Accessibility and Usability in the Development of Digital Educational Resources: The Case of MfM, a Platform for Teacher Training

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***Abstract*—Despite their importance, the dimensions of accessibility and usability are not overly present in the usual design and development processes of open educational resources by educators and instructional designers. This paper aims to fill this gap in literature, with the objective of evaluating and validating a teacher training platform (Mestres que formen Mestres–MfM) in terms of user experience (usability) and web accessibility. This has been done from the perspective of 15 participants from the three teaching profiles of potential users: university teacher educators, in-service teachers in schools and preservice teachers (initial teacher training). A mixed methodology in two phases has been applied through the sequential application of a heuristic and aprioristic evaluation of web usability and accessibility and a second evaluation of the design applying standardized scales (System Usability Scale–SUS and Usability Metric for User Experience–UMUX). The development of MfM has considered usability and web accessibility as essential characteristics to ensure that digital educational resources are functional and inclusive, and so the positive results show. This article documents this accessibility and usability analysis, as well as its main results as a practical example. In this sense, and as practical implications, this example can serve as a model to evaluate the accessibility and usability when developing other digital educational resources.**

***Keywords*—usability, accessibility, teacher education, digital educational resources**

I. Introduction

The leap from Web 1.0 to Web 2.0 and beyond opened up countless possibilities for all educators concerning the development of digital educational resources. Educational professionals can conceive more freely which resources they need to implement in the teaching-learning processes they design and can even develop them themselves. Nor is there any doubt regarding how many avenues of personalization and universalization this offers. Indeed, the increasing digitalization of society can lead to the generation or intensification of digital divides in education [1], if these educational resources do not serve their potential users as openly as possible (and contribute to issues involving access, use or meaning-making). Here is where concepts such as accessibility, usability and universal learning design emerge, which are key to progress towards a more inclusive education from the digital sphere [2–4].

Often neglected or relegated to the background, these requirements challenge both the teachers who design their educational resources - more or less simple, and with a broader or narrower scope outside their interventions -, and the instructional designers and teaching teams - in charge of the design and development of more complex educational resources, intended for widespread use [5, 6]. The latter is the case of the platform Mestres que formen mestres (MfM), conceived as a space for sharing resources, and especially teacher training experiences in video format. It was created to be used intensively and in a widespread manner in the initial and continuous training of teachers in the Catalan educational and university system, and to be extended in the future to other contexts. In its design and development, the accessibility and usability requirements are perhaps the same as those that should be applied to any other educational resource designed with a smaller scope. However, developing an accessible and usable resource in the best conditions for its potential users is greater, insofar as MfM is an educational resource that was created with the aim of generalization and use in other teacher training contexts in Catalonia and beyond.

MfM is an inter-university initiative coordinated by the University of Lleida and with the participation of the Department of Education and Professional Training of the Regional Government of Catalonia. It is built upon two competitive research projects granted by the Department of Research and Universities of the Regional Government of Catalonia, through the Agency for Management of University and Research Grants, in the calls for research grants for the improvement of the initial training of primary and secondary school teachers (ARMIF) (2020 ARMIF 00019 and 2023 ARMIF 00010). The MfM platform proposes the pedagogical use of videos of teacher training experiences in real educational contexts to help promote the professional point of view through their analysis [7, 8]. The organization of the video experiences on the platform includes: the educational stage, the area of knowledge and the type of teaching actions to be observed [9, 10]. In addition, supplementary materials are included to support this pedagogical use, such as educators' interviews and training strategies [11].

In digital educational resources such as this one, the process of analyzing and validating acceptable levels of accessibility and usability is uncommon insofar as they are not evaluation processes that are applied systematically and included in the design protocols for educational resources. The literature shows a gap precisely on this topic, which is difficult to fill from a practical perspective with concrete models [6, 9, 11]. Indeed, a simple search of any of the academic repositories will identify how the topic of accessibility and usability in digital educational resources is residual; and even more so in relation to the standards that should lead to them. In this context, this article aims to

document the accessibility and usability validation process that has been followed with the MfM platform, to serve the discussion on the subject and as an example of practical application of these concepts.

II. Literature Review

There is no doubt that participation in all areas of the Knowledge Society in the 21st century requires the mobilization of different digital literacies [1]. As media education has made clear in the context of the varied and wide-ranging reflections on digital competence, these are some of the key competences of citizenship in our time [12]. The risks of the various forms that the digital divide can take undoubtedly threaten the empowerment of the people we serve in the Western world's education system (physical access, competence and use gaps, according to Van Dijk [1]). This is especially crucial in a society characterized by media convergence and participatory culture [13]. Here, participating means not only consuming, but also actively producing; and, in doing so, contributing to a multidirectional, collaborative and communal media cultural flow. Therefore, it is not only necessary to be able to read digitally, but also to write, navigate and jump from one platform to another.

At this point, we can also draw on the reflections on digital divides by Deursen and Helsper [14], who point out that the impact of the factors that become digital barriers is not only in people's actions in the digital sphere, but also in the results of their analogue activities - in a hybrid world, the digital has implications for the analogue and vice versa, without clearly defined limits and consequences. This is also pointed out by Aissaoui [15], who links the very concept of accessibility, due to its subsequent consequences, with the performance of subjects in activities associated with the use of digital resources, regardless of whether the result should be analogue or digital. This would be our case insofar as the accessibility of this platform can partly condition the learning of its potential users and, consequently, their performance as teachers in the classroom.

Finally, Aissaoui [15] also points out the need to focus on the hindering elements that affect the first two waves of the digital divides (access and meaning), insofar as practice and literature have been focusing on the second wave, i.e. the need to empower individuals to avoid digital skills gaps. The reflection on the gaps at the first level (access), can also be formulated from the perspective of the characteristics that technological products inherently present in their design, which minimize the obstacle to their consumption. It is in this context that the concepts of accessibility and usability must be addressed.

Born in the field of care for people with disabilities, accessibility refers to the properties of an object, resource or technology that guarantee its accessibility by its users. And, although from this first approximation, it would seem that it is a dichotomous concept (accessible/not accessible), the reality is more polychromic. Thus, in its origin accessibility is linked to the field of disability, and it is in this sense that its frame of reference can be found in the Convention of Persons with Disabilities (promulgated by the UN in 2006 and endorsed a year later by the Spanish State). However, the concept goes beyond this sphere (yet encompasses it). Therefore, the Riga Charter, also signed in 2006 by all the EU Member States [16] broadens the scope of accessibility requirements and places it at the service of any group on which our gaze must be particularly intense in order to guarantee participation rights (women, the elderly, geographically and/or economically depressed areas, etc.).

Since then, and as a requirement partly derived from these agreements, accessibility has become a technical standard that is implemented especially from the perspective of web developers. Thus, for example, the Web Accessibility Initiative (WAI) has long been developing the Web Content Accessibility Guidelines (WCAG2). These are standardized practical models based on 4 dimensions (perception, operation, cognition and robustness) and developed based on 13 principles (with their sub-principles), which guide both accessible design and accessibility evaluation of the resources already created [17].

Without denying the need to objectify accessibility, one of its current practical limitations is precisely its excessively technical translation, while it is a concept that should simultaneously be inspirational due to its utopian nature [18]. Accessibility involves everyone, and we can all do something in our different roles as educators to ensure better access and to ensure more comfortable, functional and almost pleasurable access. This is what leads us to ensure accessibility and to work towards usability. Although they are different concepts, there is no doubt that they go hand in hand. Accessibility is an indispensable condition for resources to be usable; hence a higher level of accessibility guarantees favorable conditions for usability.

We understand usability according to the definition provided by Nielsen [19] as "the quality of a system that makes it easy to learn, easy to use, easy to remember, error tolerant and subjectively pleasurable". In part, it has also been transformed into a set of standards to be applied, which, in practice, form objective elements and principles of design. However, in its definition, it places the issue in the sphere of the subjective, and encompasses three broad dimensions: effectiveness, efficiency and user satisfaction. These three dimensions should not be assessed a priori, but through the vision of potential users [20].

Among these standards, the most common are the System Usability Scale (SUS) and its reduced and extended versions. As originally stated by the US government's Usability.gov initiative (now partially subsumed within the official Digital.gov digital portal), SUS aims to be a fast and reliable tool for measuring usability. Because of its versatility and ease of use, it has become a widespread standard for evaluating a broad variety of products and services, including hardware, software, mobile devices, websites and applications [21]. As a complement to this, Arijaya *et al.* [22] extend the instrument to 16 items and propose a series of tasks whose achievement or non-achievement by the users indicates the level of usability of the evaluated resource. On the other hand, UMUX (Usability Metric for User Experience) aims to offer a shorter and more concise instrument and is oriented towards the definition of usability of the International Organization for Standardization (ISO) 9241 standard (effectiveness, efficiency and satisfaction). It contains two positive and two negative items with a seven-point response scale [23].

A few studies address the evaluation of the usability of

educational digital platforms and devices using these standards. Orfanou, Tselios and Katsanos [24] used the SUS questionnaire for the evaluation of the usability of Learning Management Systems (LMS) platforms (eClass and Moodle) to guide the respective interfaces to be more user-friendly for end users (students and teachers). To do so, they conducted 11 studies involving 769 university students in Greece. The authors report satisfactory results and confirm the validity of the SUS questionnaire for the evaluation of LMS platforms. On the other hand, Lirola Sabater and Garcias Pérez [25] propose this evaluation in the context of distance vocational training in the Balearic Islands (Spain) with teachers, for the LMS Moodle platform used in these studies. For their study, these authors also used the SUS questionnaire based on two factors (ease of use and ease of learning) with a sample of 24 teachers, who rated the platform positively and confirmed the validity of the questionnaire for this task. In a later study, Lirola Sabater [26] used the UMUX questionnaire to evaluate the usability (user experience and degree of satisfaction) of the Chromebook by 47 students in the third cycle of primary education in a school in Mallorca (Spain), obtaining a high positive rating.

As mentioned above, beyond these examples of areas like ours, there are few cases in which usability analyses are approached from the pedagogical design of educational resources; on the contrary, they are approached from the most technological aspect of their development [27] or their use [28]. However, what is common to all these experiences (and is also reflected in the literature reviews) is that projecting usability evaluation into the design process of educational resources predisposes the design itself towards higher-than-average levels of accessibility and usability (insofar as it activates awareness of its importance in preliminary decision-making).

Finally, we will refer to the conclusions of the study by Estrada-Molina, Fuentes-Cancell and Morales [29], which highlight that only a few cases achieve an adequate integration between usability evaluation criteria of a much more technical profile (related to the technological development itself), standardized methods and models for evaluating usability, and criteria established from a pedagogical dimension to guide the design educationally. It, therefore, seems that this integration is difficult to find and, except on rare occasions, these elements do not converge in the figure of an instructional designer who brings together all these perspectives when defining and developing educational resources. Hence the need to guide practice with this case study, which attempts to answer the following question: how can accessibility and usability be rigorously and systematically evaluated in the process of developing digital educational resources?

To do so, we start from the assumption that an evaluation model can be constructed, based on the technical standards of reference in the digital field. This can be applied in an agile, rigorous and effective way, in the field of design and development of digital educational resources from the pedagogical side of the process.

III. Materials and Methods

Because of the above, this article aims to analyze the accessibility and usability of an educational resource (the MfM platform) in a comprehensive, operational and effective manner, aimed at both technical and educational improvement. And, subsequently, we intend to offer it as a model of evaluation of these two characteristics, from the technical (engineering) and the pedagogical perspectives, for the design of digital educational resources. To this end, as will be seen, we articulate a mixed methodology, both quantitative and qualitative, with two main phases, one carried out by professionals with a technical profile and the other by professionals with an educational profile:

Phase 1. Accessibility and usability analysis. It considers commissioning professionals with a technical profile to carry out an initial analysis using the following strategies:

- Heuristic evaluation of usability by experts, based on Nielsen's model (1990), revised by Granollers [30], which analyses 15 heuristic principles.
- Initial evaluation of the user experience with a small group of potential users (in our case, two university teacher educators, an in-service teacher and a preservice teacher).
- Evaluating web accessibility with assistive technologies.

In our specific case, this assignment was carried out in the context of a Bachelor's thesis in the context of the Higher Polytechnic School of the University of Lleida [31]. The outcome of the work was a report containing both the results of these analyses and, above all, a set of recommendations for improvements to be made to the educational resource in order to address the critical dimensions and improve usability and accessibility as a whole. Once these interventions had been carried out, the next phase followed. The second phase is the focus of this article, as follows.

Phase 2. In-depth usability analysis. Led by the pedagogical development team of the MfM resource. It considers the following actions:

- Task resolution within the platform and first satisfaction assessment (replication of the user experience evaluation of phase 1, with an extended sample).
- Usability assessment according to the SUS scale.
- Usability assessment according to the UMUX scale.
- Concluding remarks (open questions).

A. Participants

The starting point was the profile of the potential end users of the MfM platform, who are university teachers involved in teacher training, pre-service teachers and in-service teachers (whether they are involved in teacher training or not). To this end, a sample of 15 participants was recruited from among the members of the project's work group and those close to them. From these 15 participants, five from each of these three profiles were recruited, including both females and males and diverse technological profiles (more and less experienced in the use of digital educational resources, with higher and lower profiles of digital competence).

Insofar as the aim was to use the sample to gather the different possible profiles of users of the platform, with the possible ranges of digital competence, and not to achieve a representative sample for psychometric purposes, the number of informants with whom we have worked would satisfy the needs of the study and fulfil the need for information.

B. Data Collection and Analysis

The participants were presented with a sequence of tasks

to do within the platform (register, log in, navigate through pages, watch a video), after which they had to complete a questionnaire of five parts. The questionnaire was implemented online with the digital forms tool offered by the institution (Microsoft Forms):

1) Rating of perceived difficulty for each of the tasks within the platform (on a nominal five-grade scale: very difficult, difficult, neutral, easy, very easy).
2) Assignment of feelings and emotions elicited by each task (from a nominal set of nine excluding options: cheerful, excited, relaxed, calm, indifferent, bored, irritated, tense, sad).
3) SUS. As mentioned above, created by Brooke [21], this scale provides a quick and reliable tool for measuring usability. It consists of a 10-question questionnaire with five response options for respondents, ranging from Strongly Agree to Strongly Disagree.
4) UMUX. This short, synthetic, four-item scale orients usability towards the ISO 9241 standard (based on the concepts of effectiveness, efficiency and satisfaction), and seeks responses to two positive and two negative items with a seven-point scale [23].
5) Open questions. At the end of the questionnaire, two optional open questions were included, so that participants indicated what they valued most about the platform and what improvements they suggested.

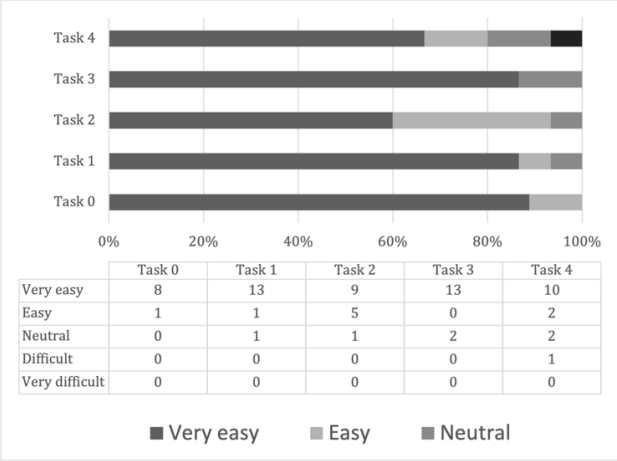
The qualitative data from part 5 regarding what participants valued most about the platform were analyzed according to the frequency of lexical occurrences in a word cloud, in order to bring out the most relevant negative and positive dimensions in a more visual way. As for opportunities for improvement, as detailed in the corresponding section later, they were categorized according to priority level and topic. The quantitative data from the scale parts of the questionnaire were analyzed and graphically represented based on frequencies (parts 1 and 2), results per informant (part 3-SUS scale) and averages (parts 3 and 4 - SUS and UMUX scales) using Microsoft Excel.

Before data collection, all participants signed an informed consent form, which included information about the project and this study, as well as about the processing of personal data. This informed consent is part of the ethical requirements that the broader research project fulfilled in the different actions to obtain a favorable evaluation of the research ethics committee of the hosting institution. The anonymity of their identities in the study, the voluntary nature of their participation, the non-transfer of the data to third parties, the use of the data only for the purposes of this project, as well as the access, rectification and deletion of their data, were guaranteed. This consent followed the format defined in the report of the data protection officer of the University of Lleida obtained after the request for ethical approval of the project. The project was also favorably assessed by the Research and Transfer Ethics Committee (CERT) of the University of Lleida.

IV. Results and Discussion

A. Perceived Difficulty of the Tasks Performed

The entire sequence of tasks performed within the platform is well-rated by the participants in terms of perceived difficulty. Therefore, a positive assessment of the initial usability of the user experience involved in this first contact with the platform emerges. In no case are the tasks perceived as very difficult, and only in one case, in task 4 (search for a specific interview from a university teacher), a rating of difficulty is documented. This may be related to the fact that the object to be found (the interview) was not as straightforward to locate at first glance as the other tasks. It was among the supplementary material, at the bottom of the page of a set of training videos. This can be seen in Fig. 1.



	Task 0	Task 1	Task 2	Task 3	Task 4
Very easy	8	13	9	13	10
Easy	1	1	5	0	2
Neutral	0	1	1	2	2
Difficult	0	0	0	0	1
Very difficult	0	0	0	0	0

Fig. 1. Perceived difficulty in performing tasks.

B. Feelings Generated During the Performance of the Tasks

A similar conclusion can be drawn if we analyze the sphere of feelings that the performance of these tasks generates in the participants, which can be seen in Fig. 2. There is a certain degree of diversity between the most markedly positive (cheerful, excited) and moderately positive (relaxed, calm). However, the favorable assessment of the interaction with the platform is significant, as it does not arouse feelings of rejection or discomfort.

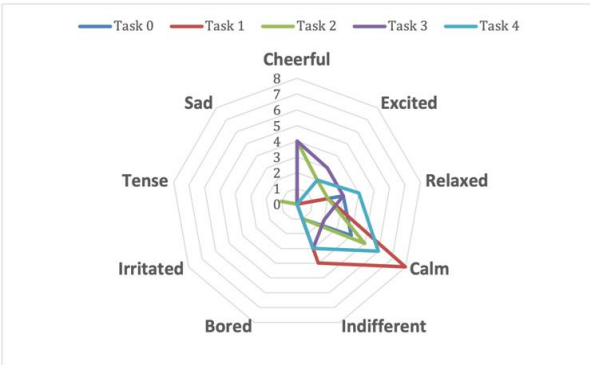


Fig. 2. Feelings generated during the performance of the tasks.

C. SUS Usability Scale

The evaluation obtained with the SUS scale is also positive, as can be seen in Fig. 3. After having calculated the final scores for each of the informants, a usability indicator from 0 to 100 was obtained. In our case, the average of all of them is 90.5, which places MfM in a resoundingly positive score. It is also positive if we look at each of the evaluations separately.

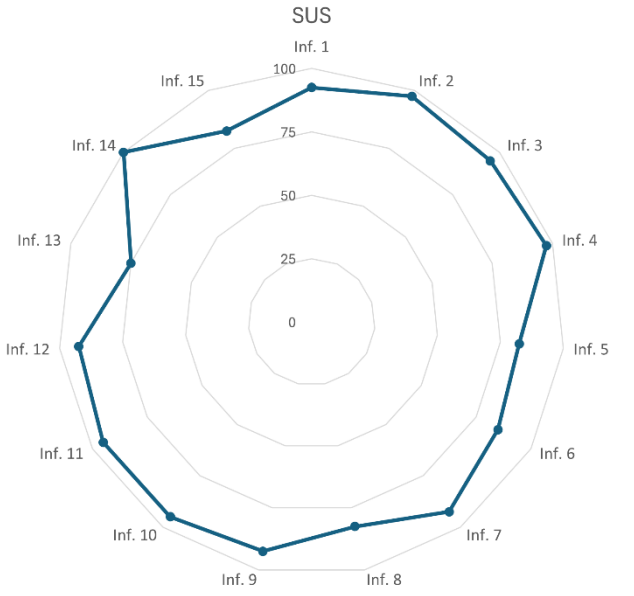


Fig. 3. SUS usability scale. Results per informant.

D. UMUX Usability Scale

Equally positive are the results of the UMUX reduced usability scale, which can be seen in Fig. 4. The two items formulated in positive gradation obtained high levels in the indicators linked to the areas of satisfaction in the sphere of 6 on a 7-point scale. On the other hand, for the two items formulated in negative gradation, the scores are just above the lowest threshold. Both correspond to the dimensions of efficiency and effectiveness. We can conclude, as in the previous cases, that the assessment of the usability of MfM is significantly positive.

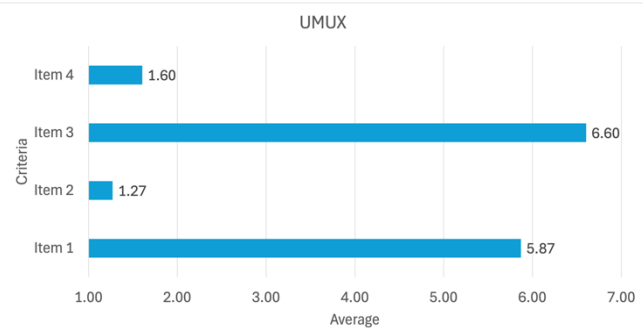


Fig. 4. UMUX results.

E. Open Questions

The final part of the study offered us the possibility of finding out which aspects are most highly valued by informants and what can be improved. About the former, the word cloud in Fig. 5 identifies what these positive aspects are (in Catalan). Important elements can be seen, such as the availability of resources (recursos, en la nube), the specific orientation for teacher training (formació, mestres), and specific features of its design, such as its intuitive and attractive nature (intuitiva, atractiu/iva, disseny), the ease of use (fàcil, facilitat), the availability of the web interface, etc.

Regarding the question on areas for improvement, the responses were categorized into three dimensions in order to prioritize them:

- Accessibility or usability proposals identifying design flaws that need to be addressed in the first instance (display problems, functionality errors, interoperability, structural stability, etc.).
- Proposals relating to accessibility or second-level usability that can serve as guidelines for improvement (generalisation of subtitling, improvements in structure, additional content, chromatic improvements to aid browsability, etc.).
- Proposals of a different nature to be assessed by the development team from the technical and pedagogical perspectives (addition of interaction elements, generalisation of complementary content, etc.).

As seen above, the results demonstrate the achievement of high standards of web accessibility and usability from the perspective of potential end users by MfM. From this process, a model for evaluating these two dimensions (accessibility and usability) can be inferred to be generalized and replicated as part of the design and development process of digital educational resources. In summary, this process would consist of the sequential application of a heuristic and aprioristic evaluation of web usability and accessibility and a second evaluation of the design applying standardized scales with a representative group of potential users.

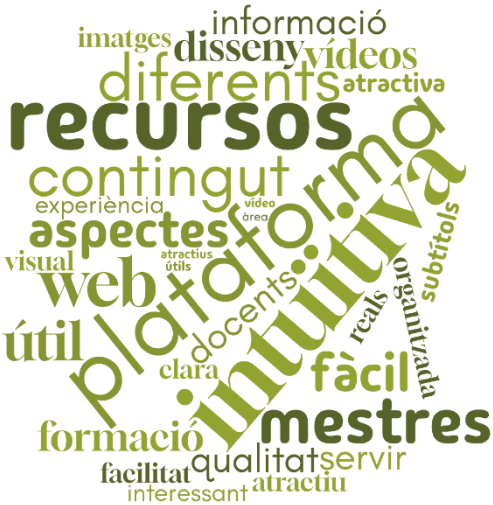


Fig. 5. Positive aspects highlighted by informants.

V. Conclusion

This study has presented the procedure for evaluating the usability of an educational platform (MfM), using standardized tools that had already been validated in scientific literature (SUS and UMUX) [24–26].

Both accessibility and usability are considered important elements for the design of digital educational resources and platforms, and specifically the evaluation of usability allows us to improve the use and user satisfaction from a pedagogical perspective [26]. The involvement of users in this sense is relevant, as they are a fundamental part of the platform's (re)design process, and their contribution is key to ensuring its continued use. And, beyond that, we can see that considering the evaluation of a digital educational resource's usability from the beginning of its design also predisposes it towards higher standards of accessibility - to the extent that, to a certain degree, this can be considered the prerequisite for usability. Planned formal evaluations, in all contexts, guide performance in a clear way; and, in our case, they allow the

educational design itself to be born with a vocation for usability and to be developed precisely in that same key. Consequently, when formal evaluations by users occur, their outcome is confirmatory [27].

The results of the study validate the MfM platform as an easy-to-use and easy-to-learn educational resource (with a high level of usability). At the same time, the findings provide significant improvement proposals to further optimize the platform for its current and future users. In this sense, previous studies also obtain good usability results in relation to educational digital platforms and highlight the importance of involving the different stakeholders (teachers, students) [24–26]. Although the road to improving usability and user experience is always a long one, this process ensures that, from design and in its early stages, MfM is already an accessible and usable digital resource at an acceptable level according to international reference standards.

Finally, because of all the above, and as one of the main milestones of this contribution, we can offer a concrete model for evaluating the accessibility and usability of educational resources that can be replicated in other educational design processes and that can be taken as a reference, in the service of a more inclusive education. As we previously mentioned at the end of the Results and discussion section, in brief this model would consist of the sequential application of a heuristic and aprioristic evaluation of web usability and accessibility and a second evaluation of the design applying standardized scales with a representative group of potential users.

As limitations of the study, we acknowledge the small sample of participants and the focus on a specific educational resource, in a concrete context such as the Catalan one. – However, the aim was not to generalize the specific results of the accessibility and usability study on MfM, but rather to put into practice a rigorous and systematic procedure that could be implemented for the evaluation of other digital educational resources.

Future lines of work could consider broader samples of each participant profile and apply the process presented in other types of educational resources different from those already common in literature (educational digital platforms); for example, open educational resources, specific digital tools for collaboration or communication, among others.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

VIM conducted the research, analyzed the data, wrote the paper, obtained the funding; ASG conducted the research, analyzed the data; JGM conducted the research, wrote the paper; all authors had approved the final version.

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