PAPER NAME

Application of VIPSTA experiment works heet an attempt to reduce students cogni tive load in learning

AUTHOR

Anna Fitri Hindriyana

WORD COUNT

3964 Words

CHARACTER COUNT

23242 Characters

PAGE COUNT

8 Pages

FILE SIZE

461.5KB

SUBMISSION DATE

Apr 6, 2023 4:13 AM GMT+7

REPORT DATE

Apr 6, 2023 4:14 AM GMT+7

7% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

- 7% Internet database
- 3% Publications database
- Crossref database
- Crossref Posted Content database
- 4% Submitted Works database

Excluded from Similarity Report

- Bibliographic material
- Quoted material
- Cited material
- Small Matches (Less then 8 words)
- Manually excluded sources
- Manually excluded text blocks

Application of VIPSTA experiment worksheet: an attempt to reduce students cognitive load in learning biology

Application of VIPSTA experiment worksheet: an attempt to reduce students cognitive load in learning biology

A F Hindriana*, Handayani, and I Setiawati

[1]Pendidikan Biologi, Universitas Kuningan, Jl. Cut Nyak Dhien No.36A, Kabupaten Kuningan 455313, Indonesia

*anna@uniku.ac.id

Abstract. This research aimed to analyse the decrease in students' cognitive load while performing laboratory activity using "VIPSTA" experiment worksheet. The subjects of the research were 72 students in grade 11. The cognitive load was measured in three aspects; *intrinsic cognitive load* (ICL), e*xtraneous cognitive load* (ECL), and g*ermane cognitive load* (GCL). The data were analysed descriptively to show differences in the component of cognitive loads and tested for multivariate correlation-regression to show relations between the components of cognitive load. ICL and GCL were measured inversely proportional with score of students science process skill, due to well performed science process skill and knowledge construction skill are results from low ICL and GCL respectively. Whereas ECL was measured proportionally with students' metal effort because students bear low mental effort in thinking when the ECL is low. After the implementation of VIPSTA experiment worksheet, students obtained increment for science processing skill and knowledge construction skill and decrease for mental effort which indicated low ICL, GCL, and ECL. Meaning that the use of VIPSTA experiment worksheet enables a decrease in students' cognitive load. Furthermore, the data analysis showed that the decrease of GCL was heavily influenced by the decrease of ICL and ECL indicating that VIPSTA experiment worksheet was able provide meaningful laboratory activity by facilitating knowledge construction through lower load in processing information and performing procedure while conducting experiment.

1. Introduction

Biology Education is one of the ways that enables students to develop their potential following the aim of the national curriculum. However, the practice of biology teaching and learning activities in school are not decent enough to facilitate students in achieving the learning objectives. The emphasis of conceptual understanding in schools does not meet topics related to issue in daily life and lacks of study focusing on the value of learning biology, which should have been explored when learning biology. The condition is originated from incomprehensive and unintegrated biology learning. Numerous science teachers do not realize the importance of developing all three aspects of learning and focus on one aspect only, which is cognitive aspect, hence the learning process is inconsistent with the objective of science learning. The emphasis of learning only on the cognitive aspect instigates students' hardship in developing psychomotor and affective aspects that represent the proficiency of science values. Students are unable to value laboratory experiments because they do not find it meaningful, while teachers find difficulties to put meanings in designing experiments, especially in

developing essential concepts and skill and encouraging students' attitude from the conducted experiment.

Teachers' load in designing experiment following the curriculum demand is fairly high. Some teachers are not able to relate concept and method in designing experiment. The common experiment design with verification or confirmatory approach contradicts science value which states that a science learner cannot only know how to receive knowledge but also know how to attain knowledge. This is in line with study stating that the aim of laboratory experiment in learning science are: (1) giving experiment experience similarly with how scientist using scientific method to gain proofs to support or object a hypothesis (2) Training students to be skilful in experimenting, using laboratory tools, processing data and applying scientific theories [1]. Therefore, the VIPSTA experiment worksheet was developed to help teachers conducting meaningful laboratory activity in order to lower students' cognitive load. VIPSTA Experiment worksheet was named after the four characteristics in the worksheet: Knowledge Valuation, Knowledge Internalization (i.e Internalisasi Pengetahuan in Indonesian), Science process skill, and Transformation and Analysis of data. Furthermore, VIPSTA experiment worksheet emphasizes on coherency in presenting theories for observing objects or phenomena, contextual characteristics due to analysis and discussion of experiment are associated to students' daily problems, and inquiry development due to its encouragement on investigation and discovery by students [2].

Moreover, the study followed a notion that experiment worksheets are able to facilitate meaningful learning only if the worksheet has an ability to help students to explicitly connect the new acquired information with their prior knowledge by connecting concept and action as instrument [3]. This statement is in line with study which stated that experiment worksheet which enables meaningful learning simultaneously improves thinking skill, facilitates students in constructing cognitive scheme, and enables students to gain holistic knowledge through relationship between conceptual material being learned and relevant study [4]. Experiment worksheet must be able to explain primary idea by considering basic knowledge and knowledge constructing process during experiment. The design needs to emphasize relation between conceptual and methodology as well as encourage students to actively include laboratory experiment as one aspect of framework of understanding which is constructed in accordance with the discussed topic, in order for the worksheet to improve skill and direct students to construct their own knowledge. Thus, students do not only learn about procedural aspect but also learn to construct their knowledge.

2. Methods

This study is a qualitative study with DBR method (Design-based Research) aiming to develop an experiment worksheet which effectively lowering student's cognitive load in order to conduct meaningful laboratory experiment. DBR method includes four stages: 1. Problem identification and analysis, 2. Solution design, 3. Repeated cycle in design testing and development, 4. Reflection results in design principles and implementation [5]. The subject of this study were 72 students of eleventh grade of a high school in Kuningan, Indonesia.

Measurement of implementation effect of VIPSTA experiment worksheet on students' cognitive load was conducted through three components namely intrinsic cognitive load (ICL), extraneous cognitive load (ECL), and Germane cognitive load (GCL). Data for ICL was obtained from observation on students processing skill during laboratory activity using assessment rubric, data for ECL was obtained from measuring students' mental effort using affective scaled questionnaire, while GCL was measured from students' knowledge construction skill using a rubric.

ICL and GCL were measured inversely proportional with score of students science process skill, due to well-performed science process skill and knowledge construction skill are results from low ICL and low GCL respectively. Whereas ECL was measured proportionally with students' metal effort due to students bear low mental effort in thinking when the ECL is low.

Result of students cognitive load measurement was then statistically tested using regression test and multi-variance correlation test to obtain contribution and relation among the three components of cognitive load.

3. Result and Discussion

3.1. Measurement of Intrinsic Cognitive Load (ICL)

ICL was measured inversely proportional with score of students' science process skill using a rubric. The four science process skill aspects obtained high score with average score of 3.35 out of maximum score 4 (see Table 1)

Table 1. ICL based on science process skill

Aspects of science process skills	Score
Classification	3.3
Interpretation	3.2
Communication	3.0
Experiment skill	3.9
Average	**3.35**

The result in Table 1 showed that the four aspects of science process skill obtained high score and indicated low ICL, resulted from well-facilitated laboratory experiment with the implementation of VIPSTA experiment worksheet. Furthermore, as shown by the rubric, the classification component scored 3.3, meaning that students had capability to compare and contrast observed object, contrast characteristics, compare and decide basic of classification. Students gained classification skill due to VIPSTA experiment worksheet enabled them recognize qualitative traits from observation during the conduction of experiment. The qualitative traits leaded students to obtain observation pattern and resulted in students' ability in contrasting and comparing observed object.

The observation pattern which directed by VIPSTA experiment worksheet acted as a scaffolding to help students obtaining observation data during experiment. Scaffolding helps improving students cognitive development in a way that the students are able to complete challenging task and activity [6].

Aspect of interpretation skill was defined as high with the score of 3.2 out of 4, meaning that students were able to interpret observation result from every variable of the observed object to decide observation pattern leading to conclusion. The interpretation skill was facilitated by VIPSTA experiment worksheet due to valuation principle and knowledge internalization principle emphasized in the worksheet. The valuation principle helped students obtain comprehensive information and express positive attitude in interpreting experiment result. On the worksheet, valuation principle was expressed in explanation of advantages from learning specific observed object, completed with question in assessment which is being related to daily problem, in order for the students to be able to claim biology value from the experiment. Whereas the internalization principle was associated with reasoning the cause of certain object or phenomena and way to observe it. Students comprehended the experiment through integration of basic theory, basic concept, and principle of the discussed topics and complemented with detailed information of how to do observe the object or phenomena in conducted experiment, hence students gained awareness of process in obtaining knowledge which expressed in their attitude. This attitude is the basic scientific mind which positively correlates with scientific process skill. Furthermore, the scientific process skill affects learning achievement, thinking skill, and positive attitude toward science [7].

Communication skill aspect was defined as high with score of 3.0 out of 4.0, this meant that students were able to describe empirical data from observation using graph and table and explain experiment result due to analysis and data transformation principal in VIPSTA experiment worksheet that leads students in communicating data and fathoming data pattern from experiment result. Data

transformation increases students' skill in relating information and facilitates them to enhance their science process skill especially in communication skill [8]. VIPSTA experiment worksheet encourages students to translate data into other representation type by directing them to provide their data analysis with a graph or a table. Numerous students have insufficient prior experience in integrating science and mathematics, thus relating observation result and interpretation data from a graph became a complexity. According to Kirschner [9], complexity in processing information leads to high ICL due to inter-element interactions, accordingly prior experience is needed in relating elements. However, in this study, students were able to interpreting, relating, and transform data as part of communication skill due coherent basic knowledge, observation instruction, and assessment provided in VIPSTA experiment worksheet.

Conducting experiment aspect was defined as very high with score of 3.9, meaning that students were able to properly and reasonably use laboratory equipment and material, decide experiment variables includes thing to observe, adjust, and write for categorizing and interpreting data. The conducting experiment skill was facilitated by VIPSTA experiment worksheet due to the emphasis on science process skill principle leading students to be able to conduct experiment by observing, thinking critically, and solving problem and providing meaningful experiment. This is in accordance with statement from Marzano [10] that learning process is defined as meaningful if students are able to make decision, conduct investigation, do experiment, and solve problem.

3.2. Measurement of Extraneous Cognitive Load (ECL)

ECL in this study was measured inversely proportional with students' mental effort in conducting experiment using VIPSTA experiment worksheet. The result showed that ECL obtained low score with 1.85 out of 5 (see Table 2).

Table 2. ECL based on students' mental effort in using VIPSTA experiment worksheet

Mental Effort Aspects	Score
Conducting Experiment	1.25
Relating experiment and theory	1.70
Observation	1.80
Claim value	2.0
Implementing science in daily context	2.0
Average	**1.85**

Based on data on Table 2, students mental effort in conducting experiment using VIPSTA experiment worksheet was categorized as low. This means that VIPSTA experiment worksheet helped students in conducting all mentioned ECL aspects as the ECL is proportional with the mental effort. All aspects were defined as low, if not for the aspect of conducting curriculum was defined as very low. This is because VIPSTA experiment worksheet facilitated meaningful experiment by providing coherent information with observation of objects or phenomena through knowledge internalization, has contextual characteristics due to relating experiment result with problem in daily settings, and develops inquiry by investigation and discovery on observed objects or phenomena. Knowledge internalization in VIPSTA experiment worksheet provides interconnected meaningful information that helps students to process data. The provision of data follows information processing theory stating that interconnected information will omit limitation of working memory in processing information [11]. VIPSTA experiment overcomes working memory limitation by increasing interaction among knowledge elements and methodology in order to ease the conduction of experiment. The high interaction of knowledge elements on the worksheet helps students to keep relevant information in long-term memory [12].

Furthermore, contextually conducted experiment emphasizes by valuation principle encourages students' curiosity and desire to broaden their mastered knowledge as well as encourages students to think logically, result in meaningful learning due to the knowledge is implemented for solving problem in daily life. This moment is reflected in students' swiftness in claiming value and

implementing science for solving real life problem. The valuation principle in VIPSTA experiment worksheet develops scientific mind and facilitates the emerging of science values related to moral responsibility, moral values, and science benefit for human life. This study result agrees with previous studies stating that contextual learning has a role in developing understanding, especially on subjects that need analyzation and problem solving [13].

3.3. Measurement of Germane Cognitive Load (GCL)

GCL was depicted by students' score in constructing knowledge. The result showed high score of knowledge construction skill aspects with average of 3.0 out of 4.0 (see Table 3). Data on Table 3 shows that students' knowledge construction skill was categorized as high after the implementation of VIPSTA, meaning that students were able to interpret, analyse, synthesis, or evaluate information and implement their knowledge in new context and bearing low GCL while performing the tasks.

Table 3. Knowledge construction skill

Knowledge Construction Skill Aspects	Score
Knowledge claim	3.1
Value claim	2.7
Knowledge application	3.2
Average	**3.0**

The said result was due to VIPSTA experiment worksheet helped students constructing knowledge through interpreting and analysing data in order to obtain a pattern from observation. Take an example of knowledge claim process during interpretation of catalase enzyme content in several organs from both animal and plants. The result of interpretation yielded a regular uniform pattern leading to conclusion that amylase is contained in the organs that actively do oxidation reaction. The said knowledge claim then was analysed to obtain information on why catalase enzyme is needed by an organ to do oxidation process. By relating theory and basic concept in VIPSTA experiment worksheet, students were able to analyse the relation between metabolism results during oxidation process with the function of enzyme catalase.

Students' competence in implementing knowledge on a novel context is heavily influenced by students' analysis skill. This is because in implementing knowledge on novel context, students need to be able to synthesize or evaluate problems in daily life based on analysis on relation between theory and basic concept. VIPSTA experiment worksheet was able to facilitate students in synthesizing or evaluating due to basic concept from knowledge internalization principle serves as a foundation to implementing knowledge on novel context.

3.4. Correlation among three component of cognitive loads

Correlation analysis was done to obtain relation among components of cognitive. The result of correlational analysis showed significant correlation among the three cognitive load components ($p = 0.00^{*}<0.01$) indicating that ICL and ECL significantly influence GCL (see Table 4).

Table 4. The result of analysis between cognitive load components

Components	Coefficient of Correlation	Note
Intrinsic load on germane load	0,956 r = 0,91	p = 0,00*<0,01
Extraneous load on germane load	-0,899 r = 0,81	p = 0,00*<0,01
Intrinsic load on extraneous load	-0.921 r = 0.85	p = 0.00*<0.01

Germane load was highly influenced by intrinsic load and extraneous load with correlation of r = 0.956 and r = 0.899 respectively. Positive correlation between intrinsic load with germane load showed that the lower students' mental effort in comprehending information, the higher students reasoning skill is. Similarly, the negative relation between intrinsic load and extraneous load showed that the lower students mental effort in comprehending information, the higher students skill in analysing information.

Coefficient of determination (r) between intrinsic load and germane load in experimental class was 0.91. This showed that knowledge construction skill was influenced by science process skill. While coefficient of determination between extraneous load and germane load was 0.81, and depicted that 81% of knowledge construction skill was also influenced by students' mental effort during the implementation of VIPSTA experiment worksheet. Meanwhile, coefficient determination between intrinsic load and extraneous load was 0.85 meant that 85% of science process skill was influenced by students mental effort from the implementation of VIPSTA experiment worksheet.

From the data on Table 4, it can be concluded that intrinsic load and extraneous load affect the increasing students skill in constructing knowledge (germane load), because students cognitive source enabled them to invest their knowledge of inter-correlating information in their cognitive scheme.

Students who scored low on knowledge construction skill, would have high mental effort and low science process skill. On the contrary, students who scored high on knowledge construction skill, would have low mental effort and high science process skill. Data analysis result showed that germane load is originated from students bearing both intrinsic load and/or extraneous load. Germane load contributes in relating new information with information in long-term memory. Thus, the decrease in germane load is caused by the decrease of intrinsic load and extraneous load due to students' knowledge construction skill is facilitated when students acquire an ease in processing information (thinking process) to follow experiment procedures during laboratory activity.

The development of students' cognitive scheme due to the decrease of intrinsic load and extraneous load helps students in integrating new knowledge and restructuring knowledge on their prior knowledge. The discovery of students' cognitive scheme development that showed a decrease in germane load lies on the indicator of applying new acquired knowledge. This indicates that students are able to choose their mastered knowledge to be implemented on new situations. The discovery is in accordance with statement that skill in implementing knowledge on new situation will increase when a cognitive scheme is kept in long-term memory. Students whose cognitive scheme develops well will be able to make use of their knowledge kept long-term memory and quickly provide steps to make a problem solution. [6], [14]

4. Conclusion

Based on study result about implementation of VIPSTA experiment worksheet on experiment in laboratory, it can be concluded that a worksheet with four characteristics, namely developing science values (biology valuation), developing knowledge comprehensively (knowledge internalization), developing science process skill (science process perception), and developing data transformation and data analysis skill (transformation and analysis) could be an alternative way to facilitate meaningful learning with low cognitive load in schools. Effectivity of VIPSTA experiment worksheet in reducing

cognitive load during experiment is shown by better quality of science process skill, lower mental effort in comprehending information, and high ability in knowledge construction.

The correlation test showed significant interrelation among the three components of cognitive load. A positive correlation is shown between intrinsic load and germane load, while extraneous load and germane load showed negative correlation. Meaning that students are facilitated in constructing knowledge when they bear low cognitive load in performing science process skill and information processing skill.

5. References

[1] Safdar M Hussain A Shah I and Rifat Q, 2012 Concept Maps: An Instructional Tool to Facilitate Meaningful Learning. *Eur. J. Educ. Res.* **1**, 1 p. 55–64.
[2] Hindriana A, 2018 Pengembangan Lembar Keja Praktikum Berbasis Diagram Vee untuk Memfasilitasi Kegiatan Laboratorium secara Bermakna.
[3] Darling-Hammond L Flook L Cook-Harvey C Barron B and Osher D, 2020 Implications for educational practice of the science of learning and development *Appl. Dev. Sci.* **24**, 2 p. 97–140.
[4] Hindriana A, 2016 The development of biology practicum learning based on vee diagram for reducing student cognitive load *J. Educ. Teach. Learn.* **1**, 2 p. 61–65.
[5] Amiel T and Reeves T C, 2008 Design-based research and educational technology: Rethinking technology and the research agenda *J. Educ. Technol. Soc.* **11**, 4 p. 29–40.
[6] Ormrod J E, 2013 *Educational psychology: Pearson new international edition: Developing learners* Pearson Higher Ed.
[7] Farsakoğlu Ö F Şahin Ç and Karsli F, 2012 Comparing science process skills of prospective science teachers: A cross-sectional study in *Asia-Pacific Forum on Science Learning and Teaching* **13**, 1 p. 1–21.
[8] Karamustafaoğlu S, 2011 Improving the science process skills ability of science student teachers using I diagrams *Int. J. Phys. Chem. Educ.* **3**, 1 p. 26–38.
[9] Kirschner P A Sweller J Kirschner F and Zambrano J, 2018 From cognitive load theory to collaborative cognitive load theory *Int. J. Comput. Collab. Learn.* **13**, 2 p. 213–233.
[10] Marzano R J, 1992 *A different kind of classroom: Teaching with dimensions of learning.* ERIC.
[11] Jaeger A J Shipley T F and Reynolds S J, 2017 The roles of working memory and cognitive load in geoscience learning *J. Geosci. Educ.* **65**, 4 p. 506–518.
[12] Leppink J, 2017 Cognitive load theory: Practical implications and an important challenge *J. Taibah Univ. Med. Sci.* **12**, 5 p. 385–391.
[13] Nawas A, 2018 Contextual teaching and learning (ctl) approach through react strategies on improving the students' critical thinking in writing *Int. J. Manag. Appl. Sci.* **4**, 7.
[14] Kalyuga S, 2009 Knowledge elaboration: A cognitive load perspective *Learn. Instr.* **19**, 5 p. 402–410.

Acknowledgments
Authors wishing to acknowledge support and assistance from colleagues and administration staff in Universitas Kuningan as well as teachers and students from cooperate school.

7% Overall Similarity

Top sources found in the following databases:

- 7% Internet database
- Crossref database
- 4% Submitted Works database
- 3% Publications database
- Crossref Posted Content database

TOP SOURCES

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	scilit.net Internet	2%
2	repository.unmuhjember.ac.id Internet	1%
3	journal.stkipsingkawang.ac.id Internet	<1%
4	simakip.uhamka.ac.id Internet	<1%
5	ejmste.com Internet	<1%
6	repository.up.ac.za Internet	<1%
7	researchonline.ljmu.ac.uk Internet	<1%
8	R Bahari, D Rohmat, Nandi. "The influence of teachers pedagogic com... Crossref	<1%

Excluded from Similarity Report

- Bibliographic material
- Cited material
- Manually excluded sources
- Quoted material
- Small Matches (Less then 8 words)
- Manually excluded text blocks

EXCLUDED SOURCES

A F Hindriana, Handayani, I Setiawati. "Application of VIPSTA experiment wor... 73%
Crossref

researchgate.net 5%
Internet

risbang.unuja.ac.id 2%
Internet

EXCLUDED TEXT BLOCKS

International Conference on Mathematics and Science Education (ICMScE) 2020J...
Syiah Kuala University on 2021-04-06

Journal of Physics: Conference SeriesPAPER • OPEN ACCESSYou may also like
SDM Universitas Gadjah Mada on 2023-03-29

Improving the spatial resolution of artificialvision using midget retinal ganglion cell
pubmed.ncbi.nlm.nih.gov

populations modeled at the human foveaMichael L Italiano, Tianruo Guo, Nigel HL...
Eleonora Borda, Diego Ghezzi. "Advances in visual prostheses: engineering and biological challenges", Progr...

Polycyclic Aromatic Hydrocarbon EmissionToward the Galactic Bulge
academic.oup.com

The preservation of living cells withbiocompatible microparticlesJing Yang, Yingna...

china.iopscience.iop.org