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Web-Integrated Digital Microscope to Improve Students' Spatial Visual Intelligence in Blended Learning-based Plant Anatomy Practicum

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ABSTRACT

Students really need a digital microscope because it can make it easier to observe cells, make it easier to visualize observational images easily and clearly, make it easier to identify observations, make it easier to measure and count the observed objects. students want a plant anatomy practicum to be able to display streaming video of the object being observed using a digital microscope, and students want a plant anatomy practicum report using a web/application that can be used face-to-face and online. The aim of this study was to develop a web-integrated digital microscope to train students' visual-spatial intelligence in plant anatomy practicum based on blended learning.The type of research used in this research is Research and Development. The test subjects in this study were prospective biology teacher students in the second semester of the Biology Education Study Program IAIN Syekh Nurjati Cirebon, which consisted of 5 classes and a total of 1735 students. Sampling used the cluster random sample method, consisting of 2 classes, namely Bio A (experimental class) and Bio C (control class) provided that the population is homogeneous. The results of the development of a web-integrated digital microscope used in a blended learning-based plant anatomy practicum were stated to be very valid. The developed web-integrated digital microscope can train students' visual-spatial intelligence in blended learning-based plant anatomy practicum, in the high category. There is a significant difference in students' spatial visual intelligence between classes using a web-integrated digital microscope and classes using a binocular light microscope.

ARTICLE INFO

Keywords
Web-Integrated Digital Microscope, Spatial Visual Intelligence, Blended Learning, Plant Anatomy Practicum.

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INTRODUCTION

Learning activities are said to be successful if they are in accordance with the learning objectives in the sense that students are able to master the material in a certain basic competency. The plant anatomy course is a basic course that is loaded with practicum observing cells, tissues and plant organology, and the microscope is a very important supporting tool in this practicum. The objectives of the practicum can be achieved well if the supporting facilities can facilitate all the needs in the practicum, because according to Sagala (2013) that with practicum students are given the opportunity to experience themselves, follow the process, observe an object, analyze, prove, and draw their own conclusions about an object, state or process of something.

Based on the results of a preliminary study on the learning process of plant anatomy practicum at IAIN Syekh Nurjati Cirebon in the biology education study program it can be said to be ineffective, because the microscope used is an optical microscope, so that when visualizing the results of cell observations with the microscope students must directly observe through the ocular lens and draw them manually so that it takes a lot of time. Students have difficulty imaging the parts of the anatomical structure of roots and stems. Parts of the root anatomy that are less clear are imaged by optical microscopy, including the pericycle of a dicot root, which has only 1 layer of cells, the often-erroneous number of protoxylem arms, and the location of xylem in dicot and monocot roots. The parts of the anatomical structure of the stem that are less clear are imaged by optical microscopy including, the vascular bundles in monocot stems are less clear between the xylem and phloem, the ground tissue bundles connecting the pith to the cortex in dicot stems, and the shape of the ground tissue in monocot stems. As seen in Figure 1.1, which is a photo of the results of student observations using an optical microscope.

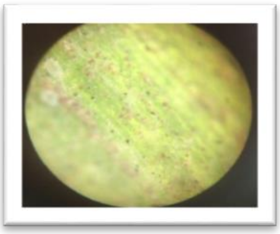

Figure 1. Riccinus communis Stem

Observations based on Figure 1 have the aim of knowing the various types of tufts and the elements of the tufts in plant stems, However, if you look at Figure 1, it is clear that the objectives of the practicum have not been achieved, because the image focus is not sharp enough and the magnification is imperfect, causing the image to not clearly show the type of vascular tissue and the elements of the vascular tissue. This resulted in students having difficulty identifying or analyzing the results of their observations. The experience of learning plant anatomy practicum using a light microscope indicates that students are not trained in visual-spatial intelligence in making observations, such as visual-spatial intelligence. In visual-spatial intelligence, students are less careful in observing shapes, colors and spaces between cells in plant tissues.

Based on the results of a research survey on the need for microscopes at IAIN Syekh Nurjati Cirebon, it shows that students really need a digital microscope because it can make it easier to observe cells, makes it easier to visualize observation images easily and clearly, makes it easier to identify the results of observations, makes it easier to measure and count the observed objects, students want a plant anatomy practicum to be able to display streaming video of the object being observed using a digital microscope, and students want a plant anatomy lab report using a web/application-based digital microscope that can be used face-to-face and online (Sugianto et al., 2020).

It is necessary to develop digital microscope technology for supporting plant anatomy practicum. The results of research on various kinds of digital microscopes show that virtual microscope systems increase learning productivity, learning efficiency, critical thinking, ease of communication and student confidence (Tian et al., 2014), because slide virtual microscope is easy to navigate, and virtual image quality is better than normal microscope (Hamilton et al., 2015). The interactive application of smartphone microscopes can facilitate the stimulation of exploration of observation of microscopic organisms, the interactive design of this smartphone microscope combines elements of learning microorganisms and games (Kim et al., 2016). The use of Atomic Force Microscopy (AFM) in biology class can improve spatial visual intelligence as follows: 1) students can directly observe nano bio-micro nano structures, 2) students have the scientific opportunity to prove how nano-micro-structures work in biological samples related to engineering-the application of engineering science - as well as learn the various applications of nano-micro-structures, 3) The formation of student experience in the learning process that can be beneficial in learning science (Lee et al., 2013). Epifluorescence microscopy can motivate learning and conduct scientific investigations of students (Rosen & Stewart, 2015), because epifluorescence microscopy has several advantages such as selective plane illumination microscopy (SPIM) which lasts several hours to several days (Kaufmann et al., 2012), It consists of two detection lenses and a lighting objective, which enables fast toto fluorescence imaging of biological specimens with subcellular resolution (Krzic et al., 2012), and has a design in a flexible auto form with the ability to ease transitions and so on Barber et al. (2013).

Based on the results of research on various types of digital microscopes, it is necessary to update a web-integrated digital microscope that is used face-to-face and online in plant anatomy practicum, so that it is expected that students' visual-spatial intelligence can increase. Blended learning (BL) is learning that combines e-learning systems with conventional or face-to-face learning models. Graham (2015) suggests:

"...The idea that BL is a combination of instruction from two historically separate models of teaching and learning: traditional face to face learning systems and distributed learning systems. It also emphasizes the central role of computer-based technologies in Blended Learning".

Blended learning systems can facilitate active learning among students and provide insights to strengthen the quality of teaching and learning anatomy (Ngan et al., 2018). Blended learning laboratory in microscopic anatomy delivers histology learning content effectively, so that students' will be more interest in learning (Barbeau et al., 2014). Path analysis shows that blended learning experiences affect students' motivation, namely learning control and intrinsic goal orientation, affect students' self-efficacy, influence students' critical thinking, and influence metacognitive regulation. (Kassab et al., 2015). The attitude of medical students towards blended learning elements is very positive (Ocak & Topal, 2015) namely the effectiveness of the learning process, increasing motivation (Noour & Hubbard, 2015), active involvement of students in learning oral radiology (Kavadella et al., 2014), and effective clinical skills (Mccutcheon et al., 2015), and influence on student achievement (Al-Qahtani et al., 2013). Most (80%) of the students in the treatment group preferred embedded blended learning through traditional live lectures. Student responses to open-ended survey questions suggest that students in the treatment group value: (a) the ability to control the pace of teaching; (b) the new role of the classroom teacher; (c) lack of distraction in a mixed learning environment; and (d) the accessibility of embedded multimedia lessons outside the classroom (Smith & Suzuki, 2015).

METHOD

Design

The aim of this study was to develop a web-integrated digital microscope to train students' visual-spatial intelligence in plant anatomy practicum based on blended learning. The type of research used is Research and Development. This research and development method in the field of education was put forward by Borg & Gall (2003). as “a process used used to develop and validate educational”, namely the process used to develop and validate educational products.

The research procedures and steps used follow the procedures and steps proposed by Borg & Gall (2003), suggested that there are ten steps to the implementation of the research strategy. The main steps of R&D (Research and Development) put forward by Borg & Gall (2003) as follows: 1)Research and Information Collecting, 2) Planning, 3) Develop preliminary form of product, 4) Preliminary field testing, 5) Main product revision, 6) Main Field Testing, 7) Operational product revision, 8) Operational field testing, 9)Final product revision and, 10) Disessemination and implementation. The research design used to test product effectiveness uses a quasi-experimental design method with a pretest-posttest control group design.

Sample

The test subjects in this study were prospective biology teacher students in the second semester of the Biology Education Study Program IAIN Syekh Nurjati Cirbon, which consisted of 5 classes and a total of 174 students. Sampling used the cluster random sample method, to determine the legibility of the results of the development of a web-integrated digital microscope in plant anatomy practicum based on blended learning with visual-spatial intelligence competence. The large-scale trial uses 2 classes, namely Bioma (experimental class) and Bio C (control class) with the condition that the population is homogeneous.

Instrument

Data analysis techniques consist of analysis of test trials, and analysis of student spatial visual intelligence data. The results of the validity of the questions show that all questions can be said to be valid with a value of rcount > r table, namely 0.3673, and all item items for each variable used in this study are reliability with a Cronboach's Alpha coefficient value of 0.933.

Data Collection and Analysis

Analysis of data on the results of spatial visual intelligence of prospective biology teacher students was carried out after main field testing (wide scale trials). In order to test research questions and test hypotheses, to obtain spatial visual intelligence data were analyzed using the N-Gain score test, prerequisite test and independent sample t-test.

RESULTS AND DISCUSSION

Based on the identification of the problem, a design draft was prepared in the form of a web story board for a digital microscope application and a modification of the light microscope into a digital microscope that can meet the needs of plant anatomy practicum based on blended learning. The main focus of this research is to develop a web-integrated digital microscope, while the digital microscope used is a digital microscope that is already on the market, however, due to the conditions at the research site, they did not have a digital microscope and limited budget to buy a digital microscope on the market, the light microscope at the site was modified into a digital microscope with the help of a smartphone, a 100 times magnification telescope, and the droidcam application. The method is 1) remove the eyepiece of the light microscope and replace it using a telescope that has a clamp, 2) clamp the telescope on the smartphone right at the rear camera, 3) then install the droidcam application on the smartphone and PC (laptop/notebook), 4) the last step is set the droidcam as a camera and connect the distance between the PC (Laptop/Notebook) and the smartphone on the light microscope. As can be seen in Figure 1.

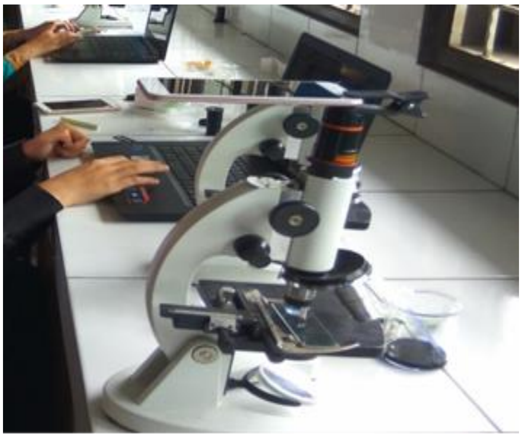

Figure 1. Modification of a Light Microscope to a Digital Microscope

The preparation of a digital microscope web design application starts with adjusting the color of the web appearance, login and register, profile, home, homepage, friendship, inbox, activity, and consists of several other tools. The digital microscope website can be accessed at https://microscopblended.com. Can be seen in Figure 2.

Figure 2. Digital Microscope Application Web

The results of the development of digital microscopes based on blended learning add to the list of the latest types of digital microscopes, especially in the field of education, such as the types of digital microscopes mentioned by Emily (2020) among them; 1) Kooletron Digital Microscope is a portable handheld microscope suitable for all science subjects, 2) Plugable Digital Microscope, capable of identifying garden parasites, analysis of jewelry, stamps and coins, and more, this microscope is suitable for elementary school students, 3) Celestron Digital Microscope , a microscope that can be used in middle school biology classes, or even for elementary school students that can provide high-resolution images and videos with high-quality glass lenses for sharper images, 4) Yinama Digital Microscope, has a solid base, and is weighted so avoid vibrations and the image remains focused, 5) Tsaagan Digital Microscope, a microscope that can be connected to cellphones and portables, 6) Celestron Digital Microscope type 44341, 7) Amscope Digital Microscope, 8) Celestron Penta Digital Microscope, and 9) Omax Digital.

Results of spatial visual intelligence data analysis

To find out the average value of spatial visual intelligence in the experimental class and the control class, it is necessary to test the N_gain score. Table 1 shows the N-gain test for spatial visual intelligence scores using SPSS 22.

Table 1. N-Gain score of Visual Spatial Intellegence

	Grup		Statistic	Std. Error
N-gain Visual Spatial	experiment	Mean	,8321	,01531
		Minimum	,50	
		Maximum	,96	
	control	Mean	,3691	,02402
		Minimum	-,05	
		Maximum	,65	

Based on the results of the calculation of the spatial visual intelligence N-gain score test in Table 1, it shows that the average value of the spatial visual intelligence N-gain score for the experimental class (using a web-integrated digital microscope) is 0.8321 in the high category. With a minimum N-gain score of 0.3 and a maximum of 0.7. Meanwhile, the average visual-spatial N-gain score for the control class (using a binocular light microscope) was 0.3691, which was included in the medium category. With a minimum N-gain score of 0.3 and a maximum of 0.7.

Thus, it can be concluded that plant anatomy practicum based on blended learning using a web-integrated digital microscope has a high category in training students' visual-spatial intelligence. While the plant anatomy lab using a binocular light microscope has a category that is in training spatial visual intelligence.

The results of research by Bouker & Scarlatos (2013) show that digital microscopes can train the physical so that they can improve visual-spatial intelligence, and improve memory performance. As well as the research results of Sasidharakurup et al., (2015) showing the use of blended learning-based laboratories can improve academic visual spatial intelligence in biotechnology virtual laboratories. Online learning to teach clinical skills is no less effective than the traditional way, and a blended learning approach to teach clinical skills in undergraduate nurse education (Mccutcheon et al. 2015).

Hypothesis Test Results

Post-test data analysis of experimental and control classes was carried out to answer research questions and hypotheses. The independent sample t test is used to test the hypothesis, while the hypothesis proposed is as follows:

H1 : There is a difference in students' spatial visual intelligence between classes using web-integrated digital microscopes and classes using binocular microscopes in plant anatomy labs

H0: There is no difference in visual spatial intelligence of students between classes using web-integrated digital microscopes and classes using binocular microscopes in plant anatomy labs

Posttest Data Normality Test

The data normality test is carried out with the aim of knowing whether the data is normal or not as a prerequisite for using parametric or non-parametric statistical tests. The following are the results of the posttest data normality test for students' multiple intelligence abilities.

Table 2. Uji Normalitas Data Postes Eksperimen dan Kontrol

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	grup	Statistic	df	Sig.	Statistic	df	Sig.
Post-test	experiment	.102	37	.200*	.971	37	.441
	control	.160	39	.137	.930	39	.185

The significance value (p) in the Kolmogorov-Smirnov test was 0.2 in the experimental class and 0.2 in the control class ($p > 0.05$), so based on the normality test of the Kolomogorov-Smirnov data the data was normally distributed. So it can be concluded that the post-test data for the experimental class and the control class are normally distributed data, so that an independent sample t-test can then be carried out to find out the difference in the average post-test data for the experimental and control classes.

Test the difference between the mean posttest experimental and control data

The results of the normality data distribution test in Table 3 show that the experimental and control class post-test data are normally distributed, so the following are the results of the experimental and control class different post-test tests using the independent sample t-test.

Tabel 3. Post-test Difference Test between Experimental and Control Classes

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Post-test	Equal variances assumed	11.859	.095	28.454	74	.000
	Equal variances not assumed			28.952	53.969	.000

Based on Table 4, it is known that the Levene's Test for Equality of Variances has a value of 0.095 > 0.05, which can be interpreted to mean that the variance of the data for multiple intelligences in the experimental class and control class is homogeneous or equal. Thus, the interpretation of Table 4.3 is guided by the values present in the "Equal variances assumed" table.

Based on Table 4, the output of the "Independent Samples Test" under the "Equal variances assumed" section shows a Sig. (2-tailed) value of 0.00 < 0.05, and the calculated t-value is 28.454 > the tabulated t-value of 2.376. According to the decision-making principle in the independent samples t-test, this indicates a significant difference between the spatial visual intelligence of students using blended learning-based digital microscopes (experimental class) and students using binocular light microscopes (control class) in plant anatomy practicals. Therefore, it can be concluded that H1 is accepted and H0 is rejected.

This research finding is reinforced by the results of a study conducted by (Tian et al., 2014), which demonstrated that the test scores of the digital microscope group showed a significant improvement compared to those in the light microscope group ($p < 0.05$). The implementation of digital microscopes has enhanced teaching and learning in practical classes within histology laboratories and facilitated consolidation and material revision outside the laboratory (Gatumu et al., 2014). Virtual microscopes have the capability to enhance collaborative group work and can be used efficiently (Triola & Holloway, 2014).

The Virtual Microscope Database (VMD) serves to facilitate the use of virtual microscopes for research and teaching. VMD also has the potential to improve the quality of histology and pathology learning and make this subject more accessible to students worldwide (Lee et al., 2018). Just as digital microscopes can train the physical aspect and enhance spatial visual intelligence, the BrainRank application can also improve spatial visual intelligence by training the physical aspect and enhancing memory performance (Bouker & Scarlatos, 2013). A smart learning environment and blended learning model can improve students' knowledge of programming (Kose, 2012). Replacing optical microscopes with digital microscopes in histology practicals not only saves costs but also improves students' understanding (Martínez et al., 2016). There is overall improvement in performance by students in both veterinary schools that use virtual microscopes and glass slide microscopes, but digital technology is identified as having many advantages (Brown et al., 2016).

The development and integration of new virtual microscopes into face-to-face approaches for teaching microscopic anatomy can result in changes in student learning behavior, group work, and social interaction (Bernard et al., 2014). The research results show a significant influence on spatial-visual intelligence and numerical ability together on mathematics learning achievement. There are significant differences in social and cognitive presence between the two course formats and a higher perception of presence in the blended learning process (Akyol et al., 2009). The research results show statistically significant differences among the three methods in terms of student learning achievement preference for blended learning (Al-Qahtani et al., 2013).

Structural Equation Modeling (PLS-SEM) analysis partially reveals that student engagement in face-to-face mode has a significant positive effect on their engagement in management-based learning and web-based learning. Additionally, the use of time and tool management in the system-based approach positively influences student learning performance in a blended learning environment (Baragash & Al-Samarraie, 2018). E-learning directly affects peer learning and critical thinking but indirectly affects metacognitive regulation. Resource management, time, and learning environment regulation strategies directly affect student exam scores (17% of the variance explained) (Kassab et al., 2015).

Students in the blended learning group perform significantly better than their peers in the conventional group in post-course knowledge tests, and female students in the blended learning group perform better than male students (Kavadella et al., 2014). The research results show that competency does not impact IM and AM dimensions. This implies that competency does not affect learners' motivation to accept the Blended Learning concept, but it shows that competency influences EM (Noour & Hubbard, 2015).

CONCLUSION

The results of the normality data distribution test in Table 3 show that the experimental and control class post-test data are normally distributed, so the following are the results of the experimental and control class different post-test tests using the independent sample t-test.

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