Assessing Using Technology: Is Electronic Portfolio Effective To Assess the Scientific Literacy on Evolution Theory

https://doi.org/10.3991/ijet.v15i12.12227

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Abstract—This study used a sequential exploratory mixed method to examine the effectiveness of using an electronic portfolio to assess the scientific literacy of evolution theory. As much as 135 university students majoring in biology education were involved as research participants. They were asked to create the electronic portfolio by using any learning artifacts produced during the classroom activities including direct and virtual practicums, reading activities, direct and online discussions, quizzes, and formative examinations. Evolutionary Scientific Literacy by electronic portfolio consists of Scientific Literacy skills namely Nominal, Functional, Conceptual, Multidimensional levels, and electronic portfolios skills namely beginner, intermediate, proficient and advanced level. The results depicted that the Evolutionary Scientific Literacy skills of students were at the beginner-nominal level (71.4%) and the advanced-multidimensional level (9.5%). Another finding disclosed was that students showed a positive response to the electronic portfolio creation. This study suggests that an electronic portfolio can be used as an assessment tool of the scientific literacy of evolution theory relevant to industrial revolution 4.0.

Keywords—Assessment, electronic portfolio, evolution theory, scientific literacy

1 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 phenomenon happened due to human activities [1]. Its components comprised of broader knowledge of sciences, including natural, physical, chemical, bio-

logical, earth, space, and science-based technological sciences. Other components involve are scientific investigation and scientific purpose justifying a particular discipline [2].

Many previous scholars, in many disciplines rather, have developed scientific literacy assessment tools [3-5], one of which is the Test of Scientific Literacy Skill (TOSLS) [6-7]. TOSLS aims to measure skills constructing scientific literacy, such as recognizing and analyzing the use of inquiry methods leading to scientific knowledge and abilities to organize, analyze, and interpret quantitative data as well as scientific information [6-8]. The TOSLS indicators consisting of identifying the validity of scientific opinions, conducting effective literature research, understanding the elements of research design and the impact on findings, create graphs accurately from obtained data, solving problems using quantitative approach, mastering basic statistics, and producing inferences, predictions, and conclusions of data [7-8].

Literacy assessment tool specifically developed to address the theory of evolution is Evolutionary Attitudes and Literacy Survey (EALS) [9-10]. 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 [10]. 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 current 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 [11-12]. 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 discipline [11] [13-16]. Sterling et al [14] stated that self-reflection could be performed 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 [17-18], of which all things are covered in a form of portfolio [19]. 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 [20-21]. 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 [22].

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 [17] [19] [23]. Since portfolio presents gradual and sequential student's progresses and processes, it become difficult is not easy when it is associated with numerous individuals [24-25]. The process of documenting students' artifacts (e.g. students' learning products and reflection) has a potential to aptly resolve some difficulties in any test, evaluation, and advancement of the learning quality. However, there is insignificant efforts to consistently use portfolio, thus fact showed that portfolio seemed to be 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 [12] [19]. This type of portfolio promotes easy facility in organizing students' data [19]. Electronic portfolio can improve teaching and learning evaluation processes because it serves student with data organization [19]. Barrett [25] and Clarke & Boud [26] 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 [27]. Wang [28] portrayed the significance of the application of this type of portfolio could make students in groups more confident in coping with technology-based assignments compared to those with individual portfolio.

Unfortunately, several problems of the use of electronic portfolio might come with the fact that most student could not deal with the operational procedures. Stansberry [29] showed that students might feel inadequate, confused, less confident, and less efficacious when using electronic portfolio since they had 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 had 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, the purpose of this study was to bring electronic portfolio in a class as an assessment tool and introduce its procedural usage. The present study, then, aimed to find out whether electronic portfolio could be used as an effective assessment tool for scientific literacy of evolution theory.

2 Methods

This study used a sequential exploratory mixed method [30]. The qualitative data were collected by six experts on evolution theory. Assessment was developed 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. As much as 135 students registered in evolution course at Biology Department were involved in the current 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 study. First, students defined the context and purpose of the portfolio in order to meet the notion of assessing scientific literacy skills of evolution theory, of which was comprised of scientific communication, observation and experiment, scientific and creative thinking, professionalism, and portfolio organization and content. Second, students made electronic portfolio using the assistance of http://e-portofolio.id. The portfolio material covered evolutionary topics previously discussed in class with lecturer. The artifacts were formatted as 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.

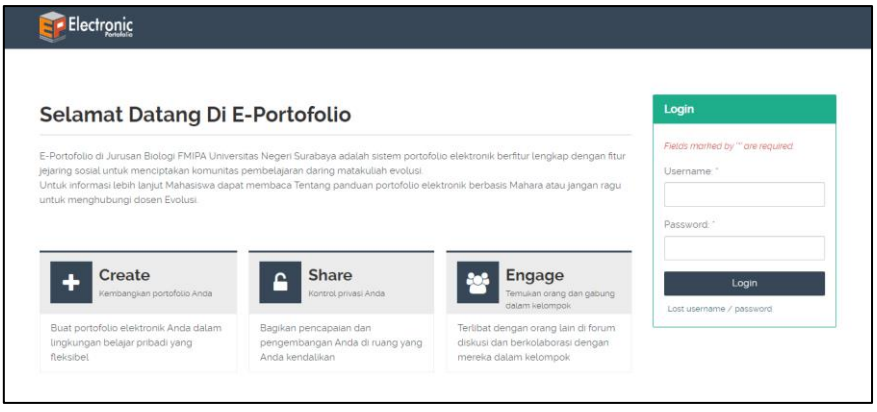

Fig. 1. Dashboard page of electronic portfolio.

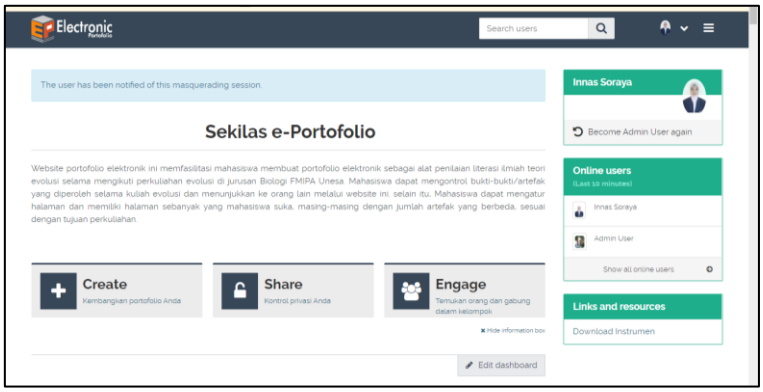

Fig. 2. Wall page of student electronic portfolio.

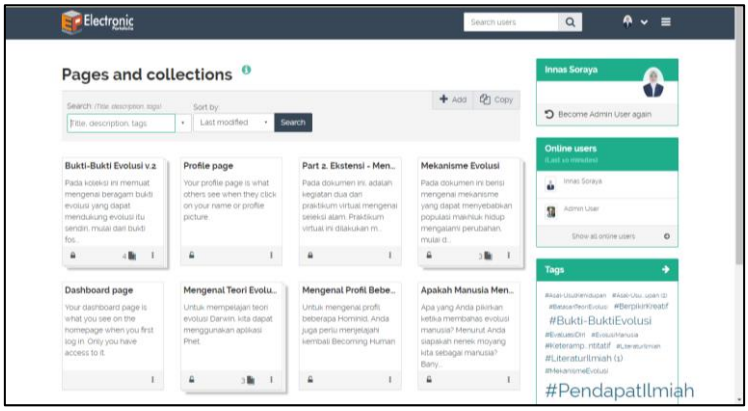

Fig. 3. Collection page of electronic portfolio showing contents of literacy skills.

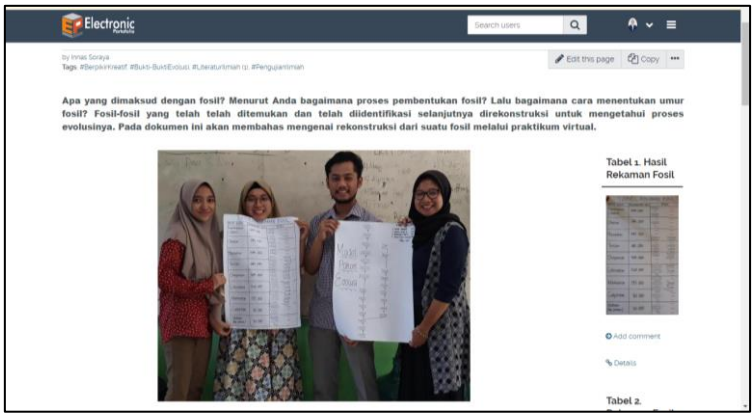

Fig. 4. Artifact page of electronic portfolio.

3 Results and Discussion

3.1 Forum group discussion

Focus Group Discussion was conducted to get feedbacks from expert fellows using Evolutionary Scientific Literacy Assessment (ESLA). General scheme of ESLA description is presented in Figure 5.

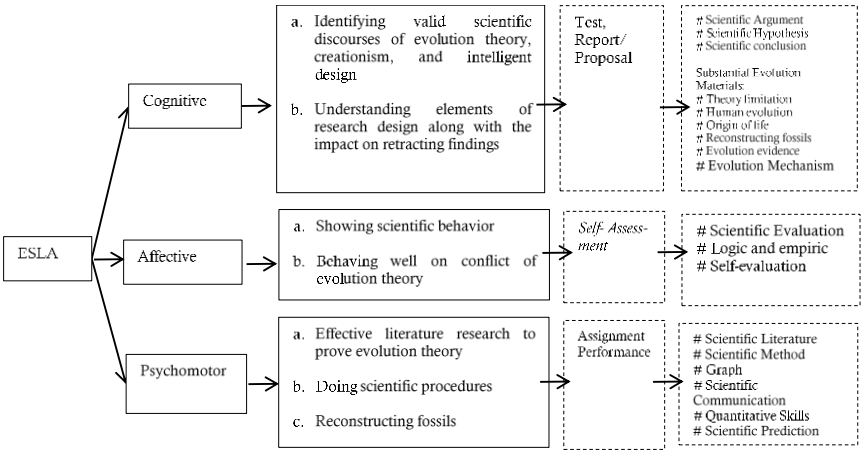

Fig. 5. Scheme of ESLA Model.

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 help lecturer assess the scientific literacy of evolution theory easier. It also helps quality assurance team of the institution to obtain students' learning progresses easier. 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.

3.2 ESLA for assessing electronic portfolio

Result of assessment of students' electronic portfolios using ESLA instrument, is presented in Table 1.

Table 1. Result of electronic portfolio assessment using ESLA

		The Level of Scientific Literacy Skill				
		Nominal	***Functional***	***Conceptual***	***Multidimensional***	∑
The Level of electronic portfolio Skill	**Beginner**	-	66%	10%	-	76%
	Intermediate	-	-	10%	4%	14%
	Proficient	-	-	-	10%	10%
	Advanced	-	-	-	-	0%
∑		0%	66%	20%	14%	100%

The use of Evolutionary Scientific Literacy Assessment (ESLA) on electronic portfolio were: first, 66% of students were categorized in functional Scientific Literacy level, i.e Students could describe a concept correctly, but had limited understanding of evolutionary knowledge; 20% of students were categorized in conceptual Scientific Literacy level, i.e students could develop some understanding of the main conceptual schemes of a discipline and link these schemes with their general understanding of science (Table 1). Result of assessment of had procedural skills and understanding of the process of scientific inquiry and technological design were 14% of students were categorized at multidimensional Scientific Literacy level, in which students could develop some understanding and appreciation of science and technology regarding their relationship with their daily lives. Students were able to make connections in scientific disciplines, and between science, technology, and the larger issues facing society. The results showed 0% of students were categorized at nominal Scientific Literacy level which meant that no one's student recognized a concept related to science, but the level of understanding experienced misconceptions.

Second, skills to make electronic portfolios from the best artifacts of students were aimed to describe the development of evolutionary learning processes and outcomes during one semester, in which 76% of students were categorized in the beginner level, where Electronic Portfolio Contents were less supported by artifacts, media formats were not varied and only consisted of text and documents (.pdf), besides students did not explain the relevance of artifacts to the concept of electronic portfolios, ideas and objectives were not delivered, students paid less attention to spelling, grammar, writing references and copyrights, and did not pay attention to layout and access to electronic portfolios. Creating electronic portfolio was considered as a new thing by students. However, as much as 10% of students were categorized in the competent level, meaning that the contents of the Electronic Portfolios were supported by artifacts with varied media formats including text, videos, photos, documents (.pdf), and website links. Portfolios were managed attractively, making it easy to track artifacts. Students could explain the relevance of artifacts to the concept of electronic portfolios, as well as convey ideas and goals by paying attention to spelling, grammar, writing references, and copyrights. The results of student electronic portfolios showed that 0% of students were categorized at advanced levels, because creating an electronic portfolio was considered as novel by students.

The scientific literacy abilities of students on the theory of evolution showed that students were at the beginner-functional level (66%); beginner-conceptual (10%); conceptual development (10%); developing-multidimensional (10%) and competent-

multidimensional (10%). Based on these, lecturers and students could find out the level of ability and make efforts to improve to achieve the desired goals at the highest level exemplary-multidimensional level. This was because the electronic portfolio is an ongoing assessment based on the work made by students to show the development of student learning [20-21] [31]. Ultimately, electronic portfolios can enhance cognitive skills and higher-order thinking skills and help improve thinking skills, solving skills, technology skills, learning achievement, and creative thinking [32].

3.3 ESLA for assessing integrative learning

After creating an electronic portfolio that could describe the students' ability of scientific literacy in evolution theory, students 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.

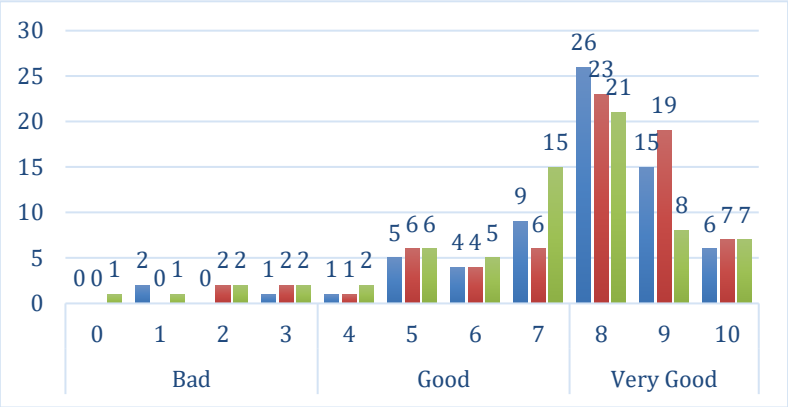

Fig. 6. Response of students on the relationship between electronic portfolio and integrative learning.

Figure 6 portrayed 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. The Artifact consists of various media as well as to encourage reflective writing and blogging skills that could facilitate metacognition in both group collaboration and individual work. Metacognition is an educational character that can develop honesty, teamwork, self-efficacy, self-expectations, and self-reflection [33]. They also provided an electronic portfolio linkage response to exhibit works (see Figure 7).

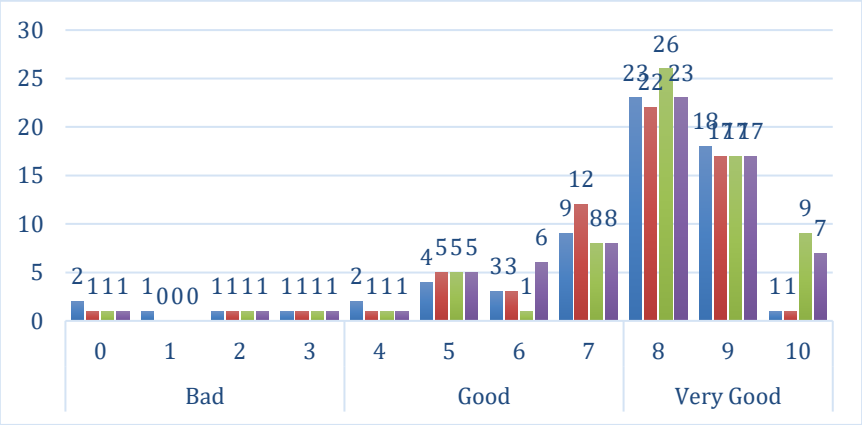

Fig. 7. Response of students on electronic portfolio as a forum of artifact exhibition.

Figure 7 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 shared artifacts with each other regardless what classes they belonged to [28] [34]. Students had a long-term access and could easily upload the contents of portfolio [35]. This phenomenon was consistent with the student's responses on the electronic portfolio used as an assessment in the evolutionary lecture (see Figure 8).

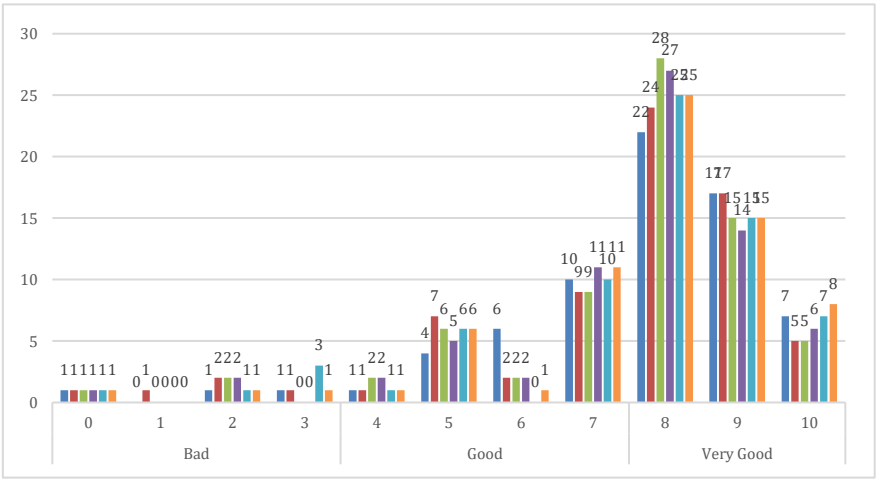

Fig. 8. Response of students' responses on electronic portfolio for assessment tool.

Figure 8 explains that the electronic portfolio students used received very good responses regarding the 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 [36] and helped to solve problems with multi-activities and assessment instruments [37]. In addition, the portfolio was able to collect, store, and create working products dealing with various multimedia or 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 assisted to understand the evolutionary materials. Then, Introduction to Assessment by Electronic Portfolios requires recommendations to make this assessment more efficient and profitable for teachers and students [38].

In short, there were several advantages of using electronic portfolio as an assessment tool. First, electronic portfolio could facilitate lifelong learning because it helped to capture, manage, and examine students' learning experience [39]. Second, through electronic portfolio, lecturers and students could construct better metacognition, communicate true concept or new information, and use data analysis [34] [40]. Third, students could use multimedia artifacts including video and audio to make the portfolio more interesting.

Fourth, electronic portfolio was more practical compared to conventional methods because it was sufficiently stored in flash drives and did not require large space [37]. 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. Fifth, this portfolio offers a new philosophy in discussion and learning, providing opportunities for students to help themselves, to show past work and one's experience for all interested parties ranging from teachers to prospective employers [41]. At last, the electronic portfolio could introduce and train students to computer literacy skills, of which become more and more relevant in the 21st century [42-44].

4 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 relevant to the industrial revolution 4.0.

5 Acknowledgement

The researchers would like to thank Ministry of Research, Technology and Higher Education of the Republic Indonesia for the support of this study in scheme of Most Outstanding Research of Higher Education in 2018.

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Article submitted 2019-11-05. Resubmitted 2019-12-06. Final acceptance 2019-12-08. Final version published as submitted by the authors.