Analysing the Effectiveness of a Social Digital Repository for Learning and Teaching: A Fuzzy Comprehensive Evaluation

Akrivi Krouska[a], Christos Troussas[b], Phivos Mylonas[c] and Cleo Sgouropoulou[d]
Department of Informatics and Computer Engineering, University of West Attica, Egaleo, Greece

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Abstract: Since the beginning of the 21st century, Open Education has emerged as an important field in education. Open Educational Resources (OERs) are closely related to it, which are hosted in Digital Repositories. OERs, despite their global recognition and their growing number, are not yet established widely. Teachers face many challenges when they want to use them, including the lack of pedagogical knowledge about their value, the way to use them, produce them and integrate them into teaching process. The purpose of this research is to strengthen the movement of OERs and to realise their full potential. To this end, a social digital repository was developed, for promoting OERs in primary education. This platform aims to create an open and interactive community of teachers, where through interaction, communication and collaboration, the teachers will be educated on OERs. The effectiveness of this digital repository is assessed using the fuzzy comprehensive evaluation model, in order to handle the subjective and imprecise information and better interpret the results of the survey. The results are very encouraging regarding the adoption of this technology.

1 INTRODUCTION

The Open Educational Resources (OERs) constitute the recently emerging concept in education, having attracted the interest of researchers as well as the recognition and support of international institutions, governments and funders (Santos-Hermosa, Ferran-Ferrer, & Abadal, 2017; Xie, Di Tosto, Chen & Vongkulluksn, 2018). OERs can support the role of education as an engine of social change (Barrueco & Termens, 2021), creating knowledge societies and contributing to the provision of quality, equitable, open and participatory education. At the same time, they enhance the academic freedom and professional autonomy of teachers by expanding the range of available educational materials (Admiraal, 2022). Through providing access to a variety of resources, information and practices, they contribute significantly to improving education in all sectors and promote Open Education (Santos-Hermosa, Ferran-Ferrer, & Abadal, 2017; Admiraal, 2022).

OERs are high-quality educational resources that teachers can use to prepare, improve or supplement their teaching practice (Admiraal, 2022; Xie, Di Tosto, Chen, & Vongkulluksn, 2018). The open licenses that accompany OERs allow for their modification, a process that fosters creativity and shapes new content that can be used for personalized instruction (Blomgren, 2018). Furthermore, OERs can contribute to the achievement of effective learning (Tang & Bao, 2020), as they stimulate learners' interest in learning and increase satisfaction from the learning experience (Chen, 2020).

Educators and learners spend many hours of creating educational materials, searching, locating, acquiring and reusing, with or without revisions (Blomgren, 2018). OERs are a viable solution for them to address the challenges of access, quality and cost (Blomgren, 2018; Chen, 2020). However, despite their global recognition and the growing number of OERs, the levels of their use remain low (Admiraal, 2022; Ossiannilsson et al., 2020; Schuwer

[a] https://orcid.org/0000-0002-8620-5255
[b] https://orcid.org/0000-0002-9604-2015
[c] https://orcid.org/0000-0002-6916-3129
[d] https://orcid.org/0000-0001-8173-2622

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& Janssen, 2018) or may be hidden (Beaven, 2018), meaning that teachers find resources online, receive them from colleagues or already have resources in their personal collections without being aware of OERs (Admiraal, 2022). On the one hand, teachers face many challenges when they want to use OERs, and on the other hand, not enough attention has been paid so far to their improvement and promotion (Chen, 2020). In fact, according to Tang, Lin, & Qian (2021), the levels of acceptance of OERs remain low especially in primary and secondary education (K-12 education). Other reasons why teachers' adoption of OERs is limited are their low quality (Huang, Tlili, et al., 2020), their insufficient pedagogical value (Abramovich & McBride, 2018) and the difficulty of finding resources that are up-to-date and thematically relevant to the subject they teach (Admiraal, 2022).

In order to overcome the above limitations, this paper introduces a social digital repository for promoting OERs in primary education. A digital repository refers to an online storage system or database designed to collect, manage, preserve, and provide access to digital content and assets. Digital repositories can host and provide access to OERs, serving as platforms where educators and institutions share educational materials openly. The developed platform aims to motivate and facilitates teachers to be actively engaged in using, creating and sharing OERs. As such, this social digital repository provides a user-friendly interface to search, develop and rate content, as well as its social networking functionality enables the communication and collaboration among the repository community. For assessing its effectiveness, a fuzzy-based evaluation process was conducted. The fuzzy evaluation method is used in order to deal the subjective and imprecise information and better interpret the results of the survey.

2 SOCIAL DIGITAL REPOSITORY OVERVIEW

The developed social digital repository belongs to the category of Thematic Repositories, and specifically to the subcategory of independent repositories, as it hosts content related to a specific topic and is initiated by the authors of this paper. It is aimed at primary education teachers, hosting OERs that can be used to prepare, improve or supplement their teaching practice.

The repository's OERs are characterized by heterogeneity in terms of their educational and technological characteristics on the basis of which they are organized into categories. In particular, the repository includes interactive exercises, quizzes, crosswords, presentations, videos, images, assessment tests, worksheets, etc. To facilitate searching and selecting them, OERs have been organized into six main categories according to the grade of primary education to which they are addressed and into subcategories based on the subject in which they fall. In addition, for the categorization of OERs, one or more tags, i.e., keywords or phrases, have been added to them, which act as descriptive elements (Troussas, Krouska, & Sgouropoulou, 2021). The open licenses that have been chosen to accompany OERs are Creative Commons (CC) licenses and, in particular, three types of licenses have been utilized: Attribution – Non-Commercial – Share Alike (CC BY-NC-SA), Attribution – Non-Commercial – Share Alike 3.0 Greece (CC BY–NC–SA 3.0 GR), and Public Domain Dedication (CC0).

Each OER is associated with metadata, i.e., a set of data that identifies it. The metadata schema of the repository is based on the Dublin Core metadata schema, which is the responsibility of the Dublin Core Metadata Initiative IEEE Learning Technology Standards Committee. In particular, each resource is accompanied by its title and a representative image (thumbnail), as well as metadata that constitute either general data or data related to its classification. The general elements include a brief description of the content, keywords, the date of creation, the author, the source and the licence under which the OER is distributed. The classification elements include the subject area in which the resource belongs, the class(es) to which it is addressed and the type of resource. Each AEP can be rated by the repository members by clicking on one of the five stars to indicate its quality or can be commented.

The social networking feature of the repository enables the members to the following actions. They can exchange public/private messages with each other, make friends, create groups and become members of them. Furthermore, they can make status updates (posts), publish and share OERs they have developed or customized and receive feedback on them. Finally, they can identify, rate, comment and share opinions on OERs and share them on their personal profiles. The members of the repository can create and/or join groups based on their interests. Groups are aggregations of members, posts and any other user-generated content. The activity stream records all kinds of activity, such as blog posts, new friendships and blog comments. A central aspect of the user experience is receiving notifications.

3 FUZZY COMPREHENSIVE EVALUATION FRAMEWORK

In order to assess the usability of the developed social digital repository, the fuzzy comprehensive evaluation method was used. This model incorporates fuzzy logic to handle uncertainty and imprecision in the evaluation process. In particular, it provides a fuzzy mapping process of each evaluation criterion, i.e., content quality, usability, social engagement, and educational effectiveness, to a set of linguistic variables, i.e., "high", "medium" and "low". Establishing these fuzzy sets allows a specific rating, e.g. the average rate of 4.34 in a question on 5-point scale, to be associated with both categories of "high" and "medium" based on the degrees of membership. As such, a better understanding of the questionnaire feedback is obtained by transforming the quantitative rating into qualitative one using fuzzy sets.

The steps of the fuzzy comprehensive evaluation method are illustrated in Fig. 1.

Figure 1: Steps of Fuzzy Comprehensive Evaluation.

3.1 Define Evaluation Criteria

The evaluation criteria defined for assessing the social digital repository were four, namely content quality, usability, social engagement and educational effectiveness. Each criterion was measured based on 4 indicators, as shown in Table 1. The selection of these criteria was made because they cover all the aspects of the social networking-based digital repository for learning and teaching, contributing to a comprehensive evaluation of its overall features and capabilities.

The set of the selected n evaluation criteria can be represented as a vector, where n = 4:

$C = \{c_1, c_2, c_3, c_4\}$ = *{content quality, usability, social engagement, educational effectiveness}*

Moreover, the indicators are represented as $I = \{I_1, I_2, \ldots, I_{16}\}$.

Table 1: Evaluation Criteria and Indicators.

Criteria	Indicators
Content quality (CQ)	1. Is the content rating aligned with its quality?
	2. Does the repository offer a diverse range of learning objects?
	3. Do the metadata of the learning objects correspond properly to their content?
	4. Is the content presented accurate and up-to-date?
Usability (U)	5. Is the interface user-friendly?
	6. Do you enjoy interacting with the repository?
	7. Can you easily find and access the educational resources you need?
	8. Do you like the way with which the learning objects are presented?
Social engagement (SE)	9. Do you enjoy the social interaction feature provided, such as commenting or group discussions?
	10. Do you find the interactive features of the social digital repository engaging and helpful?
	11. Do the social interaction features facilitate the communication and knowledge sharing among repository community?
	12. How responsive and supportive is the repository community in providing feedback or assistance when needed?
Educational effectiveness (EE)	13. Does the repository contribute to measurable learning outcomes?
	14. Is the design of the learning objects aligned with effective pedagogical principles and instructional strategies?
	15. Is the content aligned with educational objectives?
	16. Do you find the repository an effective tool for learning and teaching?

3.2 Establish Fuzzy Sets and Linguistic Variables

The indicators are aligned in the same m grade levels, being represented as a vector, where m=3:

V = {v1, v2, v3} = {low, medium, high}

As such, the fuzzy set of each indicator has the same linguistic variables, namely low, medium and high. The evaluation process aims to provide a mapping from I to V. For each criterion c_i the fuzzy mapping of its indicator I_k to grade levels vector V is represented by the vector:

$$Rik = \{r_{ik1}, r_{ik2}, \ldots, r_{ikm}\},$$

where r_{ikt} indicates the fuzzy membership degree of the indicator k of criterion i to the grade level t. For example, if $R_{11} = \{0, 0.3, 0.7\}$, it means that the indicator "Is the content rating aligned with its quality?" of the criterion "Content quality" has a membership degree of 0.3 in the "medium" level and 0.7 in the "high" level.

As such, the fuzzy matrix of each criterion i is represented as follows:

$$R_i = \begin{bmatrix} r_{11} & \cdots & r_{1m} \\ \cdots & \cdots & \cdots \\ r_{k1} & \cdots & r_{km} \end{bmatrix}, \text{ where k = 4 and m = 3}$$

3.3 Determine Membership Functions

In this paper, each indicator is evaluated by the participants using a 5-point scale. Therefore, a score emerged from the average rating of all participant is assigned to each indicator. The value of this score ranges from 1 to 5. Then, the triangular membership function is used to calculate the degree of each grade level, as follows:

$$\mu_{low}(x) = \begin{cases} 0, & x \le 1 \\ \frac{x-1}{1}, & 1 \le x \le 2 \\ \frac{3-x}{1}, & 2 \le x \le 3 \\ 0, & x \ge 3 \end{cases}$$

$$\mu_{medium}(x) = \begin{cases} 0, & x \le 2 \\ \frac{x-2}{1}, & 2 \le x \le 3 \\ \frac{4-x}{1}, & 3 \le x \le 4 \\ 0, & x \ge 4 \end{cases}$$

$$\mu_{high}(x) = \begin{cases} 0, & x \le 3 \\ \frac{x-3}{1}, & 3 \le x \le 4 \\ \frac{5-x}{1}, & 4 \le x \le 5 \\ 0, & x \ge 5 \end{cases}$$

Fig. 2 shows the triangular membership functions scheme.

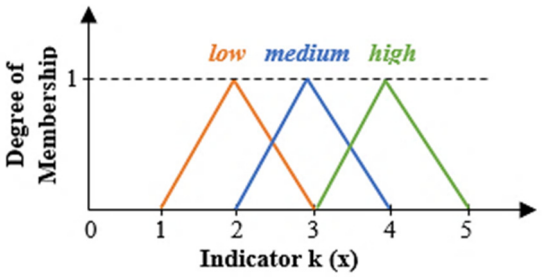

Figure 2: Triangular membership functions representation.

3.4 Define Fuzzy Rules

In this step, a set of fuzzy rules are established to define the relationships between evaluation criteria and overall evaluation of system's effectiveness, named Overall Effectiveness (OE). The fuzzy rules are designed based on the authors' knowledge as expert on the field, regarding how each criterion contribute to the overall evaluation.

A sample of the defined fuzzy rules is the following.

- IF CQ = medium and U = high and SE = medium and EE = medium THEN OE = medium
- IF CQ = high and U = high and SE = medium and EE = medium THEN OE = high
- IF CQ = medium and U = medium and SE = low and EE = low THEN OE = low
- IF CQ = high and U = medium and SE = medium and EE = medium THEN OE = medium
- IF CQ = low and U = medium and SE = low and EE = medium THEN OE = low

3.5 Determine Criteria Weights

Determining criteria weights is a crucial step, since relative importance is assigned to different evaluation criteria. These weights affect the decision-making in the overall assessment process. Each criterion's weight indicates its contribution to the final

evaluation, allowing for a more context-aware analysis. The sum of the weights should be 1 to maintain normalization.

The criteria weights can be determined through various methods, including expert opinions, surveys, or analytic hierarchy process (AHP). In this paper, the weights are defined based on authors' expertise. As such, the weights of each indicator I_k of each criterion c_i are the following:

$$W_1 = [0.325, 0.155, 0.295, 0.225]$$
$$W_2 = [0.255, 0.155, 0.305, 0.285]$$
$$W_3 = [0.175, 0.235, 0.315, 0.275]$$
$$W_4 = [0.175, 0.315, 0.235, 0.275]$$

4 EXPERIMENTAL WORK, RESULTS & DISCUSSION

The developed social digital repository was used by 40 teachers at public primary schools in Greece, during the school year of 2022-2023. Table 2 illustrates the demographical characteristics of the participants.

Table 2: Demographic characteristics of 40 participants.

Characteristic		Percentage
Gender	Female	57.5%
	Male	42.5%
Age	<30	12.5%
	30 – 40	42.5%
	40 – 50	25%
	>50	20%
Computer literacy	High	70%
	Medium	20%
	Low	10%
Educational level	Bachelor	27.5%
	Master	67.5%
	PhD	5%

The participants were interacting with the system, utilizing the provided learning objects to their teaching, commenting them, uploading their learning objects, communicating with repository community through private and public discussion rooms. At the end of the school year, a 5-point Likert scale questionnaire was delivered through Internet to the participants, including the 16th indicators. All participants corresponded positively to the process, answering the questionnaire. Table 3 shows the results of the survey.

Table 3: Results of survey.

Criterion	Indicator	5-point scale					Avg
		1	2	3	4	5	
CQ	I1	4	5	11	10	10	3.425
	I2	2	2	7	11	18	4.025
	I3	4	8	7	11	10	3.375
	I4	3	6	11	11	9	3.425
U	I5	8	9	7	9	7	2.95
	I6	4	7	8	10	11	3.425
	I7	6	10	10	7	7	2.975
	I8	3	3	9	9	16	3.8
SE	I9	2	2	5	12	19	4.1
	I10	2	3	6	14	15	3.925
	I11	1	1	9	13	16	4.05
	I12	4	6	11	9	10	3.375
EE	I13	3	9	11	8	9	3.275
	I14	4	9	8	9	10	3.3
	I15	4	6	7	9	14	3.575
	I16	5	3	10	13	9	3.45

Based on the results of the survey, the following fuzzy matrixes are structured:

$$R_1 = \begin{bmatrix} 0 & 0.575 & 0.425 \\ 0 & 0 & 0.975 \\ 0 & 0.625 & 0.375 \\ 0 & 0.575 & 0.425 \end{bmatrix}$$

$$R_2 = \begin{bmatrix} 0.05 & 0.95 & 0 \\ 0 & 0.575 & 0.425 \\ 0.025 & 0.975 & 0 \\ 0 & 0.2 & 0.8 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0 & 0 & 0.9 \\ 0 & 0.075 & 0.925 \\ 0 & 0 & 0.95 \\ 0 & 0.625 & 0.375 \end{bmatrix}$$

$$R_4 = \begin{bmatrix} 0 & 0.725 & 0.275 \\ 0 & 0.7 & 0.3 \\ 0 & 0.425 & 0.575 \\ 0 & 0.55 & 0.45 \end{bmatrix}$$

After calculating the above fuzzy sets, the fuzzy rules and the weights are applied to estimate the degree of each criterion. The fuzzy variables emerged from the required calculations are described in Table 4.

The content quality is rated in medium and high level. This suggests that the repository is perceived positively in terms of representative content rating, diversity of learning objects, metadata correspondence, and the accuracy of presented content. The repository's strength lies in providing accurate and diverse content, aligning well with user expectations.

Table 4: Fuzzy evaluation results.

Criterion	Indicator	Linguistic Variables based on Survey	Overall Evaluation
CQ	I1	Medium and High	Medium and High
	I2	High	
	I3	Medium and High	
	I4	Medium and High	
U	I5	Low and Medium	Medium
	I6	Medium and High	
	I7	Low and Medium	
	I8	Medium and High	
SE	I9	High	High
	I10	Medium and High	
	I11	High	
	I12	Medium and High	
EE	I13	Medium and High	Medium and High
	I14	Medium and High	
	I15	Medium and High	
	I16	Medium and High	

The overall fuzzy result for usability is medium, with variations in user-friendliness and ease of access across different indicators. While interactions are generally enjoyable, there are areas of improvement identified, such as a less user-friendly interface and challenges in easily accessing educational resources. The repository may benefit from addressing specific usability concerns to enhance the overall user experience.

The high fuzzy result for social engagement indicates that users find the social interaction features enjoyable and engaging. Additionally, the repository is perceived to facilitate effective communication and knowledge sharing within the community. The strong social engagement suggests that the repository is successful in fostering a collaborative and interactive environment.

The fuzzy result for educational effectiveness is medium to high, reflecting positive perceptions regarding the repository's contribution to measurable learning outcomes, alignment with pedagogical principles, and effectiveness as a learning and teaching tool. The repository appears to be a valuable resource for supporting educational objectives and learning outcomes.

5 CONCLUSIONS

OERs and digital repositories play a crucial role in modern education, offering various benefits that contribute to the accessibility, flexibility, and quality of learning. As such, this paper presents a social digital repository for promoting OERs in primary education. The paper aims to assess the effectiveness of the digital repository regarding the content quality, the usability, the social engagement and the educational effectiveness, using the fuzzy comprehensive evaluation model.

The fuzzy evaluation results show the social digital repository's strengths and areas for improvement. The evaluation across different criteria and indicators highlights the multifaceted nature of the repository's performance. The social digital repository generally performs well across content quality, usability, social engagement, and educational effectiveness. The findings can guide further enhancements to optimize user experience, content quality, and educational impact.

Part of our future work is to improve the social digital repository functionalities in order to increase its effectiveness and user experience. Another future plan is the enhancement of fuzzy comprehensive evaluation model with the application of other weighting techniques, the application of further evaluation frameworks and the comparison of the repositories with other ones.

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