ASSESSING USING TECHNOLOGY: IS ELECTRONIC PORTFOLIO EFFECTIVE TO ASSESS THE SCIENTIFIC LITERACY OF EVOLUTION THEORY

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Article Info	Abstract
	This study used a sequential exploratory mixed method to examine the effectiveness of using electronic portfolio to assess the scientific literacy of evolution theory. 135 university students majoring biology education were involved as the research participants. They were asked to create the electronic portfolio by using any learning artefacts produced during the classroom activities including direct and virtual practicums, reading activities, direct and online discussions, quizzes, and formative examinations. Results depicted that electronic portfolio was effective for assessing the scientific literacy of evolution theory that consisted of some skills namely scientific communication, observation and experiment, scientific and creative thinking, professionalism, and electronic portfolio organization and content. Another finding disclosed that students showed a positive response on the electronic portfolio creation. This study suggests that electronic portfolio can be used as an assessment tool of the scientific literacy of evolution theory relevantly to industrial revolution 4.0.

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INTRODUCTION

Scientific literacy refers to an ability to use scientific knowledge to identify and resolve problems based on factual evidence, which further can be used to understand any natural phenomena happened due to human activities (Bybee, 2009). Its components include broader knowledge of sciences comprising natural, physical, chemical, biological, earth, space, and science-based technological sciences. Other components involve scientific investigation and the scientific purpose justifying a particular discipline (Faragher, 2013).

Many previous scholars, in many disciplines rather, have developed scientific literacy assessment tools (Rusilowati *et al*, 2018; Fives *et al*, 2014; Waldo, 2014), whereby one of which is the Test of Scientific Literacy Skill (TOSLS) (Segarra *et al*, 2018; Gormally, 2012). TOSLS aims to measure some skills constructing scientific literacy such as recognizing and analyzing the use of inquiry methods that leads to scientific knowledge and abilities to organize, analyze, and interpret quantitative data as well as scientific information (Segarra *et al*, 2018; Udompong & Wongwanich, 2014; Gormally, 2012). The TOSLS indicator comprise identifying the validity of scientific opinions, conducting effective literature research, understanding the elements of research design and the impact on findings, graphing accurately from obtained data, solving problems using quantitative approach, mastering basic statistics, and producing inferences, predictions, and conclusions data (Udompong & Wongwanich, 2014; Gormally, 2012).

Literacy assessment tool that is specifically developed to address the theory of evolution is Evolutionary Attitudes and Literacy Survey (EALS) (Rusilowati *et al*, 2016; Hawley, 2015; James *et al*, 2015; Short & Hawley, 2012). This tool aims to measure the factors that influence individual's perspectives toward the debates of evolution theory, which take account of political activity and learning, spiritual learning, knowledge of evolution theory, creationist's ideology, evolutionary misconceptions, and scientific endeavors to study evolution (Short & Hawley, 2012). EALS is indeed different from TOSLS, which focuses on measuring scientific literacy for Biology materials. Another tool is Evolutionary Scientific Literacy Assessment (ESLA), developed in the present study, aims to measure scientific literacy of evolution theory that

encompasses identifying scientific opinions about valid theory of evolution, creationism, and intelligent design, conducting effective literature research to prove the theory of evolution, understanding the elements of research design to test theories and the impacts on findings, graphing precisely from the obtained data, solving any problems using quantitative approach, drawing conclusions, and stating individual positions against conflicting theory of evolution. ESLA, moreover, is used as the assessment tool in the current study.

A teacher could conduct an effective teaching and learning process of the evolution theory by having accesses to desired information of evolution theory, self and communal reflection of the undertaken teaching process, and good and creative lesson plans (Hawkins, 2017; Oner & Adadan, 2016). In other side, students are obligatory to master how to perform self-reflection after the learning process to strengthen their understanding towards the materials delivered, regardless the disciplines (Mezirow, 2018; Hawkins, 2017; Sterling *et al*, 2016; Wong, 2016; Tylor, 2008). Sterling *et al* (2016) states that self-reflection can be done during both learning and assessment or evaluation processes. A good assessment is carried out to promote intellectual trainings and self-reflection to enforce scientific thinking and literacy (Bialik *et al*, 2016; Wyse, Hayward, & Pandya, 2015), of which all things are covered in a form of portfolio (Slepcevic-Zach & Stock, 2018). Portfolio is a continuous assessment based on a set of collected reported information (e.g. previous students' works) that portrays the progresses of students' learning performance (e.g. cognitive, affective, and psychomotor aspects) in a certain period (Baird *et al*, 2018; Singh & Samad, 2013; Greenwood, 2010). By referring to this report, lecturer and students can decide further learning strategies in order to get better learning attainments. The scoring system should accommodate accurate information, student's learning encouragement, teaching motivation, and improvement of institutional performance and education quality (Gresch *et al*, 2017).

Portfolio has already met the principle of authentic assessment that includes validity, objectivity, transparency, fairness, integrations, significance, and systematic and accountable

procedure, of which all aspects are centered on numbers of criteria (Slepcevic-Zach & Stock, 2018; Bialik *et al*, 2016; Sonley *et al*, 2007). Since portfolio presents gradual and sequential student's progresses and processes, it is not easy when associated with numerous individuals (Kim & Yazdian, 2014; Barrett, 2007). The process of documenting students' artifacts (e.g. students' learning products and reflection) has a potential to ably resolve some difficulties in any test, evaluation, and advancement of the learning quality. However, there is insignificant efforts to consistently use portfolio so that the fact shows that portfolio seems unorganized, less beneficial, and relatively long to be conducted. Somehow, the implementation of portfolio is less meaningful due to no standardized scoring criteria available and insufficient portfolio storages.

Recently, information and communication technology has facilitated educators in carrying out various learning processes and devising assessment tools, including the presence of electronic portfolio. Electronic portfolio does not only assist teacher to collect students' artifacts (e.g. digital scrapbooks or multimedia presentations), but also their reflective reports (Slepcevic-Zach & Stock, 2018; Oner & Adadan, 2016). This type of portfolio promotes easy facility in organizing students' data (Slepcevic-Zach & Stock, 2018). Electronic portfolio can improve teaching and learning evaluation processes because it serves student with data organization (Slepcevic-Zach & Stock, 2018). Barrett (2007) and Clarke & Boud (2018) convey a simple formula in packing the evidence used in electronic portfolio such as Evidence = Artifact + Reflection (Rationale) + Validation (Feedback). This electronic portfolio is able to measure students' abilities in two dimensions namely organizational and individual levels (Kitimbo, 2010). Wang (2009) portrays the significance of the use of this portfolio type can make students in groups more confident in coping with technology-based assignments compared to those with individual portfolio.

Unfortunately, some problems of the use of electronic portfolio might come within the fact that most student cannot deal with the operational procedures. Stansberry (2007) shows that students might feel inadequate, confused, less confident, and less efficacious when using electronic portfolio since they have not yet even accustomed to that kind of assessment tool. Moreover, as an early observation, students were less confident to cope with the

technology-based assessments since they have no prior knowledge regarding how to use, the benefit, and weakness, including the use of different media format in the electronic portfolio such as Learning Management System (LMS). In other words, students ended up their worries with less interests on using electronic portfolio. Henceforth, this study purposes to bring electronic portfolio in a class as an assessment tool and introduce its procedural usage. The present study, then, aims to find out whether electronic portfolio can be used as an effective assessment tool for scientific literacy of evolution theory.

METHODS

This study used a sequential exploratory mixed method (Berman, 2017). The qualitative data were collected six experts' judgments on evolution theory and assessment developments regarding the effectiveness of electronic portfolio to assess scientific literacy of evolution theory. The quantitative data were obtained through scores given to assess the electronic portfolio made by the students and through questionnaire given to them. 135 students registered in evolution course at Biology Department were involved in the present study as the respondents. The qualitative data were analyzed using descriptive approach while the quantitative data were analyzed using statistical descriptive approach.

There were four stages of developing electronic portfolio used in the present study. First, students must define the context and purpose of the portfolio in order to meet the notion of assessing scientific literacy skills of evolution theory, of which was comprising scientific communication, observation and experiment, scientific and creative thinking, professionalism, and portfolio organization and content. Second, students made an electronic portfolio by the assistance of http://e-portofolio.id. The portfolio material covered evolutionary topics that had been discussed in class with the lecturer. The artifacts could be in the form of assignments, photos, videos, quizzes, and other results of evolutionary lectures. Third, students should accompany the portfolio with reflective reports. Finally, at the end of the semester, students published their

electronic portfolios and the lecturer assessed the portfolios using electronic portfolio evaluation guidelines.

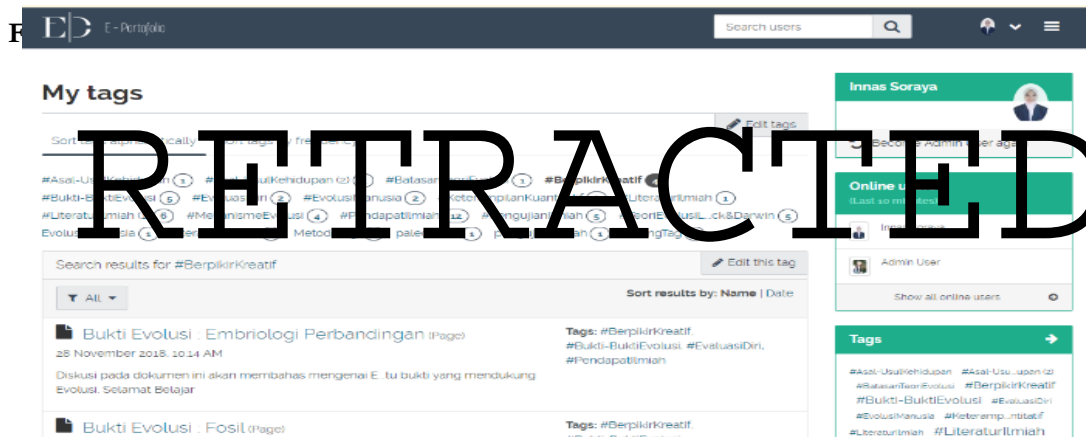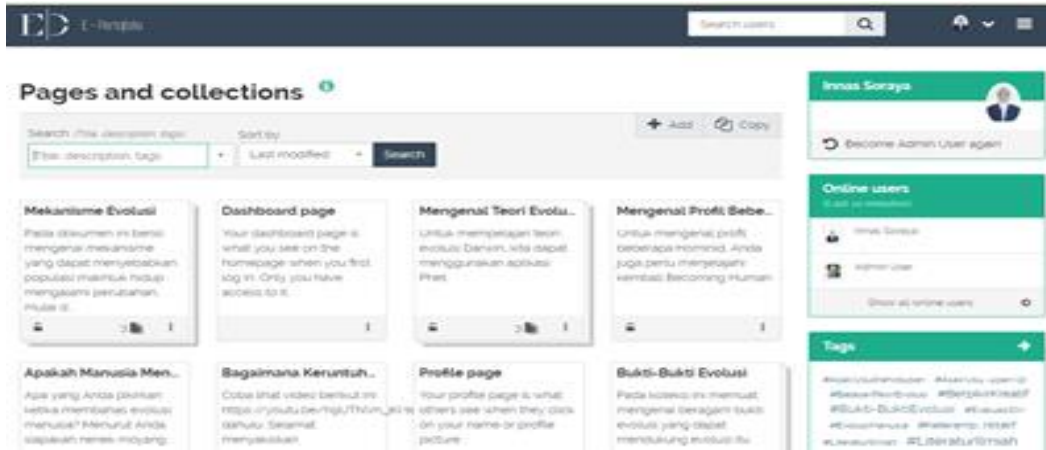Figure 1 to 3 show an example of student's electronic portfolio profile.

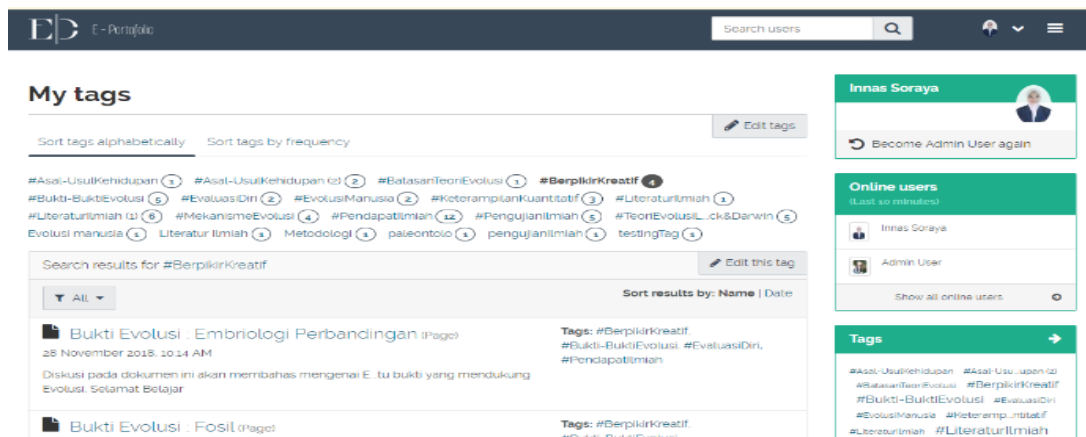**Figure 2.** Collection Page of the Electronic Portfolio Showing Contents of Literacy Skills
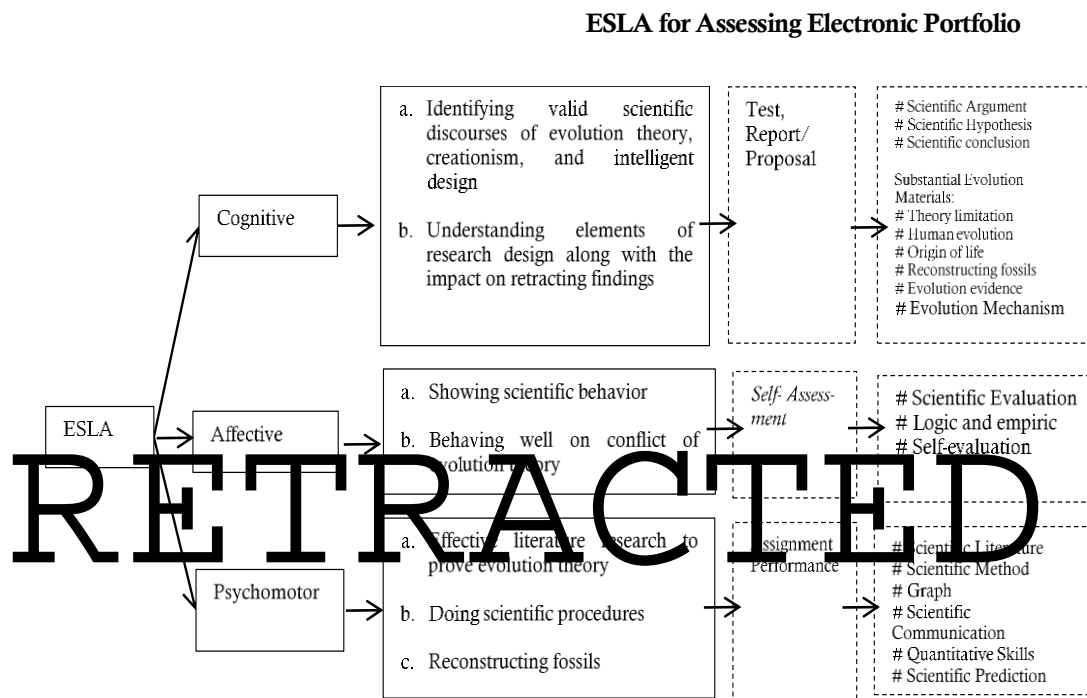

Figure 3. Artifact Page of the Electronic Portfolio

RESULTS AND DISCUSSION

Focus Group Discussion

Focus Group Discussion was conducted to get feedbacks from the expert fellows using Evolutionary Scientific Literacy Assessment (ESLA). Figure 4 depicts the general scheme of ESLA description.

ESLA for Assessing Electronic Portfolio

Figure 4. Schema of ESLA Model.

There were some specifications characterizing ESLA model used in an electronic portfolio. First, ESLA used an integrated electronic portfolio with learning activities on Moodle-based LMS available at https://vi-learn.unesa.ac.id/. Second, it used student's electronic portfolio data such as student's assignments, examinations or quizzes, and conversations. Moreover, it used electronic portfolio to make lecturer easier assess the scientific literacy of evolution theory. It also made the quality assurance team of the institution easier obtain students' learning progresses. Fourth, the electronic portfolio for assessing scientific literacy of evolution theory conveyed interesting outlooks for students to cope with more publications. At last, the effectiveness of ESLA Model using an electronic portfolio required to be tested to have better performance in future.

Students' electronic portfolios were assessed using ESLA instrument that results referred to Table 1.

Table 1. ESLA Results for Assessing Electronic Portfolio.

Aspects	Beginner	Intermediate	Proficient	Advanced
Electronic Portfolio Content	0%	0%	14%	86%
Electronic Portfolio Organization	52%	33%	10%	5%
Professionalism	10%	15%	40%	35%
Creative Thinking	0%	0%	63%	37%
Scientific Thinking	45%	35%	13%	9%
Observation and Experiment	52%	34%	14%	0%
Scientific Communication	51%	31%	18%	0%

In accordance to Table 1, 86% of students were categorized in advanced level especially in the aspect of electronic portfolio contents. Meaning that, they conveyed very good portfolio contents consisting of six topics (Limitation of Evolution Theory, Paleontology Methods, Human Evolution, Origin of Life, Evolution Evidence, and Evolution Mechanism) using 4 to 5 media formats including text, image, audio, video, pdf, and website. Moreover, 52% of students were in a beginner level of organizing electronic portfolio and conveying observation and experiment skills. Meaning that, the majority of students still faced difficulties in aspiring ideas and purposes in the electronic portfolio. They also did not explain the objectives of the experiment they conducted, the variables involved, and equipment they needed to do the experiment. In coping with their professionalism, 40% of students knew how to be a professional scientist who avoided plagiarism, provided interactive and attractive outlooks of portfolio, gave an easy access to the portfolio, and used formal and acceptable language. In regard to their creative and scientific thinking, 63% and 45% of students were categorized in proficient and beginner level, respectively. Meaning that, most students conveyed creativity rather than those dealing with advanced scientific process. At last, their scientific communication, including the way of delivering opinions was still inadequate (51%).

ESLA for Assessing Electronic Portfolio

After creating an electronic portfolio that could describe the students' ability of scientific literacy in evolution theory, they were also asked to give responses on the use of electronic portfolios. They conveyed that electronic portfolio was related to integrative learning, a student's communal understanding across curriculum.

For instance, students needed to make simple connections between ideas and experience to synthesize and transfer a conservative learning process to more new complex circumstances either in or out of the campus setting.
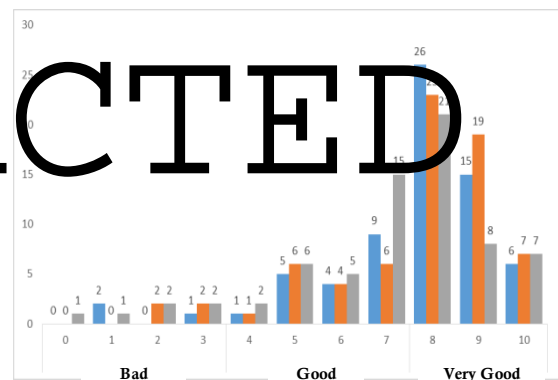
Figure 5. Students' Responses on the Relationship between Electronic Portfolio and Integrative Learning.

Figure 5 portrays that students showed a very good response in which electronic portfolio enabled them to collect artifacts from the results of evolutionary studies and other experience to create electronic portfolio with various media as well as to encourage reflective writing and blogging skills that could facilitate metacognition in both group collaboration and individual work. They also provided an electronic portfolio linkage response to exhibit works (see Figure 6).
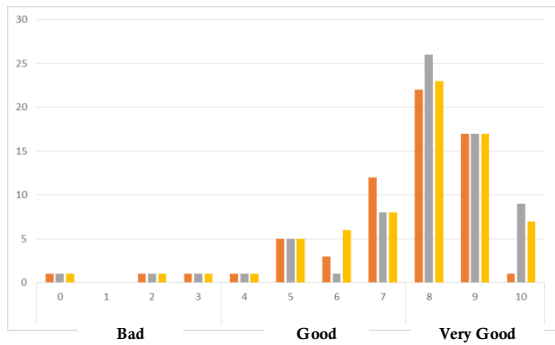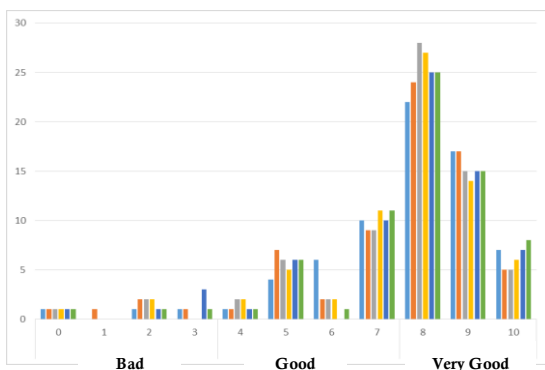
Figure 6. Students' Responses on Electronic Portfolio as a Forum of Artifact Exhibition.

Figure 6 reveals that electronic portfolio allowed students to exhibit works in the form of text and other creative media for the purposes of evaluating literacy of the evolution theory. Meanwhile, the portfolio also let students share artifacts each other regardless what classes they belonged to (Chang, Chou, & Liang, 2018; Wang, 2009). Students had a long-term access and could easily upload the contents of portfolio (Knight, Hakel, & Gromko, 2008). This phenomenon was consistent with the student's responses on the electronic portfolio used as an assessment in the evolutionary lecture (see Figure 7).

Figure 7 explains that the electronic portfolio received students' very good response regarding its suitability for assessment tool. The portfolio got first-rate evaluations in a forum of exhibiting artifacts in evolutionary lectures, particularly in scientific literacy of evolution theory. Students conveyed that electronic portfolio could be used for all disciplines (Van der Vleuten, Heeneman, & Schuwirth, 2017) and helped solve problems with multi-activities and assessment instruments (Mohamad, Embi, & Nordin, 2016). In addition, it was able to collect, store, and create working products dealing with various multimedia or

Figure 7. Students' Responses on Electronic Portfolios for Assessment Tool.

digital formats. Students, consequently, could track and share their works with other students or lecturers.

Students also could operate data analysis when using the electronic portfolio, thus, they might feel much more helped understand the evolutionary materials.

In short, there were several advantages of using electronic portfolio as an assessment tool. First, electronic portfolio could facilitate lifelong learning because it helped capture, manage, and examine students' learning experience (Hui, 2017). Second, through electronic portfolio, lecturer and students could construct better metacognition, communicate true concept or new information, and use data analysis (Chang *et al*, 2018; Haave, 2016). Third, students could use multimedia artifacts including video and audio to make the portfolio more alive and interesting. Fourth, electronic portfolio was more practical compared to those conservative ways because it was sufficiently stored in flash drives and did not require large space (Mohamad, Embi, & Nordin, 2016). For instance, the electronic portfolio could be stored on computer hard drives, USB Flash drives, MP3 players, Smart Phones, iPods, CDs, DVDs, commercial websites, Educational Websites, or any combination of these. At last, the electronic portfolio could introduce and train students computer literacy skills, of which became relevant skills in the 21st century (Fahey 2007; Janesick, 2013; Shepherd, 2011; Johnson *et al*, 2010).

CONCLUSION

Electronic portfolio is effective to assess evolutionary scientific literacy skills covering scientific communication, observation and experimentation, scientific and creative thinking, professionalism, and electronic portfolio organization and content. Another finding shows that students have a positive response on the creation of electronic portfolio. The electronic portfolio can be used as a tool for evaluating scientific literacy of evolution theory that is relevant to the industrial revolution 4.0.

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