An OER Recommender System Supporting Accessibility Requirements

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Open Educational Resources are becoming a significant source of learning that are widely used for various educational purposes and levels. Learners have diverse backgrounds and needs, especially when it comes to learners with accessibility requirements. Persons with disabilities have significantly lower employment rates partly due to the lack of access to education and vocational rehabilitation and training. It is not surprising therefore, that providing high quality OERs that facilitate the self-development towards specific jobs and skills on the labor market in the light of special preferences of learners with disabilities is difficult. In this paper, we introduce a personalized OER recommeder system that considers skills, occupations, and accessibility properties of learners to retrieve the most adequate, high-quality OERs. This is done by: 1) describing the profile of learners with disabilities, 2) collecting and analysing more than 1,500 OERs, 3) filtering OERs based on their accessibility features and predicted quality, and 4) providing personalised OER recommendations for learners according to their accessibility needs. As a result, OERs retrieved by our method proved to satisfy more accessibility checks than other OERs. Moreover, we evaluated our results with five experts in educating people with *visual* and *cognitive* impairments. The evaluation showed that our recommendations are potentially helpful for learners with accessibility needs.

1 INTRODUCTION

Open Educational Resources (OERs) are free and open-licensed educational materials that are ideally composed of course planning, thematic content, and assessment tools [8]. OERs are typically provided by OpenCourseWare systems (e.g., MIT[1]) in various formats (e.g., videos, audio, slides). Since self-learning is oftentimes the most typical way to acquire new skills or update existing skills to match the rapidly changing requirements of the labour market [12], OERs can potentially provide open access materials that can be used by a wide range of learners over the web. Consequently, there is a need to identify high-quality OERs that address learners' needs and preferences in a wide range of contexts. These learners include people with disabilities who have diverse needs, depending on the type and severity of their disabilities. As per the WHO statistics, one billion of the world population has some form of disability, and it is expected to double by 2050 [16]. At the European level, about *60%* of citizens with disabilities are employed (employment rate of persons without disabilities is *82%*), and *22.5%* of the youth with disabilities abandon education systems early (only *11%* of youth without disabilities) [9]. The lack of access to education, vocational rehabilitation, and training is among the most important reasons of low rates of employments [15].

Our research seeks to address the following questions: 1) how to represent profiles for learners with accessibility needs, and 2) how to retrieve high quality OERs with respect to these learners' preferences. In order to answer these questions, the following steps were carried out: 1) We formally represented the accessibility requirements of OCW by using the concepts of the AccessibleOCW ontology [1]. Afterwards, 2) we reused the OER recommender system [11] to implement our approach and retrieve high-quality OERs that are relevant to the accessibility needs of learners as

[1] https://ocw.mit.edu/

Preprint version – This paper has been accepted to be published in the 22nd International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '2020), October 26–28, 2020. ACM.

defined in the AccessibleOCW ontology and the learner profile. Finally, 3) we evaluated the accessibility of the results by means of manual and automatic testing, and also by getting feedback from experts.

2 BACKGROUND AND RELATED WORK

Accessibility and Design for All refers to the creation of products, environments, programs and services that can be used by all people, to the greatest extent possible, without the need for adaptation or specialized design [7]. In general, accessibility requirements are defined by the web accessibility guidelines, such as W3C Web Content Accessibility Guidelines (WCAG) 2.1 [14], W3C Cognitive and Learning Disabilities Accessibility Task Force (Cognitive A11Y TF) [13], IMS AccessforAll [6], and Easy-to-Read [3], to lead the development of accessible systems. Inclusive OCWs, therefore, should address these accessibility requirements [2].

Although there is a large amount of OCW platforms and OER repositories (e.g., MERLOT collection hosts over 40,000 openly available resources from over 250 providers[2]), accessibility is still not widely addressed by OERs [17]. According to a systematic review focusing on recommender systems in e-learning [4], from 108 papers that were studied, only one has considered accessibility in its approach. Therefore, there is a need to help learners define their preferences, and retrieve OERs matching their needs (e.g., blind users might prefer textual over video resources).

In this paper, we are reusing our AccessibleOCW ontology to represents the accessibility needs and features of OCW systems [1] and the open education recommender system [11, 12] to implement our approach. The AccessibleOCW ontology reuses and extends the *User* concept from the ACCESSIBLE ontology [5] to represent users with disabilities along with the accessibility specifications of e-learning systems as defined by the IMS Global AccessForAll (IMS AfA) [6]. The open education recommender [11, 12] is built to help learners to self develop towards skills based on their personalised needs, OER properties, and skill descriptions (from Wikipedia).

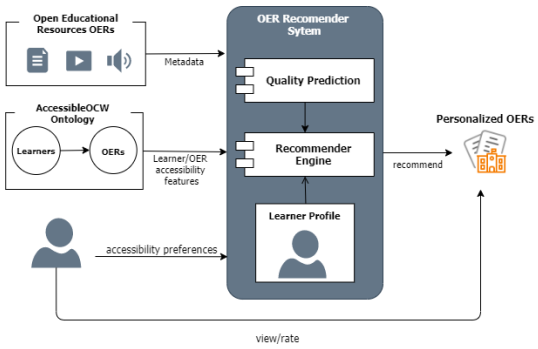
3 ACCESSIBLE OERS RECOMMENDATION APPROACH

Our recommender system[3] uses the knowledge of the AccessibleOCW ontology[4] to describe the accessibility preferences of the learner profiles and educational resources. For this, learners are asked to create a profile and the recommender engine uses the learners' profile, OER quality prediction, and learners' ratings to recommend the best matching OER, as illustrated in Figure 1 and explained as follows.

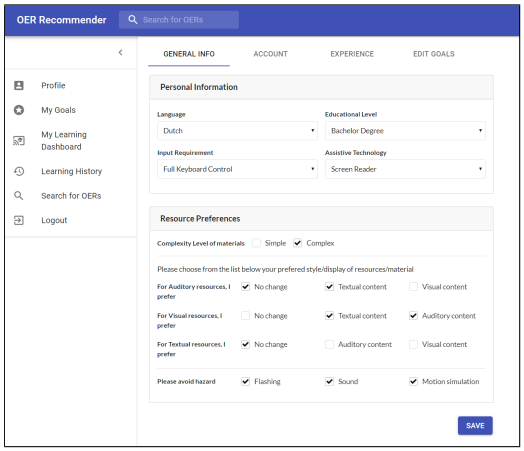
Learner Profile. During the registration, a new user is asked to optionally enter: 1) Personal information (i.e., name, gender, date of birth) and current occupation, 2) Accessibility preferences, and 3) Target skills and their current level. To avoid disability disclosure, the learner has the option to initialise her own accessibility preferences by a float number between 0 and 1 for each accessibility field. For the fields that are not filled by learners, we use the list of the users with similar disabilities and initialise the accessibility fields based on their preferences. It should be mentioned that in case that we do not find similar users, we set the accessibility preferences as defined in the AccessibleOCW ontology.

Quality Prediction. To predict the quality of OERs, we used the approach [10] that creates a scoring model for OER metadata, and a prediction model of OERs quality based on their metadata. The study showed that there is a tight relationship between OER metadata quality and OER quality control processes, in such a way that the more an OER passes quality control processes, the higher is the probability of containing high-quality metadata. Accordingly, the

[2] https://www.merlot.org
[3] https://oer-recommender.com
[4] https://vocol.iais.fraunhofer.de/accessibilityOnto/visualization



(a) Accessible OER recommendation architecture



(b) Learner Profile - Accessibility Preferences

Fig. 1. OER Recommender System supporting accessibility requirements

model predicts whether an OER passed the quality control process or not based on its metadata. Therefore, we applied this prediction model on the collected OERs and removed the ones that were indicated as *Without Quality Control*.

Recommendation Engine. In order to include accessibility in our OER recommender engine, we create a 28-dimensional vector of X (according to the available accessibility list[5]) for each OER regarding their accessibilities. For this, when an OER has a specific accessibility, we set its corresponding value in the list to 1, and otherwise set the value to 0. Respectively, for each learner, we define a 28-dimensional vector P as a preference vector based on his/her accessibilities preferences that contains a float weight (between 0 and 1) for each parameter in X. The goal is to find the best weights (P vector) for each learner based on their rating satisfaction. Therefore, we use *Gradient Descend* to optimize the preference vector (P) based on users' ratings by minimizing the following loss function:

$$LossFunction = \sum_{o=recommended\_OERs} |(P \cdot X_o) - Y_o| \quad (1)$$

where X_o is the 28-dimensional vector of an OER o and Y_o is the satisfaction rating (between 0 and 1) of the learner for that particular OER o. Finally, to recommend an OER to a learner u for a particular skill s, our system checks the available OERs according to the learner's occupation and the level that learner u has in skill s, and calculates cosine similarity for them to recommend the OER with the closest X vector to the user preference vector (P).

4 EVALUATION

We evaluated our recommender system through two use cases: *Use case 1:* English Language educational resources that are relevant to visually impaired users, and *Use case 2:* Business educational resources that are relevant to cognitive impaired users (i.e., intellectual and neurodevelopmental disabilities). For each use case, we went through our education

[5]To create our educational resources dataset, We used the APIs of *SkillsCommons* https://www.skillscommons.org/. The accessibility metadata of OER is composed of any of the following 28 accessibility features: *color, contrast, complextImageText, decorativeImages, imageAltText, hyperlinkActive, interactiveMarkup, interactivePromptText, keyboardInteractive, languageMarkup, languageMarkupAlt, multimediaAccessiblePlayer, multimediaTextTrack, multimediaTranscript, noFlickering, readingLayoutCompatible, readingLayoutPageNumbers, readingLayoutPageNumbersAlt, readingOrder, stemMarkup, stemNotationMarkup, structuralMarkupLists, structuralMarkupReaders, structuralMarkupText, tableMarkup, textAccess, textAdjustable, textAdjustmentCompatible.*

dataset and filtered the OERs according to the quality prediction model and the accessibility preferences which are required by each learner profile of the use case, as defined in our previous work [1]. Afterwards, we evaluated the accessibility of the OER search results manually (e.g., NVDA tool[6] was used to simulate the activities of visually impaired users) and using automatic (e.g., Visual ARIA bookmarklet[7]) accessibility checking approaches. We focused on testing the most important accessibility feature for each use case (e.g., *Use case 1*: color and contrast, headings and order, images description, and *Use case 2*: readability test, Easy-to-Read test, text adjustment, availability of visual content). In general, most of the resulting OERs passed these accessibility tests except for some checks (e.g., *Use case 1*: images that did not have alternative description, and heading order that failed in PDF format files, and *Use case 2*: the Easy-to-read test). A detailed analysis of the results can be found at https://bit.ly/30PY04C. Finally, we selected a sample of OERs that were not retrieved by our recommender and tested their accessibility; we found that some of these OERs are not accessible because they contain scanned PDF files which are not accessible by screen readers.

Moreover, we asked three experts (for visually impaired users) and two experts (for cognitively impaired users) to rate (between 0 to 5) the quality of recommended OERs in terms of accessibility features for each of the use cases. At the end, we received more than 100 ratings regarding the recommended OERs. Table 1 shows the percentage of the rates in each use case. As can be seen, experts rated with a score of *3.41* out of *5* on average, which shows that our recommender system works well in satisfying these users' needs.

Table 1. Results of the validation by experts

Use Cases	Rate=0 (%)	Rate=1 (%)	Rate=2(%)	Rate=3(%)	Rate=4(%)	Rate=5(%)	Average Rate
Use Case 1 (English Language)	0	6	7	21	33	33	3.8
Use Case 2 (Business)	2	14	19	26	24	15	3.01
Average	**≈1**	**≈10**	**≈13**	**≈23**	**≈29**	**≈24**	**3.41**

5 CONCLUSION AND FUTURE WORK

In this paper, we presented an OER recommender system that recommends OERs considering the learner's occupation, skills and accessibility preferences. Moreover, we used OER metadata, a quality prediction model, and user ratings to retrieve high quality OERs relevant to the learner's profile. Finally, to evaluate our approach, we validated the accessibility by manual and automatic checks and by collecting feedback from experts (i.e.,average ratings (*3.41* out of *5*). As future work, we plan to continue adding OER repositories and validating the accessibility of OER content (of various types, such as videos, slides, or images), using accessibility guidelines and available APIs. Moreover, extracting more learner preferences (e.g. length and type of educational resources) and improving the personalisation of our recommender system are among the most important next steps.

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