Enhancing Student Learning Through an Open Educational Resource Competition

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Abstract — In this paper, we present an innovative open educational resource (OER) competition for students to suggest and create OERs. The competition is based on a 3E model (Enriching lectures with OERs, Extending classroom learning through OERs, and Elevating student learning with OERs), as well as a flipped learning approach (i.e., students teaching others as teachers). Student learning enhancement is evaluated using nine learning principles/catalysts. Both quantitative and qualitative evaluations are presented and discussed. In particular, the student learning reflections provide valuable insights into how the OER competition can transform student learning (e.g., with reference to the Bloom's Taxonomy/Model), including their learning attitude. The results indicate that OER competition can provide an effective method to enhance student learning, complementing traditional teaching/learning.

Keywords — OER, competition-based learning, flipped learning

I. INTRODUCTION

In recent years, there has been considerable interest in Open Education Resources (OERs) [1]. In general, OERs have three core elements: open to access and reuse; for teaching/learning/research purposes; and resource-oriented [2]. Here, from a wider perspective, we consider OERs to be World Wide Web accessible resources in general. OERs such as videos can enhance or complement conventional teaching. For example, [3] reveals that more than 98% of students commented that YouTube videos could help in their understanding of lectures. [4] also presents similar findings (i.e., YouTube videos are well-suited for explaining concepts in computing). Apart from videos, animations, web-based lab exercises, tutorials, and other online resources can also be used effectively to complement teaching and enhance student learning. While teachers can find and create OERs, and share them, this paper studies the use of OERs from a new perspective – students themselves can find and create OERs. With reference to the Bloom's Taxonomy/Model, this aims to elevate student capability or learning to a new level. By finding suitable OERs, students not only need to understand the concept and knowledge, but also analyze the materials or contents with their critical and analytical thinking skills. By creating OERs, they need to apply high-level thinking skills (e.g., creative thinking skills) as well. These learning activities can complement the traditional teaching/learning (e.g., conventional assignments). Indeed, flipped classroom pedagogies can be used to cultivate active learning, enhancing student learning experience [5]. The aforementioned learning approach can be viewed as a flipped learning approach [6], which transforms student learning and development.

To enhance the student learning experience through OERs and flipped learning, we make two contributions in this paper. First, we represent the methodologies for organizing an OER competition for students to suggest and create OERs. Second, we present both quantitative and qualitative evaluation results in an OER competition. The remainder of this paper is outlined as follows. Section II presents related work on OERs. Section III presents the methodologies and the OER competition. Section IV discusses the evaluation results. Section V provides a conclusion.

II. RELATED WORK

In this section, we give an overview of recent related work on OERs. [7] and [8] study the challenges in the adoption of OERs and the use of OERs in higher education, respectively. In [9], it is concluded that the use of OERs is at least as good as textbooks in fulfilling students' learning outcomes. [10] presents an OER-related project (OpenMed) for 10 universities in the South Mediterranean region (i.e., with cultural differences). [11] conducts a case study on the availability of OERs for computer science based on the ACM/IEEE curriculum guidelines 2013. [12] presents the community portals in MERLOT for computer science and information technology, which are endorsed by the IEEE Computer Society and IEEE Education Society. [13] presents a study on redesigning an undergraduate course based on OERs. [14] studies the integration of e-learning and OERs into a classroom. The OER project in [15] adopts a semantic web and linked data approach to enhance OER usage. [16] proposes a score model for OER metadata and employs a machine learning (Random Forest) model for predicting OER quality based on more than 8,000 OERs. [17] presents a Digital Educational Resources platform, which employs social networking and collective intelligence to facilitate searching for OERs. To facilitate reusing, remixing and redistributing OERs, [18] presents an agent-based system for automatically generating a course by combining OERs from different repositories. [19] presents the methodologies and techniques for making OER videos. [20] shares the experience of making OER videos for blended, flipped classrooms using various software.

Complementing the aforementioned related work, we present an OER competition in this paper. In general, OER competitions have two major players. The first, is students.

Through competitions, the student role grows in importance and is the key to the development of student autonomy and participation in future learning communities. For example, in [21] students go beyond the production of OERs, establishing relationships with organizations to identify areas to investigate, directing their own learning. Another, is the teachers/professors, who act as student mentors. The mentor role is explained through the International Mentoring Program Open Education for a Better World (OE4BW) [22]. Its results in 2018 and 2019 show that mentor participation is useful in producing materials with a greater impact.

III. 3E MODEL AND OER COMPETITION

In this section, we present the 3E model and the OER competition, including examples of student work.

3E Model

We first discuss the 3E model based on the overview in [23]. As shown in Fig. 1, the 3E strategy/pedagogy has three main elements: **E**nrich, **E**xtend and **E**levate. First, to enhance classroom teaching/learning, lectures are enriched with OERs (e.g., with videos). Second, to extend classroom learning, students are encouraged to share OERs (e.g., through discussion groups or competitions). Third, to elevate student learning to a new level, students are encouraged to create OERs through flipped learning. Here, we define flipped learning as students learning through their own initiatives and preparing materials for teaching others (e.g., like a teacher).

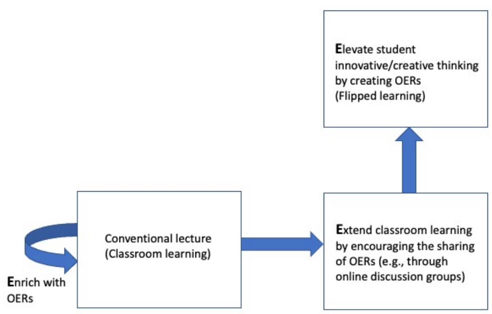

Fig. 1: 3E strategy/pedagogy

In this paper, our focus is to facilitate the Extend and Elevate pedagogies through an OER competition. Basically, for the Extend pedagogy, students are encouraged to search for OERs and write a learning reflection (e.g., to evaluate an OER and explain why it is useful). For the Elevate pedagogy, students are encouraged to create OERs, such as videos or animations, to teach other students a certain computing topic of interest (i.e., teach other students like a teacher). That means, this is a flipped learning approach. By thinking as a teacher rather than as a student, students can learn from a new perspective.

For evaluation purposes, with reference to [24], [25] and [26], Fig. 2 shows the model of nine principles/catalysts (see [24] for details) for effective learning, as enhanced by the 3E pedagogy.

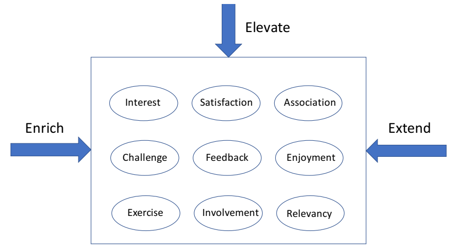

Fig. 2: Evaluation model

OER Competition

In this section, we present an overview of the OER competition. The competition has two parts: suggesting OERs, and creating OERs. For suggesting OERs, students should identify a specific learning topic, suggest a good OER from the World Wide Web, and provide a learning reflection. Optionally, they may provide additional information, such as a poster and information on its popularity. For example, suppose that a student would like to learn a sorting algorithm and find a good video. After learning from the video, the student then submits the OER by filling in a form and by providing a learning reflection and other information. This part is related to the "Extend" pedagogy of the 3E model. For creating OERs, based on a topic of interest that students have previously learned, in 2019/2020, they should create an OER (e.g., 15 pages of slides (with audio), 3-minute animation (with audio) or 3-minute video) to "teach" others. In other words, this is a "flipped learning" approach (i.e., acting as a teacher, a student teaches others using an OER). For example, suppose that a student is interested in a sorting algorithm and would like to create a short video to explain how it works, in an interesting or innovative manner. This is related to the "Elevate" pedagogy of the 3E model.

To select the winners, a judging panel comprising computing and non-computing teachers as well as a library representative, was formed. The aim is to evaluate the submissions from different perspectives. For example, for suggesting OERs (phase 2), the evaluation is based on the learning reflection according to the following aspects: critical thinking (30%), effective communications (20%), learning impact (20%), innovation (15%), and usefulness of the suggested OER (15%). When creating OERs, the evaluation is based on the created OER according to the following aspects: critical thinking (40%), effective communications (30%), innovation (15%), usefulness of the created OER (15%).

Examples of Student Work

Here, we present some examples of the student work. For suggesting OERs, students have suggested various websites and videos and provided learning reflections. The following are some examples from the contest-winning students:

Articles on Computer Science Subjects - GeeksforGeeks
https://www.merlot.org/merlot/viewMaterial.htm?id=773403097

This website provides comprehensive resources for learning data structures and algorithms. There are useful self-learning materials, videos, online exercises, and code implementations using different programming languages. This integrated approach greatly facilitates learning.

Algorithm Visualizer
https://www.merlot.org/merlot/viewMaterial.htm?id=773403099

The above website provides a visualization tool for students to learn, for example, sorting algorithms. In particular, students can see how an algorithm works, step-by-step, through an effective interface. Students can also modify the code and see the resultant effects. It is a very good demo or simulation tool for lectures and for revision purposes.

C Programming Exercises, Practice, Solution
https://www.merlot.org/merlot/viewMaterial.htm?id=773403098

This website provides a useful interface for students to learn C programming. There are many exercises with solutions for students to practice C programming. In particular, students can write C programs using the web-based code editor, and run the codes.

Map of Computer Science
https://www.merlot.org/merlot/viewMaterial.htm?id=773403549

Last but not least, this YouTube video provides a good overview or a big picture of computer science, covering the major topics. It can be used effectively in introductory lectures.

When creating OERs, students have created various learning videos using a flipped learning approach (i.e., using the videos to teach others as if the students themselves were the teachers). Here are two examples from the award-winning students.

The first student created a video to explain the concept of LZW compression (i.e., teaching others LZW compression). It is inspired by an example drawn from daily life: how can long, duplicated activities be streamlined? If we cannot avoid these activities, at least we should shorten or streamline some of them. For example, making a big pot of purple paint for coloring is much faster than mixing red and blue each time. This can be applied to LZW compression: it uses a symbol to replace a long substring. Then, the encoded string of 10 repeated substrings in the example, will become a length of 10. Although the whole string still has repeated elements, the duplicated elements are much shorter. LZW compression reduces the file size by half, making it 2GB in size and shortening transmission time.

Using an analogy, we can explain LZW compression as follows. Assume that someone wants to paint a butterfly drawing, but only has three colors: blue, red and yellow. To improve his/her art, he/she wants to add the colors purple and green. One solution is to mix red and blue for purple, and blue and yellow for green. If he/she were to mix colors every time he/she needs purple or green, it may take him/her an hour to finish. Despite being able to finish the work, it is a time-consuming task to mix colors. Instead, making a pot of purple paint is much faster, coloring purple becomes a swift job, and the task may be finished within half an hour.

LZW compression uses a similar approach. If an encoded string is "10303041032030", the number of bits is 126. Several repetitive substrings appear, such as "03", "10" and "030", and these substrings can be turned into new symbols, and added to the dictionary. The common point between this and the painting example, is the making of a new pot of color by mixing two old colors. Afterwards, the string can be written as "1036045328", with a bit-size of 90. The following are screenshots of a video that introduces this analogy, and the result of LZW compression.

In summary, the student has created a good educational video to explain a difficult concept in a simple way. By drawing concepts parallel to real life experiences (i.e., using analogies), many computing concepts can become very easy to understand.

In the second example, a first-year student created an animation to explain the basic concepts of probability. The student likes interactive teaching methods, such as watching videos and participating in different activities, so the student chose animation. For some students (e.g., without a strong mathematical background), it may be more difficult to understand certain probability concepts from a pure mathematical perspective. On the other hand, it may be easier to explain certain mathematical concepts using scenarios drawn from daily life, such as tossing a coin, calling students, or drawing balls from a box. In other words, using real-life examples can facilitate students' understanding of basic mathematical concepts. Hence, the student created colorful animations to explain the probability concepts with easy-to-understand examples.

IV. EVALUATION

In this section, we discuss the evaluation of the OER competition. We have conducted both quantitative and qualitative evaluations. The quantitative evaluation is based on a student survey using the nine learning catalysts/principles. Competition participants (both BSc and MSc students) were invited to complete a web-based survey. A total of 18 responses was received. The qualitative evaluation is based on student learning reflection. A small focus group with three prize winners was also conducted to discuss the learning reflection.

Quantitative Evaluation

Fig. 3 shows that over 90% of the students agree or strongly agree that OERs are useful in facilitating understanding/learning. The result suggests that students believe that OERs can complement other teaching/learning materials. Fig. 4 shows that about 80% of the students agree or strongly agree that OERs can improve a lecture. This is related to the Enrich pedagogy of the 3E model. In terms of the overall learning experience, Fig. 5 shows that more than 80% of students agree or strongly agree that OERs can enhance the learning experience. Further discussion is shown below, in the section on qualitative analysis. For students who participated in creating OERs, almost 90% agree or strongly agree they can learn better by creating OERs (see Fig. 6). Note that this is related to the Elevate pedagogy of the 3E model. In other words, by creating OERs, students' learning capability can be elevated to a new level. Further analysis can be found in the later learning reflections. With reference to the aforementioned evaluation model for the nine learning principles/catalysts and the survey form, Fig. 7 shows the learning enhancements for suggesting OERs, and Fig. 8 shows the respective mean scores. Note that a 7-point scale is used (1: slightly enhanced – 7: significantly enhanced). It indicates that the more significant learning enhancements are: Association, Involvement, Relevancy and Satisfaction. By finding OERs, students need to be actively involved in the searching process and to associate their knowledge with the materials. Through this relevant learning process, they should have a more satisfactory learning experience. However, the Challenge component has a relatively low score, probably because it does not require difficult problem-solving skills. In relation to Bloom's Taxonomy/Model, the learning process involves more "understanding" and "analyzing" skills. Fig. 9 shows the learning enhancements for creating OERs and Fig. 10 shows the respective mean scores. Compared to suggesting OERs, the mean scores are in general higher, indicating that creating OERs can provide more and better learning enhancements. Similar to the above, Association, Involvement, Relevancy and Satisfaction provide relatively more significant learning enhancements. In addition, Enjoyment also has a high mean score, indicating that students enjoyed this new learning process, which can complement conventional learning activities. Creating OERs is a more active learning activity, because higher level thinking skills, such as critical analysis and creative thinking, are required. Moreover, this flipped learning approach allows students to think from a new perspective (i.e., teach others as a "teacher").

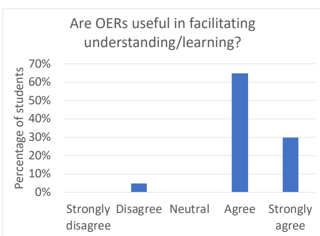

Fig. 3: OER usefulness

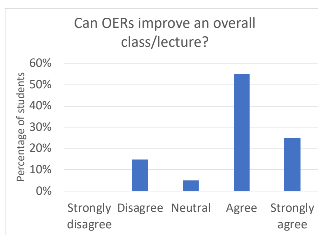

Fig. 4: OER use to improve a class

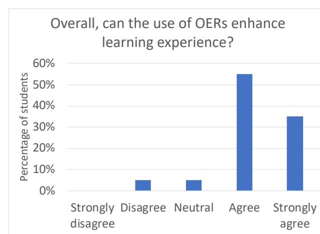

Fig. 5: OER use to enhance learning experience

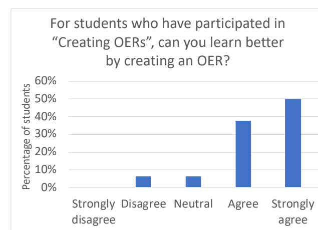

Fig. 6: Learning effectiveness by creating OERs

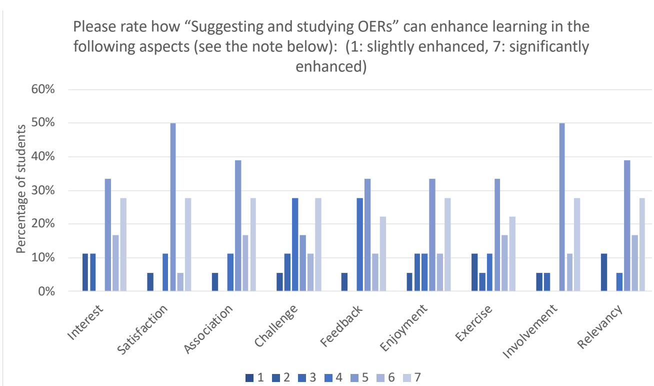

Fig. 7: Learning enhancements for suggesting OERs (1: first left bar, 7: first right bar)

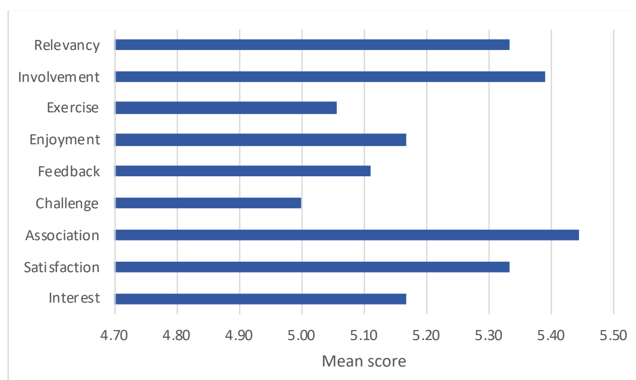

Fig. 8: Learning enhancement scores for suggesting OERs

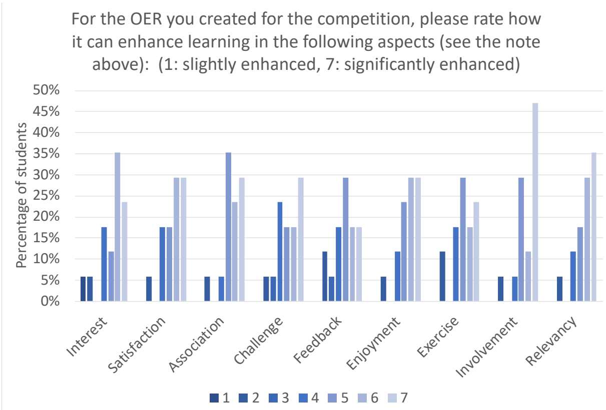

Fig. 9: Learning enhancements for creating OERs (1: first left bar, 7: first right bar)

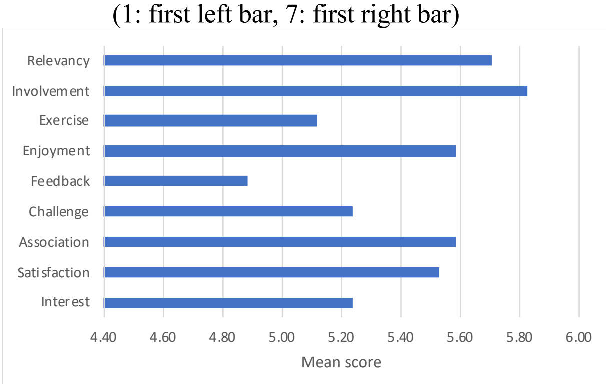

Fig. 10: Learning enhancement scores for creating OERs

Qualitative Evaluation: Student Learning Reflection

For the OER competition, we also conducted qualitative evaluation based on student learning reflections especially with reference to the Bloom's Taxonomy/Model. The following learning reflections show that the OER competition can enhance or transform student learning in various aspects. Note that to maintain the original content, student comments or reflections were only slightly edited.

"This competition has helped me discover new learning materials and learn how to make the most out of what I learned through reflection …"

"This OER competition encourages me to take the initiative in learning. I discover more useful OERs, which are helpful for my studies …"

"I think the OER competition is really a good opportunity for students to not only learn more professional knowledge, but also think about how to make complicated concepts easier to understand …"

"After the OER competition, I treasure the value of personifying abstract concepts. An intuitive and metaphorical explanation speaks for itself, and intimidating computing concepts dissolve into understandable knowledge, even in the eyes of a non-expert."

"The OER competition has provided me with the opportunity to dig deeper into interesting topics when I was preparing the teaching materials. I can relate those interesting topics to my studies and gain a better understanding of those topics …"

"The OER competition is the best motivational activity for me to not only further develop my academic knowledge, but also to review the insufficiencies of my previous learning model …"

"After I created an OER, I found that I learn more deeply on this topic, since I do more research before writing the script on this video. I think creating an OER, like doing a small project, will organize your own knowledge …"

"This OER competition gave me an opportunity to review the OERs I have learned, and reflect on them."

In summary, the above student reflections indicate that the competition has strengthened the students' understanding of the topics (e.g., explaining a complex concept in a simple manner). It also motivates the students to learn and think (e.g., to continue the self-learning process in the future) and enhances their evaluation skills (e.g., evaluating whether a resource is useful or not). Furthermore, it enhances students' organization and analysis skills (e.g., how to better organize materials or present complicated concepts in a simple manner). The above student reflections also reiterate the flipped learning approach (i.e., from the student perspective), which is related to the higher thinking and learning skills of the Bloom's Taxonomy/Model. For instance, it motivates students to create new things or new ways of presenting a concept (e.g., using a metaphor approach). This is unlike traditional exercises or assignments, allowing students to learn from a new perspective.

V. Conclusion

In this paper, we have presented an OER competition to enhance student learning. It is based on the 3E model, particularly the Extend and Elevate pedagogy. Students are encouraged to search for OERs and to create OERs. In particular, to create OERs, the flipped learning approach is used to elevate student learning to a new level. Both quantitative and qualitative evaluations have been conducted. The results show the OER competition can enhance and transform student learning in different ways. The OER competition can be a good learning activity to complement traditional exercises. As future work, an international OER contest is being organized.

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