Article

JEN-Planet: an Automatically Updating Serious Game Catalogue Designed with and for Teachers

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Abstract

Serious Games (SGs) intended for educational purposes can improve the quality of learning in many contexts and at all levels. However, their use in schools remains minimal despite their many educational and pedagogical benefits. This lack of interest is partly due to educational SGs' visibility problem. Indeed, they are mainly indexed in catalogues containing all types of SGs (not necessarily educational). Also, the existing catalogues, often designed by video game editors, do not offer relevant and practical filters to help teachers find SGs suited to their specific needs. This article proposes JEN-Planet, a catalogue designed from several research contributions to help teachers find existing educational SGs. A comparative study is carried out on its usability, relevance, and utility against those of two other major catalogues. 50 teachers explored the different catalogues and evaluated them through questionnaires. The results show that the JEN-Planet catalogue better meets teachers' needs. This catalogue could therefore improve the visibility of educational SGs for teachers, improving their searchability by teachers.

1. Introduction

Serious Games (SGs) can have many benefits for learning and training [1], [2]. Teachers appreciate their interactivity and immersive nature [3]. There are currently more than 800 SGs intended for educational purposes, in a wide range of fields, from kindergarten [4] to professional training [5]. However very few teachers use SGs. The major constraints to the adoption of these tools is simply that it is difficult for teachers to find existing SGs that could meet their needs [6]. Indeed, when searching by keyword on a web search engine, teachers only find well-referenced SGs, which are often quite expensive and require specific equipment (e.g., game console). This is often equipment that they do not have in their schools and these SGs are often ill-adapted for their pedagogical purposes [7]. Teachers may also across a few SG catalogues, but they do not have a filter system that allows them to find suitable SGs efficiently [8].

In the second part of this paper, we present a brief state of the art of these SG catalogues and their limitations. We describe their metadata systems and search filters, which are not

adapted to teacher's needs. Their ergonomics are also an obstacle for finding SGs quickly [9]. In addition, most of these catalogues are not specialized in educational SGs and teachers therefore find themselves lost in a list of non-educational SGs.

To try to answer these shortcomings, we propose the *JEN-Planet* catalogue *(JEN* stands for *Jeu Educatif Numérique,* which means digital educational SG in French),* presented in the third part of this paper. This catalogue is built on three previous proposals: a **metadata schema** to describe the characteristics of educational SGs, an **indexing model** that automatically finds the information to fill out the SG's metadata by analyzing the information found on a webpage and an **end-user-centered design method**, to create an interface adapted to teachers. To find out whether *JEN-Planet* answers the challenges raised above, it was evaluated against the following three criteria:

- The **usability**, to determine the level of ergonomics of the catalogue's interface.
- The **relevance** of the SGs' descriptions, to find out whether the search filters and the description information provided for the SGs allow teachers to find those that might be suitable for them simply and quickly.
- The **utility**, to find out whether teachers find SGs that are suitable for their needs.

Thus, in the fourth part, we present our experimentation, carried out with 50 volunteer teachers. They used *JEN-Planet*, as well as two other catalogues, to find SGs suitable for their lessons. We compare the results and the content of the interviews conducted with them. The paper ends with a discussion of the studies limitations, a conclusion, and perspectives.

2. State of the Art on Serious Games Catalogues

To better understand the difficulties that teachers encounter when they want to find SGs, we briefly present the SG catalogues currently available on the Internet.

The current catalogues can be separated into two main categories. The first category only lists educational SGs but only provides a small selection of games (maximum 42). This is explained by the fact that they are updated by educational institutions or teachers that only keep track of specific types of SG, on a specific subject or for a given age category (Table 1) [10]. In this category, one can also find catalogues of educational SG publishers but that only show games they have developed. These catalogues are therefore only useful for a very small selection of teachers who are looking for the specific type of SGs offered by these catalogues. The second type of catalogue is more promising because it provides a large selection and variety of educational SGs. The most prominent ones are *SeriousGameClassification* and *MobyGames* [11], [12] who offer 420 and 310 educational SGs respectively. However, their also contain substantially more non-educational SGs related to publicity and politics for example (Table 2). Consequently, the low percentage of educational SGs in these catalogues (i.e., 12% and 0.2%) makes it difficult for teachers to find the right SGs for their needs [13]. Ideally, teachers need a catalogue with only large selection of SGs, only related to education.

**Table 1.** Examples of specialised Serious Games web sites

Specialised web sites	Serious Games	Educational SG	% of Educational SG
MIT Education Arcade	8	7	99
Vocabulary Spelling City	42	42	100
LesEscper	6	6	100
IKIGAI games for citizens	14	14	100

Table 2. Serious Games (SGs) Catalogues

Catalogues	Serious Games	Educational SG	% of Educational SG
SeriousGameClassification	3 300	420	12
MobyGames	120 342	310	0.2

In addition, each catalogue uses its own description scheme to describe the information related to SGs. For example, the *SeriousGameClassification* catalogue uses the G/P/S (Gameplay / Purpose / Scope) classification model which classifies games according to three criteria [14]. The first concerns the game's playability: it provides information on the game's graphic characteristics, the actions induced by the game and the type of game. The second concerns the market targeted by the game (*e.g.*, health, military, education, and politics). Finally, the last concerns the target public age for the game or their type (*e.g.*, students, professionals) [15]. The *MobyGames* catalogue describes games according to the platform (e.g., PC, Android, or Nintendo), the year of publication (*e.g.*, 2008, 2020), the type of game (e.g., visual, board game or shooter) and the legal rating of the game (*e.g.*, PEGI). These classification criteria are very limited when it come to the pedagogical aspects of SGs [16]. For instance, there is no information available about the discipline or the educational objectives. These metadata models, designed to describe mostly non-educational games, do not therefore offer relevant information for teachers and it is necessary to provide a description scheme that focuses on the pedagogical characteristics of SGs [17], [18].

Finally, to be truly useful to teachers, SG catalogues must be user-friendly. However, the catalogues studied are not intuitive, i.e., they do not allow users to find SGs without considerable intellectual effort. The layout of the different areas on the catalogues, the organization of the SGs and the search filters are not compliant with the UX design models [16] (Figure 1). For example, in *SeriousGameClassification,* all filters are in checkbox format with predefined values, regardless of the information described (left of Figure 1). Offering only this format forces the user to check boxes among those available even if their values do not correspond to the real needs. For example, a teacher who wants SGs for learners aged 6 to 13 will have to check the boxes 3 to 7, 8 to 12 and 13 to 16. The search will therefor return SGs outside the required age range. Another example, in the *MobyGames* catalogue: the filters offer lists of values that are very long, without the possibility of searching by keyword. To find SGs that work on tablets or smartphones, teachers therefore need to go through the list of 270 platforms offered. In addition, the search filters disappear from the result page. Teachers therefore need to return to the previous page to refine the search results if they are not satisfactory. It seems safe to assume that these Human-Computer Interfaces (HCIs) do not allow teachers to easily find SGs according to their needs [19].
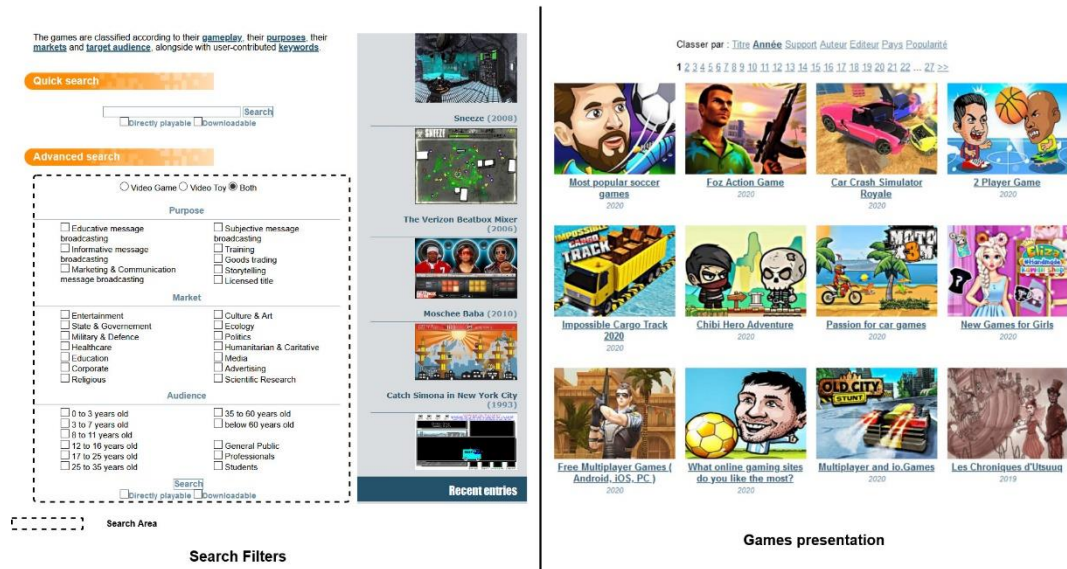
Figure 1. Catalogue SeriousgGamesClassification - search page (left) and results page (right)

In conclusion, searching for relevant SGs is a difficult task for teachers. Existing catalogues contain very few educational SGs, lost among many non-educational ones, with description information that is not adapted to teachers and with interfaces that are not user-friendly. In the following section, we describe our proposals to address these issues.

3. JEN-Planet: An Educational Serious Game Catalogue

In the next part of this paper, we attempt to address these challenges by proposing the *JEN-Planet* catalogue, which builds on three previous research proposals:

- **The LGMD metadata schema**, which describes the SG characteristics that are of interest to teachers. The objective is to answer the research question: What metadata schema is most suitable for educational SGs?
- **The ADEM indexing model**, which automatically finds the SG information on their webpage to populate the metadata. The objective is to create one catalogue, specialized in educational SGs, that combines all the educational SGs found in the catalogues presented above. The objective is to answer the research question: What models are needed to automatically extract information about SGs on the Internet?
- **The UDID interface design method** which allows teachers to be implicated in the interface design of the catalogue. The objective is to answer the research question: What catalogue interface will best help teachers find existing SGs?

Since these contributions are already described in detail in previous publications, we only present them briefly in the following section.

3.1 LGMD: an Optimal Metadata Model for Educational Serious Game Description

Currently, SG catalogues all use different description models and do not provide information about educational objectives and contexts, which are essential for teachers. As previously stated, this is because they were designed to describe games that are not necessarily educational [20]. The LGMD (Learning Games Metadata Definition) schema is designed specifically for educational SGs [21]. It contains 23 description fields with a focus on the description of pedagogical features (Figure 2). These fields are derived from the analysis of several metadata schemas in the literature (*e.g.,* LOM, LOM-SG, MG, GPS) [18], [22], [23], [24]. Only the

description fields relevant to educational SGs were kept with possible backward compatibility with the Learning Object Metadata (LOM) standard [25].

The proposed LGMD schema was validated at two levels. A first test verified that the 23 fields are sufficient to cover the information provided by SG publishers. The analysis of the information provided on 785 SG web pages showed that they only provide information for 17 fields out of the 78 or more provided by SG metadata in the literature and all these fields are included in the 23 fields of LGMD. We made the decision to keep the addition 6 fields, for which information is never provided, because they are important to teachers, and we wanted to encourage SG editors to fill them out. For example, none of the editors provide information for the knowledge validation field (list of competencies or skills that can be acquired by playing the SG). A second validation, with 17 teachers, verified that the fields are useful and sufficient to search for SGs that meet their pedagogical needs. This was done with co-design sessions and questionnaires in which they were asked to identify what information they needed to find and choose SGs for their class. These two validations show that LGMD offers an optimal number of fields: sufficiently numerous to cover the information relevant to teachers, yet not so many as to discourage SGs publishers from filling in this information.
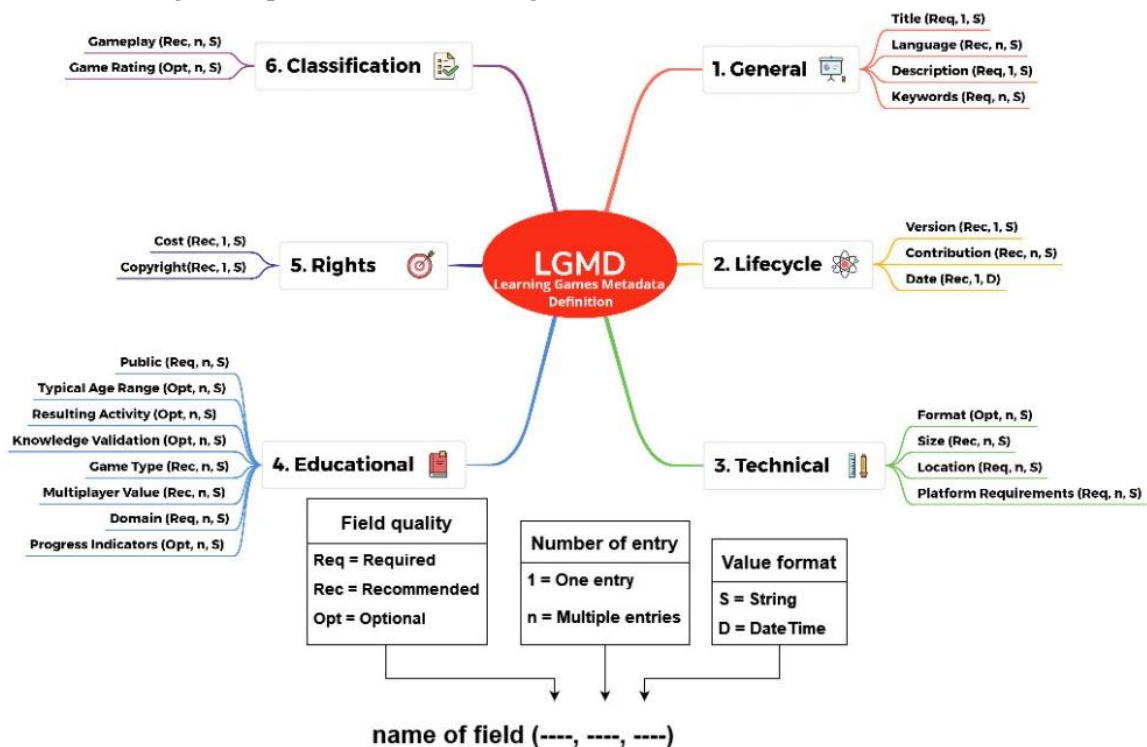

**Figure 2.** Serious Games Metadata Definition (LGMD) model

In the *JEN-Planet* catalogue, the LGMD metadata schema is used to describe the SGs but also for search filters. Thus, teachers can perform simple searches by selecting, for example, "math" for the subject, "primary" for the target public, and "free" for the price (Figure 3).

3.2 ADEM: an Automatic Indexing Model

To find and update the SG database automatically with new information, we have come up with the ADEM (Automatic Description Extraction Metadata) model. This is an automatic SG indexing model described in detail[5]. It collects information for each of the 23 fields of the previously presented in the LGMD metadata schema by scraping and analyzing the text on websites. The ADEM model consists of five major steps (Figure 3). The first three steps consist in collecting SGs through their web pages. Then, in the next two steps, the content in the HTML tags of the web pages is processed to select only the text blocks containing the SG description

information and delete publicity and general information about the SG publisher. Finally, the keywords describing the 23 metadata fields (i.e., title, language, location, public, domain, cost…) are identified as well as the image of the SG. This information can then be modified by a human in case the automatic extraction was not accurate or complete.

The ADEM model collected information on 785 web pages with SGs. The model's performance was evaluated with metrics such as precision, recall and F-Measure [26], [27] that combines precision and recall in one measure. The relevance of the information was also evaluated by 15 teachers on a representative selection of SGs. They compared a sample of websites to check whether the information automatically extracted by ADEM matched the information they were able to find by reading the pages. The evaluations resulted in an accuracy level of over 82% and a relevance score of over 4/5.
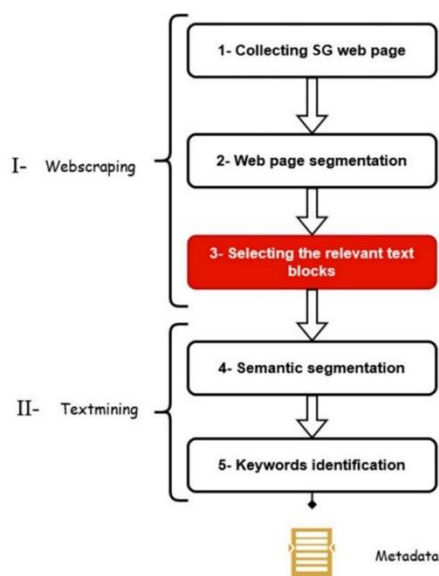
Figure 3. Steps of the ADEM (Automatic Description Extraction Metadata) model for SGs

3.3   UDID: a Method of Interface Design by Teachers

The *JEN-Planet* interface was designed with the assistance of 17 teachers, following the UDID (User-Driven Interface Design) method. Inspired by user-centered design [28], this method proposes five steps with specific materials [29]. This material consists of a white A3 sheet of paper, cards representing all available filters of the SGMD metadata schema, in different formats (*e.g.*, checkboxes, drop-down list) and empty post-its, used to represent the thumbnails of the SGs found after the search.

Following the steps of the UDID method, the teachers first decided where they would like to put the main interface zones on the A3 sheet (search, sort, and results zones). They then chose the filter cards to put on the interface. This step is particularly important as it involves identifying the most important of the 23 filters available and their formats. The size ratio between the cards and the sheet recreated the space constraints found on a web interface. This helps to identify which filters are most important. In the next step, the teachers chose the layout of the search results and represented, on post-its, the information they found relevant to describe the SGs found. A debriefing concluded the design sessions to allow teachers to explain and discuss their choices.

Thus, the UDID method allowed 17 teachers to design several mock-ups of SG catalogue interfaces (Figure 4). The paper [29] describes in detail how all these mock-ups were used to design the final interface (Figure 5).
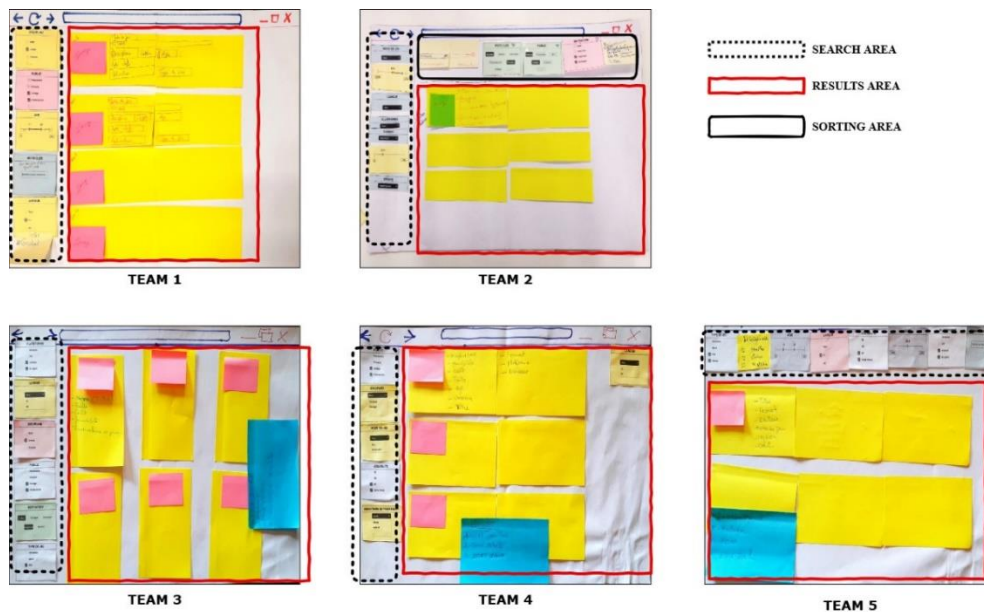

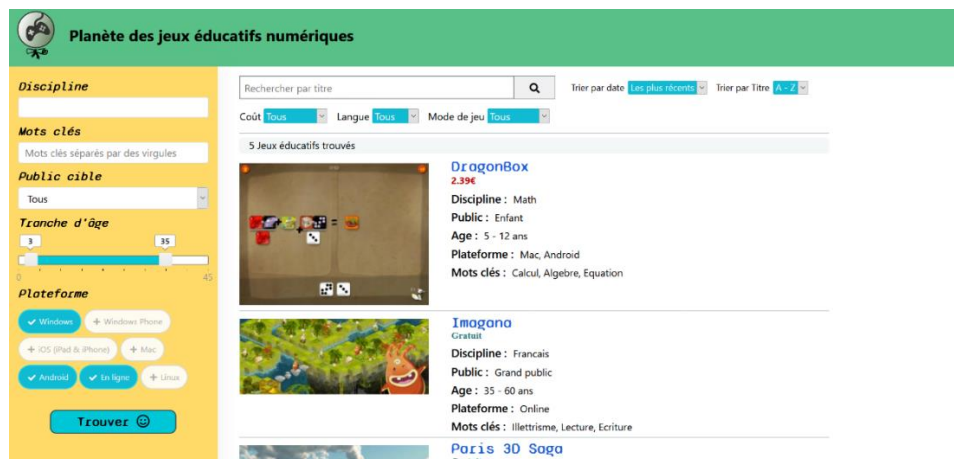**Figure 4.** Interface mockups from the design sessions

Figure 5. Catalogue JEN-Planet homepage

When the user clicks on the title or image of the SG, the catalogue opens a detailed description page about the SG (Figure 6). This page shows the information provided in the thumbnail of the result area in addition to information about the other filters. If the teachers want to learn more or test the SG, they can click on the red link on the bottom right, which leads to the original page where the information was collected. This link opens in a new tab to keep the *JEN-Planet* page open.

The interfaces shown in figure 6 are from the current version of *JEN-Planet*, available at *https://jen-planet.univ-lemans.fr*. This catalogue was developed with the PHP programming language on a MySQL database.
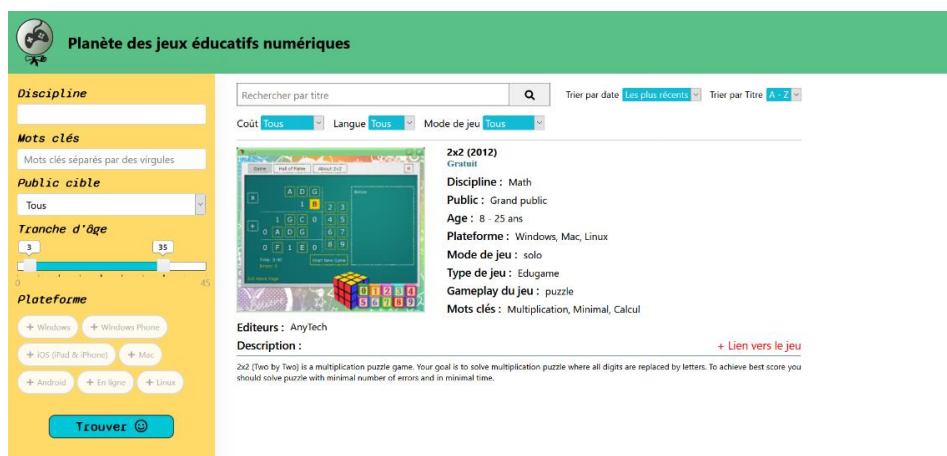
Figure 6. Serious games detail page of JEN-Planet

4. Experimentation

This section describes the experimentation aimed at identifying if the *JEN-Planet* catalogue addresses the issues raised in the introduction. The evaluation is done by comparing *JEN-Planet* to the *SeriousGameClassification* and *MobyGames* catalogues, the two major catalogues identified in the literature. Each catalogue was evaluated according to 3 criteria (relevance, usability, and utility) and the results were then compared.

4.1   Evaluation Protocol

4.1.1   Choice of Participants and Method
We solicited 50 volunteer teachers (convenience sampling) with different profiles, both in terms of level and teaching domain: 14 primary, 20 secondary and 16 higher education teachers, including 25 teachers in the literary field and 25 in science. None of the participants had experience of using educational SGs.

Each teacher received an e-mail explaining the objective and the work to be done, with links to the three catalogues, in a random order. This choice was made to avoid that the order in which the catalogues were evaluated would have an influence on the experimentation. They also did not know which of the catalogues we had created, so as not to influence them. We did not ask them to compare the catalogues; this comparison was made later, when the results were analyzed, and the teachers did not have the opportunity to consult each other.

Teachers were asked to open the link to each catalogue in a browser from a laptop or desktop computer, and to search for SGs relevant to their teaching needs. However, they had to use the same protocol for all three catalogues. They were given a maximum of 10 minutes for each catalogue which is the average time spent by an internet user searching online in E-Learning case [30]. For each catalogue, they were then asked to answer a questionnaire.

To conclude the evaluation, a recorded telephone interview was conducted with each teacher, immediately after they had sent in their answers, to gather their opinions on the catalogues and suggestions for improvement for *JEN-Planet*.

4.1.2   Evaluation Criteria
The questionnaire given to the teachers is composed of three parts. The first concerns the **usability** of the catalogue to determine the level of ergonomics of its interface. We used the System Usability Scale (SUS) [31] that consists of 10 questions whose answers are based on a 5-point Likert scale, from "strongly disagree" to "strongly agree" (Appendix). It allows us to check whether each catalogue meets the objective of intuitiveness and ergonomics.

The second part concerns the **relevance** of the SG descriptions. We used four questions with answers based on a Likert scale also ranging from "strongly disagree" to "strongly agree" (Appendix) to determine whether the information describing the SGs and the descriptive information provided for the SGs allowed teachers to find those that might be suitable for them, simply and quickly.

The third part concerns the **utility** of the catalogue, to find out whether teachers can find SGs that are suitable for their needs. The teacher was therefore asked to provide the number of SGs that they found interesting after a 10-minute search and those that they found "relevant", or in other terms, that they might want to use in their classroom (Appendix).

4.2 Results

The evaluation took place remotely, during the year 2022, i.e., the teachers evaluated the catalogues from their homes or workplaces on laptop or desktop computers. The evaluations are analyzed according to the usability, relevance, and utility. Descriptive statistics tools are used to determine the degree of correlation and confidence in the data collected. The results of the evaluations are presented in the following sections.

4.2.1 Usability

The average usability score is 82 for *JEN-Planet*, 42 for *SeriousGameClassification* and 40 for *MobyGames*. JEN-Planet's scores are highest with a median of 83.5 and MobyGames has the lowest scores with a median of 35.7 (Figure 8). Indeed, the minimum score for *JEN-Planet* (65) is close to the maximum score for *MobyGames* (67). The maximum score for *JEN-Planet* (95) is given by teachers #1, #42 and #49. *SeriousGameClassification* has the lowest minimum score, with 7, given by teacher #7, while that of *MobyGames* is 17 (Table 3).

Table 3. Usability Scores Metric

Catalogues	Min	Max	Mean	Median	SD	CV
JEN-Planet	65	95	82	83,5	7,3	0,09
SeriousGameClassification	7	75	42	39,2	14,7	0,35
MobyGames	17	62	40	35,7	16,23	0,41

The median value for *JEN-Planet*, 83.5, is very close to the mean, unlike the other two catalogues. This means that there are very few values out of range given by a participant. The standard deviations (SD) of 14.7 for *SeriousGameClassification* and 16.23 for *MobyGames* are double those of 7.3 for *JEN-Planet*. The score scatter is therefore lower for *JEN-Planet* than for the other catalogues. The values of the Coefficients of Variation (CV) attest to the fact that the participants' responses concerning *JEN-Planet* are unambiguous.

The distribution of scores across their frequency of appearance reveals a curve close to a normal distribution of scores for the *JEN-Planet* catalogue (figure 7a). The score values are concentrated around the average of 82 with an almost equal distribution on each side. The distribution is much more spread out and farther from the average in the *MobyGames* catalogue. Empty frequency zones are observed around scores of 60 and 80. After the average of 30, the frequencies are lower until the score of 90. The distribution of scores in the *SeriousGameClassification* catalogue is more even, with a pronounced imbalance to the right of the average.

Observations of frequencies of appearance corroborate the results observed in table 3. The perceived usability of participants is much more consistent for the *JEN-Planet* catalogue than for the other catalogues. Perceived usability for the *MobyGames* catalogue showed much greater differences among participants (figure 7).
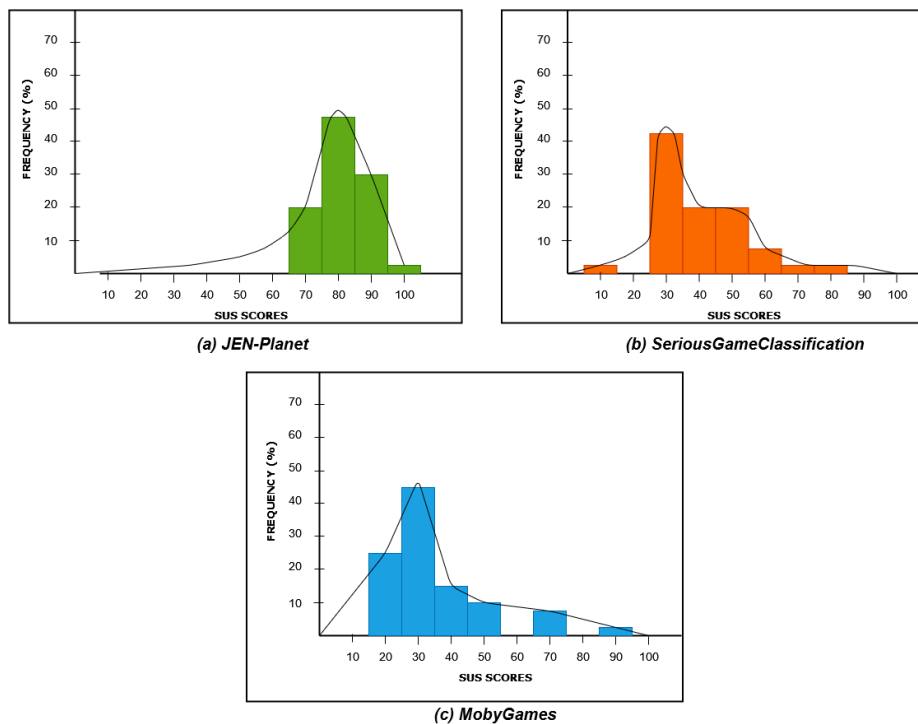
Figure 7. Frequencies of SUS Scores for each catalogue

The results show that *JEN-Planet* is better for finding SGs, both in terms of usability and in terms of information describing the SGs. The level of scores obtained shows that the catalogue designed using the UDID method is ergonomic and intuitive for teachers (Figure 8). Indeed, all the scores of *JEN-Planet* range from "good" to "best imaginable" according to the SUS interpretation (Figure 8). This user-friendliness was also emphasized by the participants during the debriefing.
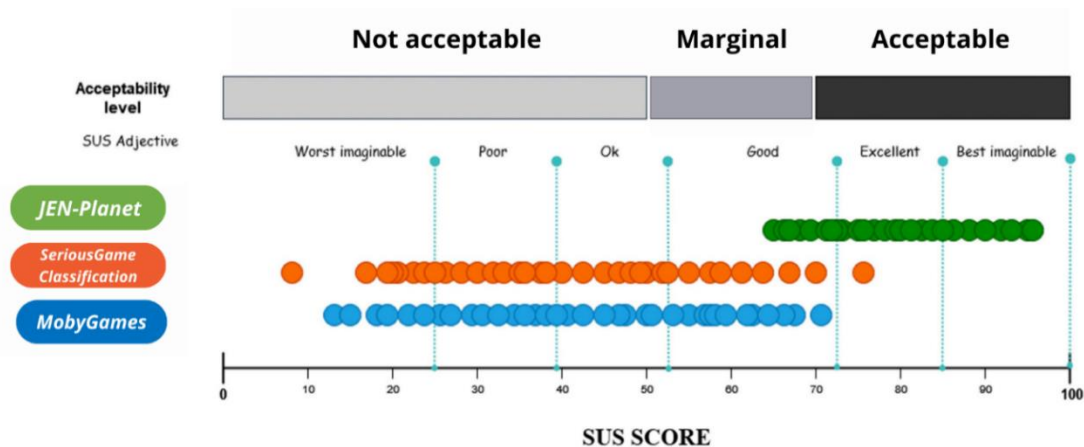
Figure 8. Distribution of evaluations by catalogue in the SUS score grid with interpretation [32].

4.2.2   Relevance

In terms of relevance, the results show that teachers found the information provided by *JEN-Planet* much more comprehensive and complete than the information provided by the other catalogues (Table 4). Let us restate the fact that *JEN-Planet* extracts data from the two other catalogues and several others so their databases are only partially the same. In addition, although *JEN-Planet* scored average of 4.10/5 on completeness, its interpretation shows some

downsides. Indeed, teachers indicated that information on "pedagogical objectives", "date ranges" or "language" was missing. As mentioned above, it is possible to search with these criteria in the advanced search options, but they are rarely provided by SG editors (less than 4% of the time). Therefore, adding these filters to the basic search options would not currently allow more SGs to be found.

Table 4. Average scores for the comprehensiveness and completeness of the information, provided by the SG catalogues.

| Catalogues	Comprehensive (/5)	Completeness (/5)
Jen-Planet	4.68	4.10
SeriousGameClassification	2.43	2.12
Mobygames	2.03	1.32

4.2.3 Utility

The objective of the questions on the catalogue's utility is to measure whether teachers found SGs and if they identified some as being worth testing. All the teachers had the same level of experience in teaching with educational SGs, in other terms: none. In the 10 minutes allotted, the number of SGs found ranged from 1 to 5 for *JEN-Planet*, compared to 1 to 11 for *SeriousGameClassification* and from 2 to 10 for *MobyGames*. Teachers #6, #31 and #23 found no SGs with *JEN-Planet*, while 33 teachers found SGs with *SeriousGameClassification* and 22 teachers with *MobyGames*. However, these figures need to be considered more closely. Most of the teachers who did not find anything with the catalogues, were stopped at the first difficulties. For example, teachers #19, #20, #21 and #22 said they were put off by the English language of the *MobyGames* catalogue, which probably influenced their search. For the *SeriousGameClassification* catalogue it was the search filters that caused problems.

Among the SGs found, 42 teachers found at least 1 SG they wanted to test in *JEN-Planet* compared to 16 teachers for *SeriousGameClassification* and 10 teachers for *MobyGames*. Moreover, the percentage of SGs they wanted to test, compared to the total number of SGs found is higher with *JEN-Planet*. The teachers found 89% of the search results provided *by JEN-Planet* relevant, while the data shows 45 and 48% for the other two. For example, teacher #1 felt that he wanted to test 1 game out of the 11 found in *SeriousGameClassification* and teacher #25 did not want to test any SGs out of the 10 he found in this catalogue (Table 5).

Table 5. Number of teachers who found JEN in each catalogue.

	JEN-Planet	*SeriousGameClassification*	*MobyGames*
Teachers who found SGs	47	33	22
Teachers want to test SGs found	42	16	10
% rate of teachers want to test SGs	89%	48%	45%
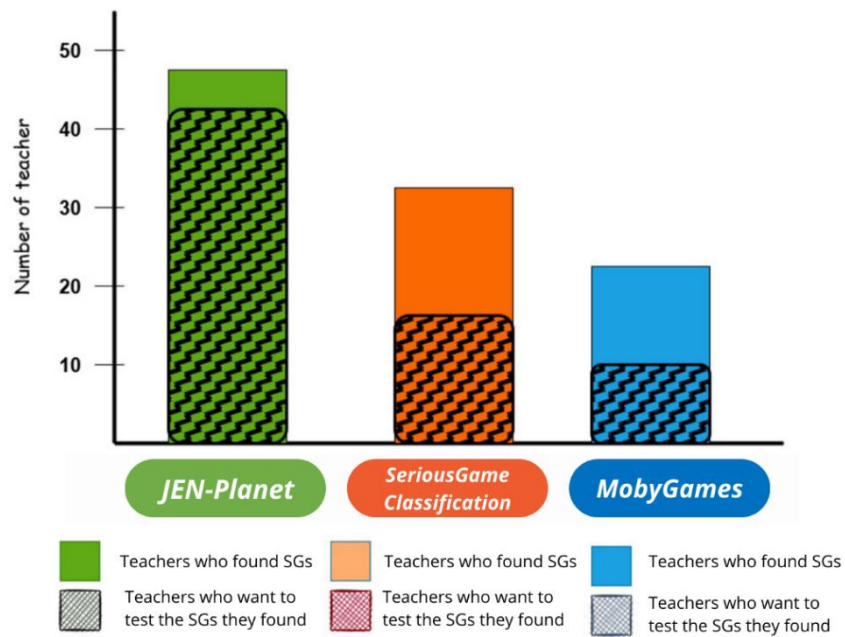
Figure 9. Proportion of the 50 participant teachers who found relevant educational SGs.

It is important to note that none of the teachers were familiar with the concept of SGs. This may explain the number of SGs found. Indeed, some teachers were not really looking for SGs for their course, but simply wanted to explore the existing SGs. Teacher #4, for example, did not want to test any of the SGs found. It appears, from the discussion, that she explored the catalogues out of curiosity rather than to find SGs for her specific classes. To the question did you find the *SeriousGameClassification* filters practical? She answered: "No, but it is easier to browse through this catalogue than the others".

In addition, some teachers confused educational with non-educational SGs. Indeed, teachers #1, #2 #5, #36 and #41, who said they found about 10 SGs, counted all the games displayed at the end of their search, without having made sure that they were educational SGs. Because *SeriousGameClassification* and *MobyGames* are SG catalogues (Figure 9), they provide both educational and non-educational SGs. Moreover, these catalogues contain many games from the 1990s which may be obsolete in view of current computer hardware, unlike *JEN-Planet* which only contains recent SGs (published since 2008). Thus, we find that some of the SGs from *SeriousGameClassification* and *MobyGames*, cited by teachers, are in fact non-educational or non-functional games. For example, teacher #6 who said that he had found 2 games in *SeriousGameClassification*, but they no longer work: *Des chiffres et des lettres* (1981) and *TuxMathScrabble* (2001). On the other hand, all the SGs found in *JEN-Planet* are indeed SGs and are more likely to work.

4.3 Discussion and Limitations

4.3.1 Discussion

The results presented above show that *JEN-Planet* has a better usability, relevance, and utility than the other two catalogues.

In terms of **usability**, the evaluation scores of the teachers for the *JEN-Planet* catalogue are the only ones in the acceptable range of the SUS scale. This can be explained by the fact that the interface of *JEN-Planet* is more minimalist and straight to the point than the others catalogue with a search area, containing only five filter fields and a result display area. In *MobyGames* and *SeriousGameClassification,* the interface also shows classification statistics, general information, information about the authors and their comments. The participants also

noted that the search filters in *JEN-Planet* are also more intuitive and flexible than in the other two catalogues. For example, teacher #7 said of *JEN-Planet*: "the filters are relevant, understandable and the interface is well organized. It is by far the most appropriate of the three catalogues for finding educational SGs. Teacher #3 also says "the interface is well organized and easy to navigate. The information on the SGs is closer to my field than in the other catalogues. Teachers #24, #49, #42 also spoke highly of *JEN-Planet*. Nevertheless, teachers raised some limitations. For example, teacher #3 noted that "the keyword filter is not explicit enough, I thought it was about pedagogical objectives". Others would have liked additional filters on the date or groupings by subject category for example. While we understand these requests, more filters would certainly overload the interface. In addition, the catalogue allows you to search with these criteria in the advanced search option. Finally, several teachers deplored the fact that the web page does not adapt well to smartphone screens. This would indeed be a useful improvement.

The results also show notable differences in terms of **relevance**. The scores for the *JEN-Planet* catalogue are twice those of the other catalogues. The information, in the SG descriptions, explains these differences. Indeed, the *JEN-Planet* catalogue uses the LGMD metadata schema, which is specially designed for describing educational SGs. The others catalogue uses non-specific metadata schemas. Indeed, *SeriousGameClassification* uses a metadata schema for all types of SGs and the *MobyGames* catalogue uses a general metadata schema for video games. Teachers are therefore more comfortable with the information provided in *JEN-Planet*.

In terms of **utility**, the number of SGs found by teachers with the *JEN-Planet* catalogue of 47 is also much higher than with the other catalogues, i.e. 33 SGs found for *SeriousGameClassification* and 22 for *MobyGames*. This could partially be explained by the fact that *JEN-Planet* contains many more educational SGs than the other two catalogues. This is because *JEN-Planet* uses an automatic SG referencing system that scans the web. The others catalogue index SGs by experts in the field or volunteer enthusiasts. However, the most important difference appears to be the number of SGs that teachers want to test out after the search. To be more precise, out of the 47 SGs found, the teachers were ready to try 42 of them out for their class, i.e. almost 90% against 48% and 45% respectively for *SeriousGameClassification* and *MobyGames*. This is since the two latter catalogues provide both educational and non-educational SGs. There were no real differences between the categories of teachers in their ability to find SGs regardless of the catalogue. STEM teachers were equally good at finding SGs as Humanities teachers.

Finally, it is important to note that the perceived usability of the catalogues among the participants did not influence the relevance scores of the information available on the SGs for each catalogue. In fact, the cross values of the SUS scores and the relevance of the information given by each participant for each of the catalogues do not follow a defined function that could explain a predictive trend in the data (figure 10). In curves a, b and c in Figure 10, the values with a high dispersion are far from the regression line determined by Equation 1. The values of *m* and *n* for each catalogue are given in Table 10.

$$y = mx + n \qquad\qquad\qquad \text{eq. 1}$$

The correlation coefficient R^2 for the *JEN-Planet* catalogue, with a value of 0.058, very close to 0 (Table 6), confirms the wide dispersion of the cross-referenced data. This means that there is no linear relationship between relevance scores and usability scores. The correlation coefficients for the other two catalogues, around 0.4 (Table 6), indicate that the relationship between relevance scores and usability scores is not strong. Thus, a high usability score may or may not induce a high relevance score. This means that the ease of use of the user interface had virtually no influence on the perceived relevance values of the catalogues' information.

Table 6. Linear regression between SUS scores (x) and information relevance scores (y).

Catalogues	m	n	R²
JEN-Planet	-0,0022	4.6064	0.058
SeriousGameClassification	0.0240	1.2858	0.419
MobyGames	0.0150	1.4315	0.449

(a) JEN-Planet

(b) SeriousGameClassification

(c) MobyGames
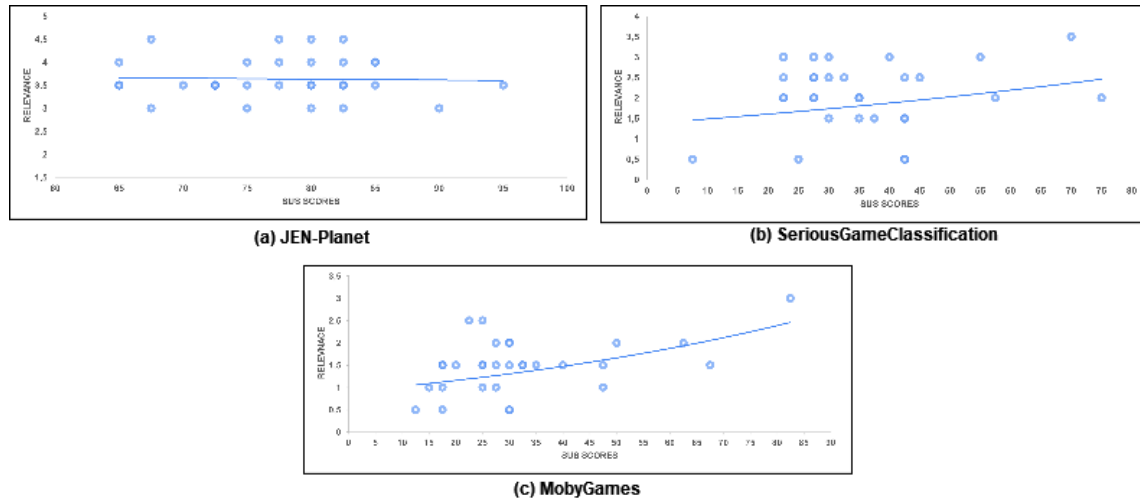
Figure 10.   Cross plots between SUS Scores item and Information Relevance Scores

4.3.2   Limitations

Nevertheless, the research carried out on *JEN-Planet* shows several limitations. First, the comparison of the catalogues is not as simple as it seems since the interface, the metadata, and the database of SGs are different from one catalogue to another. However, with the information extracted from *SeriousGameClassification* and *MobyGames*, *JEN-Planet* still shows better results in terms of relevance, usability, and utility.

The second drawback is the fact that the catalogue does not provide teachers with the possibility of giving feedback on the SGs they have tested, nor does it allow them to add their own SGs. Ideally, such a catalogue should enable users to add not only the final SG but also the source codes and work documents so that other teachers can modify them. DIY kits and non-digital SG material should also be present in the catalogue.

Teachers also raised some limitations that will be considered to improve the catalogue. Firstly, improvements can be made in the subject filter. Currently, the terms are sorted in a random order, as they are in the database. This filter starts with the term History and ends with Japanese with terms such as Art or English ending up in the middle of the list of 47 terms. To improve this, we will order and classify the entries by educational field (e.g., science, language, art). Secondly, there is no indication on the keyword filter to guide users. We will therefore add examples of keywords in the filter field to show teachers that they can search for the competences associated with their courses. These examples will disappear when the user enters a word in the field.

In terms of utility, we will add features that allow editors to add SGs to the catalogues in three different ways. Firstly, editors will be able to fill in a form with the 23 fields of SGMD metadata schema with information about their SG. Secondly, publishers will be able to provide the link to their SG's web page so that the catalogue can automatically retrieve the information to fill in the metadata fields. The publisher will then be able to complete and correct the fields

as required. Finally, for publishers with several SGs, it will be possible to enter the link to the SGs website and *JEN-Planet* will automatically retrieve all the information on the SGs, including new ones. In addition, we plan to add a rating and commentary system for each SG, so that the experiences of one SG can be used by others. There will also be an option to report issues (*e.g.,* availability, incompatibility, etc.) so that SGs can be removed from the catalogue after verification.

5. Conclusion and Perspectives

To encourage teachers to use SGs, ergonomic and intuitive catalogues with a wide range of SGs are needed. To address the problem of educational SG visibility, it is important to have catalogues specially dedicated to this type of SG and search filters that match teacher's needs. We showed in this paper that existing catalogues do not meet these criteria. We therefore propose the *JEN-Planet* catalogue, which is built on previously validated research: LGMD - an optimal metadata model for SGs description, ADEM - an information extraction model capable of populating the catalogue automatically by scanning the SGs' webpages and finally, and UDID – a design method that enabled teachers to create the catalogues interface themselves so it would best fit their needs.

The usability, relevance of information and utility of this catalogue was evaluated by 50 teachers and compared with the two main current catalogues. Thus, the high scores for usability obtained by *JEN-Planet* catalogue validate the ergonomics and intuitiveness of the catalogue. It is easy to use compared to the other catalogues analyzed. This is also true for the information on the SG descriptions. In terms of utility, the fact that teachers found, on average, three SGs for their lessons, with *JEN-Planet,* in less than 10 minutes, is a very positive point. This is not obvious for people who are not familiar with SGs. In addition, all the SGs found are recent and adapted to their pedagogical needs, unlike the other two catalogues.

However, *JEN-Planet* can still be improved. To begin with, the interface should be adapted to all screen sizes, as requested by some teachers. In addition, rating and commenting systems are needed to consider teachers' feedback on the SGs used and to facilitate the exchange of good practice. Furthermore, improvements can be made to increase the number of SGs in the catalogue. Indeed, the catalogue has collected information on 785 SGs by browsing five catalogues, but it could index many more by browsing the whole web. However, this presents a real challenge, since the currently algorithm used assumes that the link provided contains information about SGs. This situation is completely different in the global web, where pages deal with various subjects. Finally, gamification could be used to encourage teachers to leave comments to improve the catalogue, but also to encourage SG publishers to provide all the relevant metadata. More work also needs to be led to create a community around the catalogue to update the database and report issues.

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Appendixes

Catalogue evaluation questionnaire

Usability - System Usability Scale (SUS) model

Teachers were asked to rate their statements on a Likert scale, 1 "strongly disagree" to 5 "strongly agree".

1- I think I will use this catalogue frequently.
2- I think this catalogue is unnecessarily complex.

3- I think this catalogue is easy to use.
4- I think I will need a technician's help to use this catalogue.
5- I think this catalogue is well organized.
6- I think there are too many inconsistencies in this catalogue.
7- I think that all teachers will be able to learn to use this catalogue quickly.
8- Using this catalogue requires too much intellectual effort.
9- I was comfortable using this catalogue.
10- I need training before I can handle this catalogue.

Description of SG

Teachers were asked to rate their statements on a Likert scale, 1 "strongly disagree" to 5 "strongly agree".

1- I easily understand what each search filter in this catalogue means.
2- I can find all the criteria I need to search this catalogue.
3- The information on the SGs, displayed in the results area, allows me to easily identify the SGs that match my search.
4- Information on the SGs displayed is still missing to enable me to make a choice.

Utility of the catalogue

Free text

1- In a maximum of 10 minutes, how many SGs did you find interesting (read all the information)?
2- Which SGs would you like to test before using them in your courses?