Organizing and evaluating resources and tools for active learning approaches

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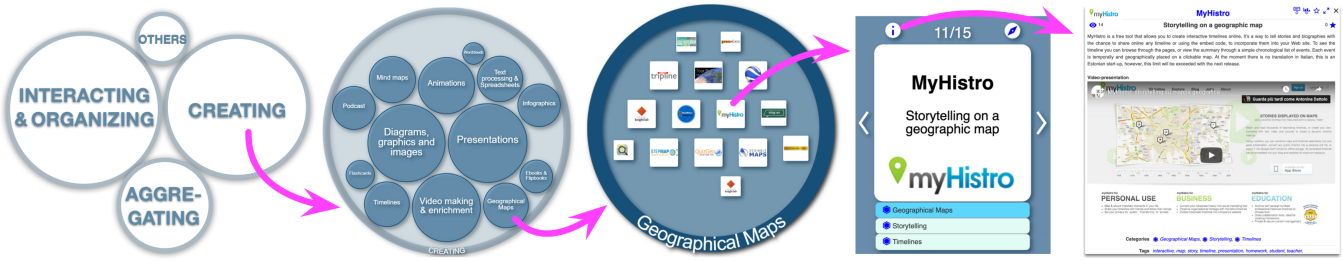

Figure 1: The AppInventory visual catalog: zooming in allows users to discover the tools.

ABSTRACT

Innovative teaching and learning practices towards active approaches, require digital tools for creating digital artifacts (such as infographics, mental maps, timelines), for improving the interaction between teachers/students and organizing work groups, for aggregating documents and sources. Although the Web proposes a large offer of applications useful for these aims, there is a lack of knowledge about their existence, their functions and their potential in educational settings.

In this paper, we present AppInventory, a visual catalog of 271 applications, organized in a purpose-based taxonomy; starting from a general view that groups the applications in three main macro-categories, users can apply different zooming levels for visualizing the details of the macro-categories, then of the categories, applications, and finally the detailed cards of applications (Figure 1). Users can explore the catalog following personal contextual paths, supported by zz-structures, assigning ratings for each visited application and leaving comments and suggestions.

KEYWORDS

Visual approach, holistic view, catalog of applications, app 2.0 taxonomy, user rating, contextual navigation, e-learning, smart teaching

*Both authors contributed equally to this research.

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1 INTRODUCTION

AppInventory is an online platform, freely available for research and teaching, not for commercial purposes, at http://appinventory.uniud.it. It contains a visual multimedia catalog of 271 applications, developed with the aim of supporting teachers and students in identifying the best tools to carry out specific tasks, improving their digital skills, and evaluating resources and tools for active learning approaches.

Over a two-year period (2017-2019), a large number of Web and mobile applications were selected, analyzed and classified according to an original purpose-based cataloging scheme. A point of reference for the AppInventory project is the European Digital Skills Framework for Citizens - DigiComp [19]; the AppInventory project is consistent with the objectives of the Digicom's framework and, in particular, it can contribute to the development of ten of the twenty-one competence dimensions stated in its conceptual reference model.

Another motivation arises from the results a preliminary study on a group of 178 teachers from north-east of Italy about the role of technology in improving teaching and learning activities [11]. From that study emerged a marked interest in the role that technology could play in educational processes, the importance attributed to the planning and diversification of learning activities, the need for a more extensive knowledge about applications for the creation of products and for communication and, finally, the expectation placed towards active teaching methods.

These premises have encouraged the development of the AppInventory project, created with the aim of supporting teachers in

identifying appropriate tools for specific tasks related to teaching, learning, collaborating and organizing and sharing. In particular, AppInventory has been modeled for:

- providing detailed and multilingual information on each app;
- cataloging the applications following an original purpose-based taxonomy;
- offering innovative mechanisms for contextual navigation;
- providing a visual representation and a holistic view of the catalog;
- collecting user comments and ratings about applications.

The rest of this work is organized as follows: Section 2 discusses the state of research in this area; Section 3 illustrates the platform by describing the structure of the catalog and the adopted cataloging scheme; Section 4 describes the navigation tools provided by the platform; Section 5 presents its architecture; Section 6 summarizes the results of a usability test. Short concluding notes and upcoming developments close the work.

2 RELATED WORK

The number of repositories dedicated to classifications of tools that can support teachers in identifying applications for specific purposes is limited [10, 16, 17], if we exclude repositories deemed too general, such as App Store, Google Play, Chrome Web Store, Appszoom, or repositories which share learning objects and didactic resources and not tools, such OER Commons.
Among them, EdShelf [4] represents a socially-curated discovery engine of websites, mobile apps, desktop programs, and electronic products for teaching and learning; the slogan "find the perfect tool for your needs" limits the user support to a traditional filtered search (by price, platform, subject, age, category and keywords), and a sorting of the results by popularity, date, and last update. The results are proposed as a long and unusable set of cards. Furthermore, subject and category are two long *flat lists* of keywords (almost a hundred for each of them). Interesting is the opportunity for users to rate and review the apps, and to create and share a shelf of apps. Essediquadro [6] is a service of documentation and orientation on the teaching software and on other resources for the learning process. The tools can be searched by subject of study (Mathematics, Italian, etc.) and by specific subject matter, but *the category of the tools is not considered.* Furthermore Essediquadro is proposed only in Italian language. Similar search fields are proposed by Apps4edu [1]. It is possible to list all the apps in it, but the result is *a flat, unusable, paged-list of tools.* An interesting set of directories for e-learning is provided by [5]: for each tool, the platform proposes an overview, the main features, pricing, reviews and also the possibility of comparing the current tool with others. CSE (Common sense education) [2] introduces between similar search filters (by platform, subject, grades, price, skills) the interesting, abstract concept of *purpose*, but it is used more as teaching context of use more than real purpose; in fact, the possible purposes are assessment, classroom management, instructional design, media literacy, productivity, and professional learning.

A comprehensive review of existing application classification systems is provided in [9]; it confirms that a good classification model needs to consider the purpose of the teachers and proposes a classification divided on skill-based, content-based and function-based applications, which implicates respectively the "Remembering and Understanding", "Applying and Analysing", and "Evaluating and Creating" levels of the Bloom's Taxonomy [7].

From our viewpoint, by the term "purpose" we mean the concrete objective of the teacher (or of a generic user), such as realize an infographic, or create a timeline, or plan a quiz.

Related work highlights some open challenges and weaknesses, which we try to overcome in our catalog.

3 APPINVENTORY

The AppInventory Web platform offers graphic and holistic views of the whole catalog, organizes the applications in a purpose-based taxonomy, facilitates users in the semantic navigation among items, and enables users to interact with the platform, rating and reviewing an app, leaving a comment or suggesting a new app. A holistic view of the catalog is shown in Figure 2, where we recognize a taxonomy of three macro-categories and 25 categories:

- *Interacting & Organizing* contains 7 categories: Assessment rubrics; Collaboration & Communication; Designing & Planning; Gamification; Groups management; Quizzes, forms, surveys; Shared whiteboards.
- *Creating* includes 13 categories of tools to create digital artifacts: Animations, Diagrams, graphics and images, Ebooks & Flipbooks; Flashcards; Geographical Maps; Infographics; Mind maps; Podcast; Presentations; Text processing & Spreadsheets; Timelines; Video making & enrichment; Wordclouds.
- *Aggregating* contains 4 categories: Augmented reality; Content collectors; Link collectors; Storytelling.

Figure 2: A holistic view of the catalog.

The last category "Others" captures unforeseen features.

In order to introduce the features of AppInventory to users, a forty-steps tour of the platform has been made available (Figure 2, bottom-left) and can be activated by the "?" icon.

As shown in Figure 1, the catalog uses a multi-resolution circle packing diagram, which starts from a general view of the applications, organized using the cited taxonomy, and, applying different zooming levels, enables user to visualize the details of the macro-categories, the categories, applications, until to open the cards of the specific applications.

Each application often integrates various distinct features: for this reason, we have adopted a weighted attribution of an application to single categories in order to highlight the primary purpose compared to secondary ones.

For each application, we applied a uniform cataloging scheme, which includes a short description of the main purpose of the app; an original video presentation of the app; a list of fields to describe the app according to the different features, such as plan and pricing, typology (Web app, Android app, Apple app, etc.), and others; a third-party video-tutorial in the currently selected language (Italian or English); a review of the app that describes its main features through text and images in order to give the user the opportunity to evaluate the adequacy of the app with respect to his/her goals. Part of the card of the application "MyHistro" is shown in Figure 1-right. On each application, users can interact also leaving personal comments, suggesting new use cases, rating the application and marking it as known. Figure 3-(1) shows the first rows of a card (specifically the card related to the Edmodo application). If the user

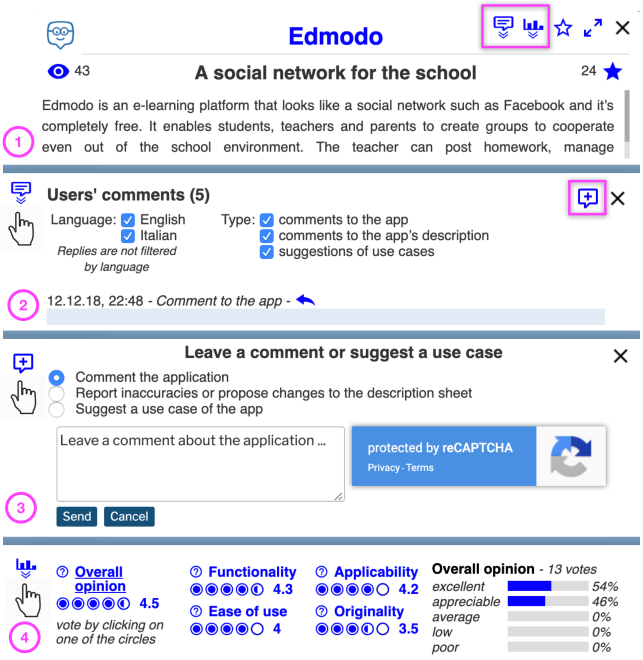

Figure 3: Comments, suggestions, and rates.

clicks on the comment icon (the first of the two icons bordered in magenta in Figure 3-(1), top-right) the list of comments, in our case 5, is displayed, as partially shown in Figure 3-(2), and the user can filter them by language and by three typologies of comments: specific to the app, to the accuracy of the app's description, or suggestions of use cases: furthermore, a user, clicking on the '+ comment' icon in Figure 3-(2), top-right, can add a new comment, as shown in Figure 3-(3). Moreover, if the user clicks on the rate icon (the second of the two icons bordered in magenta in Figure 3-(1), top-right, he/she visualizes the possible ratings, as shown in Figure 3-(4): each user can rate four features of any app, and express a general opinion in a 5-Likert scale:

- *functionality*: versatility of the app or the richness of the features provided;
- *applicability*: adaptability of the app to multiple contexts and tasks;
- *ease to use*: usability and the intuitiveness of the user interface;
- *originality* of the features provided and/or the technical solutions adopted;
- *overall opinion* is the overall degree of appreciation of the app.

For each features, the user can see the rating and its distributions on the 5-Likert scale. In addition to ratings, users can leave five different types of comments in two contexts:

- local to a single app: comments to the app, suggestions of original use cases or reports of inaccuracies / proposals of changes in the description card;
- global: comments about AppInventory or suggestions of new apps to add in the catalog.

4 CONTEXTUAL NAVIGATION

In order to support the navigation in the catalog, AppInventory provides the following tools:

- *navigation panel*
- *application panel*
- *criteria selection panel*
- *simple and advanced search*

Figure 4: The navigation panel (left), the application panel (center), and the criteria selection panel (right).

The *navigation panel*, visible in Figure 4-left, activated by clicking the "compass" icon shown in Figure 2, top-left, contains initially the list of all the applications, and then the *current navigation set*, obtained applying filters or specific choices. The list of the applications in the navigation panel can be sorted by various criteria, including user ratings, number of visits, complexity, membership to a category.

Zooming in the catalog, it is possible to visualize the applications contained in each category, such as shown, for example, in Figure 1-3rd image. Let we suppose to zoom in (see Figure 2) the macro-category 'CREATING' and then in the category 'Infographics' (on top-right), and successively click on any application in it contained, for example 'Easel.ly', we will visualize the *application panel* of 'Easel.ly' (Figure 4-center); it contains, beginning from the top:

- the 'i' icon to open the detailed card of the application. A example of card for the application 'MyHistro' is shown in Figure 1-right;
- the position index in the current navigation set. In our example, the navigation set contains all the applications belonging to the 'Infographics' category, which are 12, and the 'Easel.ly' application has as position index 5;
- the contextual 'compass' icon to open the criteria selection panel (see below);
- the name of the application, in our example 'Easel.ly';
- a short description;
- its logo;
- the list of the categories to which the application belongs, and the membership level (3 possible levels) represented by the prefixed hexagonal icons. In our example, we are three categories, and 'Easel.ly' fully belongs to the 'Diagrams, graphics, and images', and 'Infographics' categories, while only partially belongs to the last 'Collaboration & Communication' category;
- two *left/right cursors* for allowing users to move to the previous/next applications in the current navigation set.

The *criteria selection panel*, shown in Figure 4-right, allows users to dynamically modify the current navigation set, selecting new filters based on the current attributes of the application. Following the example, it is possible for example to leave the default navigation criterion 'Current category' and add 'Similar complexity' or 'No advertising": in this way it is possible to find and explore similar applications, previously not included in the current navigation set. The background color for the application names in the navigation panels will reflect the chosen criterion; for example, in our example of Figure 4-left it is white, corresponding to the 'Current category'; if we apply 'Similar complexity', it will become green and so on; for example, the results of a search will have the red background, as shown in Figure 5-center. It is also possible to combine different criteria via AND / OR operators to build the exploration dimension; in this case, the background color will be yellow.

This mechanism of contextual navigation differs from traditional filtering approach since it allows, starting from an application, to explore a specific neighborhood designated by selected criteria, also outside of the current category. This approach, derived from zz-structures [14, 18], which we used to build the underlying data model (see next Section 5), permits both to adopt a simple cursor-based navigation along a dimension and gives users the freedom to change and redefine the navigation dimension according to the current item attributes. AppInventory also provides *simple and advanced search* functions, as shown in Figure 5. The found applications define a new navigation set that can be combined, in the context of a single application, applying specific criteria. The advanced search proposed in Figure 5-left, produced a list of 10

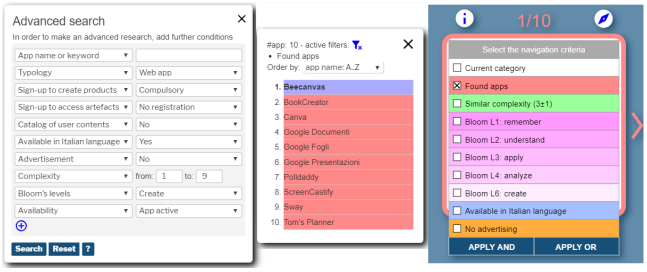

Figure 5: The advanced search window (left), the navigation panel after the search (center), the criteria selection panel of the first found app (right).

applications (Figure 5-center), and starting from any of them, in our example, the first in the list, 'Becanvas', it is possible to find, between the related criteria (Figure 5-right), the new criterion 'Found apps'.

5 ARCHITECTURE

AppInventory has been implemented as a Web application based on HTML5, SVG and CSS3 W3C standard languages and the D3js [3] framework. The client-server architecture and the main components of AppInventory are schematically represented in Figure 6. On the server side, a MySql based *DBMS server* hosts the reposi-

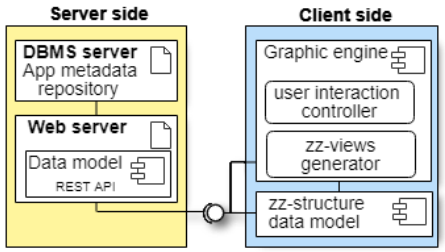

Figure 6: The architecture of the AppInventory platform

tory of the *app metadata*, containing also the information about taxonomies and the user contribution data, while a *Web server* manages the requests coming from the connected clients. Client browsers interact with server through a *API Rest* interface both to load the initial *data model* of the catalog and to dynamically retrieve/send small chunks of data according to the user actions. The adopting of this model based on Ajax calls improves the user experience by avoiding full page reloads during the navigation in the catalog.

On the client side, the data model uses the zz-structures [14, 15, 18] to structure knowledge, and to provide a representation of data and contextual navigation mechanisms. By using zz-structures, the data are connected in semantic paths, called dimensions, which define the contextual relations between the elements. Each element can belong to multiple dimensions. The visualizations of the Zz-structures and the management of user interactions are accomplished by the *graphic engine*. This module implements the zz-views which provide the visual representation of the zz-dimensions and

the mechanisms to move forward and backward along them and to generate and select new dynamic dimensions by combining the existing ones through logical operators. In order to generate zz-views a relevant tool is D3js, that provides a powerful DOM selection mechanism, based on declarative CSS patterns; a rich library of methods to create complex graphical representations and to act, with the same syntax, both on single DOM elements and on sets. The idea behind D3js is to strictly tie data to HTML or SVG elements realizing a so-called data-driven approach to DOM manipulation without hiding the document structure with opaque software layers. We recently experimented the D3's versatility in realizing the application VisualBib [12, 13] and we decide to apply here in order to create and manage a holistic and usable approach. In addition to the navigation in the catalog, the *graphic engine* also manages the user actions both by changing the views (e.g. when a simple or advanced search is performed) and by updating the data model (e.g. when a new comment or rating is inserted).

6 EVALUATION

In order to evaluate the usability of the platform we carried out a study on a sample of 68 persons (42 F, 26 M) who participated to a seminar for the presentation of the new platform and to the next workshop session. The professions of participants were teacher or researcher (76.5%), student (13,2%) or other (10.3%). Among teachers, 18.9% were from primary school (K1-5), 24.5% from middle schools (K6-8), 52.8% from high school (K9-13), 3.8% from universities. After the presentation of the platform to the participants, they were asked to perform a series of simple tasks in order to familiarize themselves with the interface and its functionalities. Subsequently the participants were given a standard SUS (System Usability Scale) questionnaire [8], to gather the degree of agreement on a 5-level scale (totally disagree, totally agree) with the following series of propositions concerning the system under consideration, formulated by alternating a positive and negative tone:

- **Q1** I think that I would like to use this system frequently;
- **Q2** I found the system unnecessarily complex;
- **Q3** I thought the system was easy to use;
- **Q4** I think that I would need the support of a technical person to be able to use this system;
- **Q5** I found the various functions in this system were well integrated;
- **Q6** I thought there was too much inconsistency in this system;
- **Q7** I would imagine that most people would learn to use this system very quickly;
- **Q8** I found the system very awkward to use;
- **Q9** I felt very confident using the system;
- **Q10** I needed to learn a lot of things before I could get going with this system.

The SUS value was computed, for each participant, with the formula $SUS = \left(\sum_{k=0}^{4}(A_{2k+1}-1) + \sum_{k=1}^{5}(5-A_{2k})\right) * \frac{100}{40}$. where A_i is the value (from 1 to 5) of the answer to the Q_i question. The measured values of SUS were in the range [37.5, 100] with a mean of 76.5 and a median of 78. The distribution of the frequencies of the SUS values, grouped in intervals of size 5, is summarized in Figure 7, while Figure 8 reports the distribution of the answers to each SUS question.

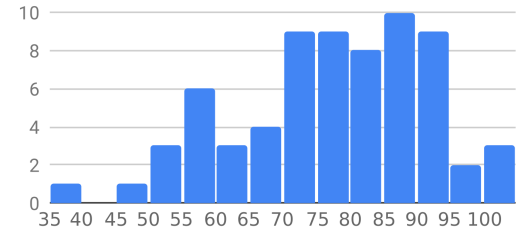

Figure 7: The distribution of the frequencies of the SUS values over intervals of size 5.

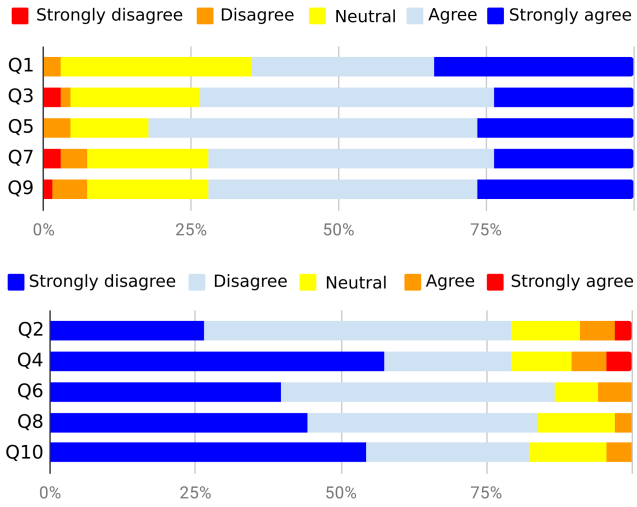

Figure 8: The distributions of the answers to the odd, positive tone, SUS questions (top) and to the even, negative tone, ones (bottom). In the second plot, the color scale has been reversed to map, as in the first plot, positive values to azure/blue colors.

From the analysis of the results it can be observed how, excluding the first question concerning the frequent use of the platform, the percentage of positive responses is always higher than 72% for positive questions and 79% for negative ones. We highlight in particular some aspects including the ease of use of AppInventory (answers Q4 and Q10), the absence of inconsistencies (Q6), the linearity of use (Q8) and the good integration of the functions offered (Q5).

7 CONCLUSIONS

In this paper, we presented AppInventory, a multimedia Web catalog of applications, organized in a purpose-based taxonomy; the platform uses a visual approach for the navigation. AppInventory represents a support for teachers during the micro-design of teaching and learning activities but also an interesting resource for students, professionals and anyone who wants to discover and experiment new tools within their activities. The results of an evaluation based on a SUS questionnaire carried out on a sample of 68 users showed a median SUS index of 78 which is between a "good" and "excellent" rating of the scale introduced in [8]. A forthcoming study, currently

being implemented, includes a comparative evaluation of the usability and other qualitative aspects of AppInventory with respect to the Edshelf and Essediquadro platforms. Other planned developments include both maintaining catalog information by checking and updating contents and videos, and developing new features and new views that allow a quantitative comparison of applications based on the data collected and their intrinsic features.

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