (M = 67.8) and control group (M = 60.1) were evaluated. The posttest was administered after each class received a distinct therapy. The posttest results for the control group (M = 61.7) and experimental group (M = 85.8). This demonstrates that the learning outcomes were higher when the students combined learning package content with a virtual laboratory. It may be said that the educational materials in the bundle are successful in enhancing the electrophoresis learning results for students. Using the virtual laboratory, five distinct cases were used for study case assignments in the experimental class. For their study case project, students in the control group were assigned similar examples to review critically in journals. The results from the project reports indicated that the experimental class outperformed the control group (M = 80.0) with a better report (M = 95.0). According to these results, students can improve their ability to use higher order thinking skills to solve cases by using the virtual laboratory.

Table 2. The assessment's learning objectives (pre- and post-test) and higher order thinking skills (project/case study)

Evaluation Test	Learning Outcome	
	Control class	Experiment class
Pretest	60.1	67.8
Posttest	61.7	85.8
Project (Makin report)	80.0	95.0

3.3. *Discussion*

One of the better options for offering comprehensive and educational learning materials to improve student learning is the creation of innovative learning materials. It has been demonstrated that innovative learning resources support students in achieving their competencies. To create an outstanding virtual laboratory, learning material development requires careful planning and time. Good project-based learning materials must take into account the needs of the students, their current knowledge, and the curriculum's desired outcome. According to the curriculum, a good learning resource should be efficient, effective, and appealing to students in order to help them improve their knowledge and skills [11]. The study's findings demonstrate that creative project-based learning combined with online laboratories can improve the learning results for kids. Their capacity to solve problems that need higher order thinking skills is further enhanced by the availability of the virtual laboratory (HOTS). This encourages students to study independently whenever and wherever they choose because the learning materials package is compatible with mobile devices.

4 Conclusion

A standard new learning resource for teaching electrophoresis subjects in the separation chemistry course has been developed by advancing and standardizing the learning project-

based material integrated with the virtual laboratory. Among the innovations are: (1). Gel electrophoresis introduction, gel electrophoresis technique, and gel electrophoresis application in daily life. Five distinct case projects have been added to the online lab. Expert responses' standardization efforts have produced a very positive assessment of the package's instructional materials for electrophoresis instruction. Research has demonstrated that utilizing an innovative virtual laboratory that integrates project-based learning is highly successful in enhancing students' learning outcomes and higher order thinking skills related to Electrophoresis themes

References

[1] Southwick, .S., (2007), Theodore E. Woodward Award: Spare Me the Powerpoint and Bring Back the Medical Textbook, Trans And Clin Climatol Assoc 118: 115-527.

[2] Silitonga, L.L., dan Situmorang, M., (2009), Evektivitas Media Audiovisual Terhadap peningkatan Prestasi belajar Siswa pada pengajaran Sistim Koloid, Jurnal Pendidikan Kimia 1(1): 1-9.

[3] Armbruster, P., Patel, M., Johnson, E., dan Weiss, M., (2009), Active Learning and Student-centered Pedagogy Improve Student Attitudes and Performance in Introductory Biology, CBE-Life Sciences Education 8, 203–213.

[4] Hoskins, S.G., Stevens, L.M. dan Nehm, R.H., (2007), Selective Use of the Primary Literature Transforms the Classroom Into a Virtual Laboratory, Genetics 176(3): 1381-1389.

[5] Situmorang, H., dan Situmorang, M., (2009), Keefektifan Media Komputer Dalam Meningkatkan Penguasaan Kimia Siswa Sekolah Menegah Kejuruan Pada Pengajaran Materi dan Perubahannya, Jurnal Pendidikan Matematika dan Sain 3(1): 45-51.

[6] Situmorang, M., Purba, J., dan Tambunan, M., (2000), Efektifitas Media Petakonsep Dalam Pengajaran Kimia Konsep Mol Di SMU, Pelangi Pendidikan 7(1): 31-35.

[7] Jippes, E., van Engelen, J.M. L., Brand, P.L.P., dan Oudkerk, M., (2010), Competency-based (CanMEDS) residency training programme in radiology: systematic design procedure, curriculum and success factors, Eur Radiol 20(4): 967-977.

[8] Situmorang, M., dan Sitorus, C.J., (2011), The Innovation of Demonstration Method to Increase Student’s Achievement in the teaching of solubility Product, Jurnal Penelitian Bidang Pendidikan 18(1): 1-7.

[9] Situmorang, M., (2013), Pengembangan Buku Ajar Kimia SMA Melalui Inovasi Pembelajaran dan Integrasi Pendidikan Karakter Untuk Meningkatkan Hasil Belajar Siswa, Prosiding Seminar dan Rapat Tahunan BKS PTN-B Bidang MIPA di Bandar Lampung, Tgl 10-12 Mei 2013, pp. 237-246.

[10] Situmorang, M., dan Situmorang, A.A., (2014), Efektivitas Modul Pembelajaran Inovatif Untuk Meningkatkan Hasil Belajar Pada Pengajaran Laju Reaksi, Jurnal Penelitian Bidang Pendidikan 20(2): 139-147.

[11] Vasconcellos, M.B.A., dan Saiki, M., (2005), Survey of the teaching and applications in radiochemistry in Latin American countries, Journal of Radioanalytical and Nuclear Chemistry 263(1): 127-129.