Testing and validation of the first implementation of the Go-Lab open access digital ecosystem for inquiry learning in Africa

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Abstract

This paper presents the results of the testing and validation activities of the first adaptation of the Go-Lab open access digital ecosystem for inquiry learning in Africa supported by GO-GA (Go-Lab Goes Africa), an ongoing action aimed at promoting and implementing digital STEM education at schools in Africa. Following the adaptation of the Go-Lab ecosystem to the educational context of the partner countries (Kenya, Nigeria, and the Republic of Benin) during the first year of the project, we describe the methods used for testing and validation, analyse the collected data and present the results. The results highlighted the need to expand the resources suitable for the national curricula of the pilot countries are, and to make the access to these resources more visible. Furthermore, the results indicated that first-time users tend to use the links in the subpages and side menus to navigate the ecosystem, rather than explore the ecosystem systematically using the main menu pages. Additional results in relation to technical observations, interaction with the ecosystem and users' feedback are presented in this paper. We further highlight the improvements introduced in the Go-Lab ecosystem which were driven by the testing and validation sessions, and we provide guidelines and suggestions to strengthen adoption and dissemination, such as implementing performance improvement techniques, creating an offline version of the ecosystem, as well as providing suggestions for the teacher training activities.

Keywords: active learning; collaborative learning; digital education; GO-GA; Go-Lab; inquiry-based learning; STEM education

Introduction

Go-Lab Goes Africa (GO-GA) is an innovation action focused on implementing digital education for Science, Technology, Engineering and Mathematics (STEM) in Africa. It is supported by the European Commission (EC) through its H2020 Framework Programme for Research and Technological Development in Information and Communication Technologies (ICT). GO-GA aims at accelerating the creation of rich learning environments and improving learning outcomes in science and technology through the deployment of digital STEM content and capacity development of teachers in three partner countries—Kenya, Nigeria, and the Republic of Benin—and further in four associate countries—Ghana, Senegal, Sierra Leone and Uganda. The project is aligned with the 2030 Global Education Goal of UNESCO's programme *Education for All* (*Education for All Movement*, 2013; Leicht et al., 2018), by focusing on the implementation of specific forms of digital education at secondary schools, such as Inquiry-based Learning (IBL) and competence-based education.

The Go-Lab ecosystem was mainly developed under the Go-Lab and Next-Lab European projects, supported by the EC's Seventh and H2020 Framework Programmes, respectively. As such, it has been implemented mainly in European schools, whose educational context is not necessarily the same as that of the targeted African context.

This paper describes the methodology for the testing and validation of the adapted and localized Go-Lab ecosystem in three pilot countries (Kenya, Nigeria, and the Republic of Benin); provides detailed information about the techniques used to collect data; presents the data analysis, an evaluation of the results, and a summary of the findings; and finally concludes with recommendations for further improvements of the Go-Lab ecosystem for Africa.

Conceptual framework

Inquiry-Based Learning and Online Labs

Active learning is a very effective learner-centred approach for science education, in which students participate in the learning process, by actually doing something more than listening and thinking. Of all the active learning methods and approaches, inquiry-based learning (IBL, Pedaste et al., 2015) with online (mostly virtual) laboratories is one of the most successful (de Jong et al., 2013). There are several advantages for using non-traditional online laboratories over hands-on labs. On the one hand, students feel more comfortable executing the experiments because they are not afraid to fail, the labs are cheaper and have less environmental impact (tools do not break apart and there is no waste), they are more easily accessible, and they offer the possibility of augmented reality. On the other hand, there is strong empirical evidence for the learning outcome achievement using virtual labs being at least the same as the one using traditional laboratories in fundamental categories, such as knowledge and understanding, inquiry skills, perception, analytical skills, and social and scientific communication (Brinson, 2015) .

The Go-Lab ecosystem was developed in order to provide learners with a digital environment supporting inquiry learning with online laboratories and including multimedia resources and apps. The ecosystem is composed of the Go-Lab sharing and support platform Golabz at https://www.golabz.eu/, which provides access to a large and unique collection of online laboratories and scientific data sets from worldwide repositories, such as PhET, Amrita, and ChemCollective, from universities, institutions, and renowned research organisations, such as the European Space Agency (ESA), the European Organisation for Nuclear Research (CERN), and the Astronomical Observatory of Coimbra's University (OGA). Additionally, the platform includes learning applications (apps) supporting inquiry and collaborative learning, assessment, and the use of learning analytics. The "Hypothesis Scratchpad" and the "Experiment Design Tool" are examples of inquiry applications, where students can formulate their hypotheses and design their experiments in the learning environment, this way being supported in their inquiry process (Zacharia et al., 2015). Using the Go-Lab authoring and learning platform Graasp at https://graasp.eu/, teachers can combine online laboratories, learning apps, and multimedia content into a rich and structured open educational resource (OER), referred hereafter as an Inquiry Learning Space (ILS), which they can then share with their students. The ecosystem supports all inquiry stages in a flexible way, it promotes collaboration and interdisciplinarity, and thus facilitates the development of activities that allow students to explore real-world challenges.

This action is in line with the priorities defined by EC and STISA-2024, by contributing to the implementation of IBL in the classroom with the help of digital tools, such as the online laboratories and apps provided by the ecosystem. By promoting teacher training programmes, focusing on the use of online applications and laboratories, and digital platforms in the classroom, GO-GA allows for the development of digital competences in both learners and teachers. It also facilitates the transformation into a digital school with the help of a roadmap that focuses on the ICT curriculum and infrastructure, professional development, leadership and planning, and technology enhanced learning culture.

Usability testing approaches

The adaptation and localization of the Go-Lab ecosystem, its content and the teacher training are at the heart of the GO-GA action. The former requires an initial study of the pedagogical and technical constraints, the elicitation of requirements (identification of the technical and pedagogical needs of the users) and, finally, the testing and validation of the ecosystem. In that regard, usability evaluation methods are widely recognized as effective ways to assess the usefulness of a product or software (Rosenzweig, 2015). Generally, there are three types of usability evaluation methods: inspection, testing, and inquiry (Hom, 1998; Rubin & Chisnell, 2008).

In the usability inspection approach, usability-related aspects of a user interface are examined. Of the inspection methods, task or action analysis emerges as an effective way to gather a deep insight into user's performance when completing a task, since action sequences performed by users are monitored throughout the inspection (Nielsen, 1994). It has the advantage, over other inspection methods, such as heuristic evaluation or cognitive walkthrough, of involving the end users in the process. However, it is time-consuming (Cheng & Mustafa, 2015).

In the usability testing approach, representative users work on typical assignments using the system, and the results are used to assess how the interface supports the users to carry out their tasks. This approach comprises, for instance, the coaching and co-discovery methods, and the thinking aloud protocol. In the coaching method, users are allowed to ask any questions during the execution of the tasks, while in the co-discovery method, users work in small groups to attempt to perform the assigned tasks. In both cases, the users are observed while exploring the platform or executing a specific task. In the thinking aloud protocol, users are invited to verbalize their thoughts, feelings and opinions while interacting with the system (Lewis, 1982).

Inquiry[1] can be typically carried out by means of field observation, focus groups, interviews or questionnaires. In a field observation, users are observed and inquired directly

[1] Not to be confused with inquiry-based learning (IBL).

in their work places; in focus groups, small teams of users are brought together to discuss issues relating to the system; in interviews and questionnaires, questions are asked to the users in order to gather relevant information.

Several of these methods were applied during the testing and validation of the first adaptation of the Go-Lab ecosystem, in the form of workshops, activities and scenarios, task analysis, observation forms, open discussions and brainstorming, questionnaires, and video recordings together with the thinking-aloud protocol. They will be discussed in the following sections.

Context of the study

The aim of the testing and validation study was to evaluate the release of the first set of requirements, including the added languages and translations interfaces, as well as the resources specific to each country. Additionally, the performance of the ecosystem with the available technical infrastructure and the usability of its platforms (Golabz and Graasp) were tested to elicit further improvement and development. The following research questions guided the study:

1. How do first-time users freely navigate the Go-Lab ecosystem?
2. How do first-time users find specific resources in the Go-Lab ecosystem?
3. Is the quality of the implemented automated translation in French good enough to support users navigate the ecosystem?
4. What technical issues emerge while using the Go-Lab platforms with the available infrastructure in the pilot countries?
5. How can the functions and features most valued by the users be further developed and improved?

Methods

In GO-GA, the professional development of the teachers, the creation of digital educational content, the use of the IBL methodology and of virtual online laboratories in the classroom are supported by the Go-Lab ecosystem. A set of online labs and ILSs selected to fit the curricula of Kenya, Nigeria, and the Republic of Benin were compiled in the *Collections* page of the platform (see fig. 1). The Collections page was at the heart of the task of adapting and localizing the ecosystem to the participating countries.

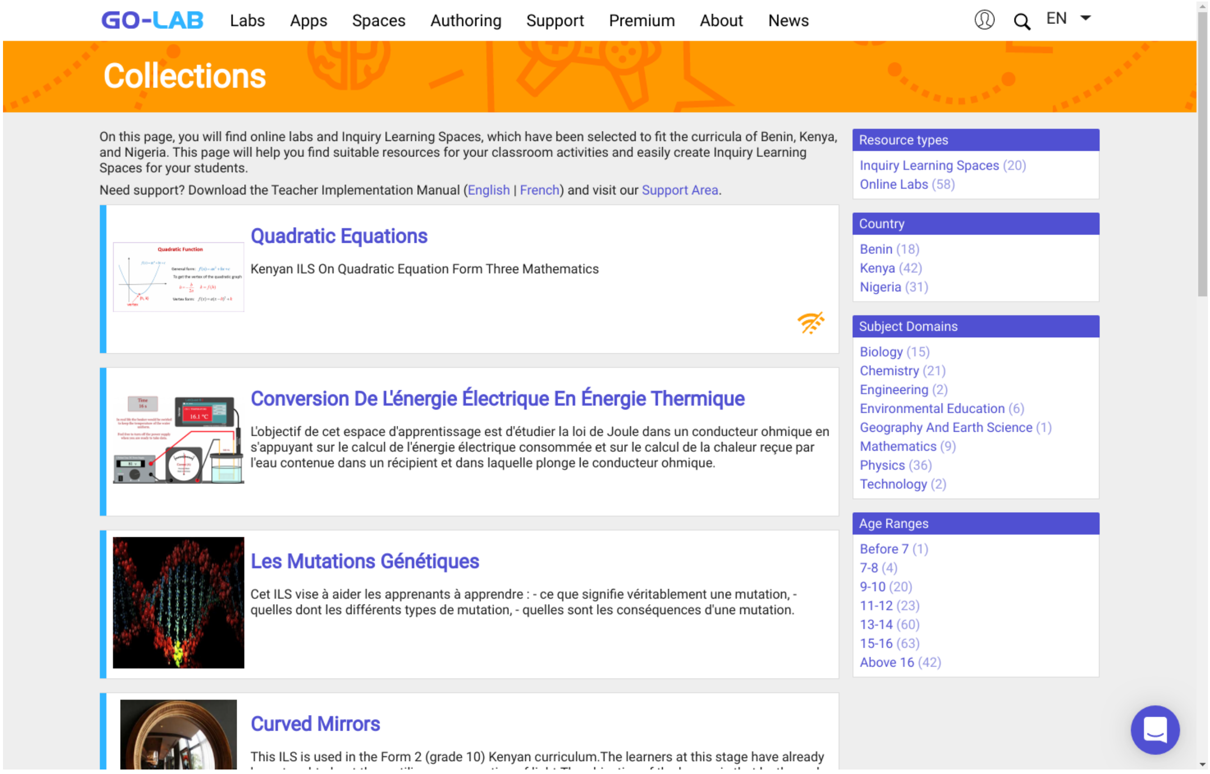

Figure 1: The Collections page in golabz.eu, a page where selected educational contents have been adapted to the curricula of Kenya, Nigeria, and the Republic of Benin.

The test and validation of the first release of the adapted and localized ecosystem were carried out during three-day intensive Train-the-Trainer (TtT) workshops in Nigeria and Kenya, and during a specific training and testing event in the Republic of Benin focusing on validating the Go-Lab ecosystem with new users. Qualitative and quantitative data were collected throughout the events by means of observation forms and questionnaires, activities, open discussions, video recordings, and the use of scenarios (see tab. 1).

The video recordings allowed the analysis of how first-time users explored the ecosystem: which pages they visited, which menus and functions they used, how they searched for content, and whether they faced any technical or non-technical issues. Teachers were invited to think-aloud while they were working. Thirteen videos were saved and analysed, totalling 405 minutes of recording, corresponding to an average recording time of 31 minutes per participant.

In the Republic of Benin, two scenarios were provided to the teachers before they were introduced to the Go-Lab ecosystem and trained to use it. The scenarios aimed at studying the first-time users' preferred navigation style(s) and search method(s) using the ecosystem, the level of difficulty in finding specific content, at collecting feedback on the quality of the automated French text translation of the main text and descriptions of labs and apps, and at introducing teachers to the different resources available.

The observation forms included items related to internet connectivity and technical feedback. They were filled in by team members while participants were completing the hands-on tasks and working with the Go-Lab ecosystem. The aim was to test if teachers were using the features previously released, to discern the challenges they faced while working with the ecosystem, and to make better-informed decisions for future developments and activities.

At the end of each event, teachers were asked to fill in a questionnaire using an online form. The questionnaire consisted of 17 items in all. Overall, 79 teachers participated in the process: 24 from Kenya, 35 from Nigeria, and 20 from the Republic of Benin. They were either master teachers (MTs) selected for the TtT programme (in Kenya and Nigeria) or new teachers specially selected for the testing and validation event in Benin. In both cases, the general ICT level of the participants was considered fair. The questionnaires were aimed at collecting the participants' perceptions and opinions on working with the Go-Lab ecosystem, as well as their feedback concerning any technical and navigational difficulties they may have faced. A five-point Likert scale, ranging from 1 ("Strongly Agree") to 5 ("Strongly Disagree"), was used and, whenever applicable, the option "I don't know, I haven't used this feature" was added. Seventy-three responses were submitted, of which 31.5% were from Kenya (95.8% of Kenyan participants), 43.8% from Nigeria (91.4% of Nigerian participants), and 24.7% from Benin (90% of Beninese participants).

Users' feedback concentrated on technical aspects and challenges, and teachers' experiences about working with the Go-Lab ecosystem. It was collected in all events, by means of open discussions, creation of group charts listing the benefits and challenges of using the ecosystem, and affinity diagrams. The latter was promoted in all sessions, as it is an effective way of organizing ideas, identifying problems and finding solutions (Britz, 2010). The feedback was documented, put together and categorized to identify common issues. However, due to space limitations, its analysis will not be covered in this paper.

Table 1: Overview of the methods used to collect the data during the testing and validation sessions.

	Kenya	Nigeria	The Republic of Benin
Video recordings			x
Scenarios			x
Observation form	X	X	x
Questionnaire	X	X	x
Participants' feedback	X	X	x

Data Analysis

The data were analysed according to three categories: Usability testing ─ analysis of the scenarios and video recording for the first-time users in the Republic of Benin; Questionnaires' results; and Participants' feedback.

Two scenarios consisting of simple tasks were proposed to the Beninese teachers before they were introduced to the Go-Lab ecosystem: in scenario A, teachers had to find a specific lab in Golabz, while in scenario B they had to write down the names of apps that would allow achieving a specified goal. In both scenarios, teachers were requested to give feedback on the difficulty of the requested task. The scenarios provided insights on how first-time users navigated through the platform and how they searched for specific content. The responses were collected in a form and subsequently analysed.

The video recordings were analysed according to a coding scheme underpinned by the following categories: cookies notification acceptance, change of language (yes/no, how and when), home page usage, main menu and corresponding submenus usage, subpages and functions exploration, search methods (with a focus on the in-context menu), internet connection and technical issues (quality of internet access and platform specific errors), browser used, video duration, and thumbnails utilisation. The video recordings allowed to (*i*) understand how teachers navigated through the Golabz.eu landing page, (*ii*) check if they accepted the cookies notification, (*iii*) verify if they used the translated version of the page (see fig. 3), (*iv*) find out how often teachers accessed the pages of the main menu (Labs, Apps, Spaces, Authoring, Support, News, About, and Collections; see fig. 4), (*v*) verify the search methods they used throughout their exploration (see fig. 5), (*vi*) identify which browser they were using, (*vii*) assess the quality of the internet connection (typically slow), and (*viii*) enumerate and tackle (a posteriori) platform errors.

The questionnaires were filled in by the teachers at the end of the events. They allowed to gather in depth knowledge about the use of the ecosystem, specifically on how comfortable teachers felt in navigating the ecosystem, how useful were the available filters, the search function and the Collections page, how easy it was to create an ILS from a lab in Golabz.eu or from the Graasp.eu authoring platform, and if teachers managed to publish one ILS (if teachers are willing to share the resources they have created and used in class with other teachers, they can publish them under creative commons licenses on golabz.eu). In addition, they allowed to assess technical difficulties teachers were facing when exploring the ecosystem. Thirteen questionnaires were collected and analysed.

Results

Scenarios: Most of the teachers found the automatic French translation clear enough, they used the in-context filters to search for a specific lab, and they considered the scenarios somehow difficult to execute. The results are compiled in fig. 2

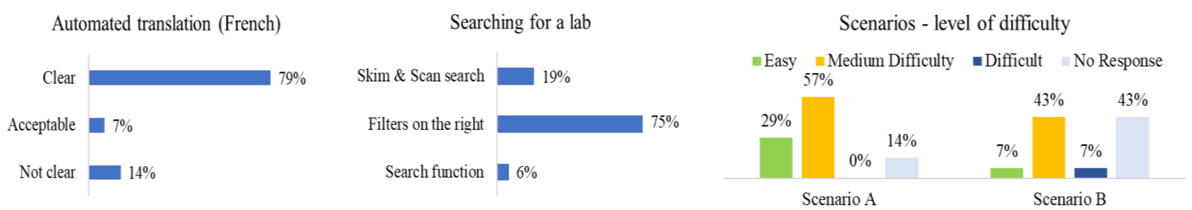

Figure 2: Teachers' feedback on the quality of the automated translation into French (*left*), on how they searched for specific contents (*centre*), and on the difficulty level of the scenarios (*right*).

Video recordings: Teachers used their own laptops during the sessions, and most of them (9 out of 13, *i.e.*, 69%) did not accept the cookies. Firefox was used by 61.5% of the teachers, Chrome by 30.8%, and Chromium by 7.7% of the participants. Most of the software (including operating systems) was outdated, which brought additional difficulties in navigating the ecosystem and in having access to its full content. The details of the outcomes of the analysis of the videos are highlighted in figs. 3 to 5.

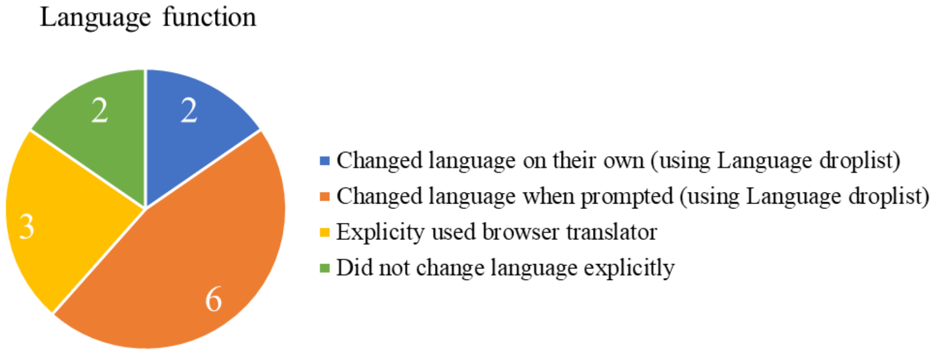

Figure 3: Number of users per language selection option (French) in the Golabz platform: 15.4% changed the language on their own, 46.2% changed the language when prompted, 23% explicitly used a browser translator tool, and 15.4% did not change the language at all.

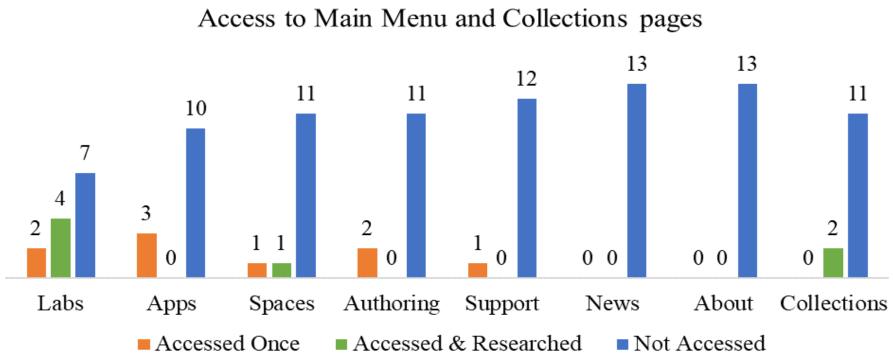

Figure 4: Number of users per type of access in each of the indicated subpages of Golabz. The most accessed pages were the Labs and the Apps. The News and About tabs were never accessed, and the Collections page was accessed and researched by only two teachers.

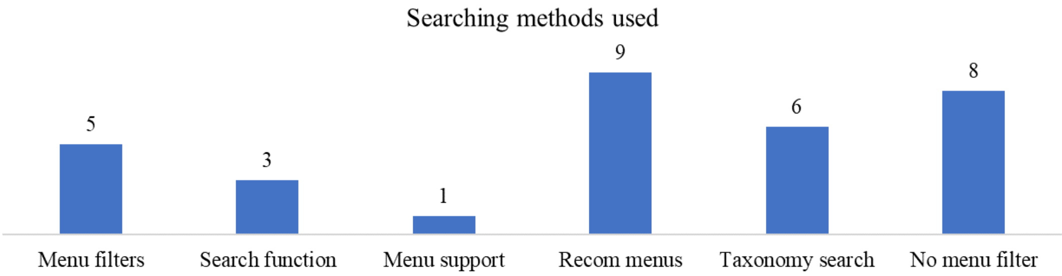

Figure 5: Number of users per searching method. From left to right, the columns stand for *In-context menu and filters* (Golabz main pages), *Search function* (Golabz), *In-context menu* (support page), *Recommendation & Used in...* (Labs & Apps subpages), *Meta data in description subpages* (taxonomy search), and *Did not use any menu or filter* (skim and scan), respectively. The “Recommendation”, “Used in…” and skimming and scanning method were the most used strategies for finding content.

Questionnaire: From the 17 items in the questionnaire, we focus on the users’ personal feedback regarding what they value the most in the ecosystem and the changes they would like to see. Overall, the resources, the educative value and the interactivity, engagement and motivation for the learners were the most appreciated features. The most requested changes were related to the offline availability of educational content and the need for more resources related to the local curricula. However, a considerable number of teachers—especially in the Republic of Benin—were happy with the current state of the ecosystem. The overall results are highlighted in figs. 6 and 7.

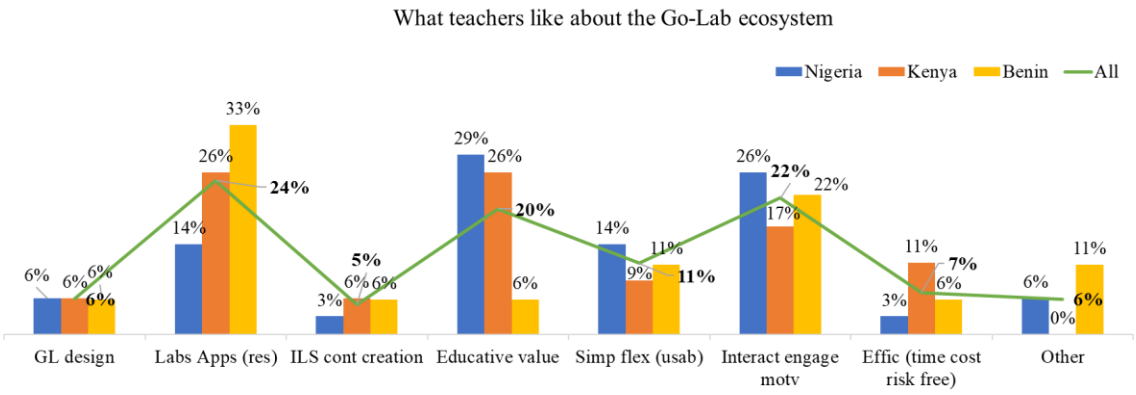

Figure 6: Users' preferences about the Go-Lab ecosystem per country. The percentages in the green line indicate the average of the three countries in each category. From left to right, the groups of columns respectively stand for *Golabz & Design*, *Labs & Apps* (resources), *ILS content & creation*, *Educative value*, *Simplicity & flexibility* (usability), *Interactivity, engagement & motivation* (learners), *Efficiency* (time & cost, risk free), and *Other*.

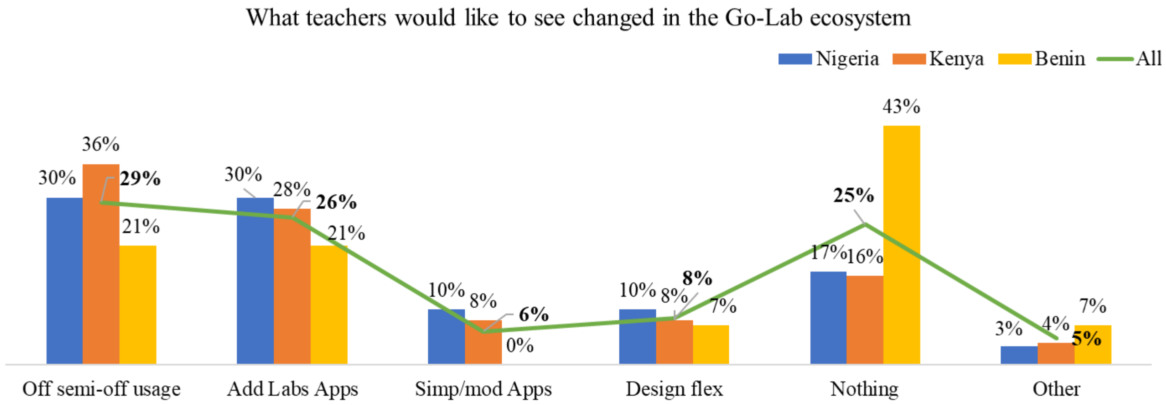

Figure 7: Changes proposed by the users per country. The percentages in the green line correspond to the averages in each category. From left to right, the groups of columns respectively stand for *Offline/semi-offline usage*, *add more labs and apps* (local curriculum and subject domain), *simplified/modified apps*, *Design & design flexibility* (changing colours, fonts, background, *etc.*), *Nothing*, and *Other*.

Discussion

The analysis of the data allowed to conclude that the translation of the platform was very important for French speaking countries. Most of the times, teachers changed the language using the drop-list function available in the platform instead of using the automatic tools from the browser. They were thus able to carry out their tasks successfully up to an acceptable extent (*i.e.*, the automatic translation did not prevent teachers to understand the contents or impaired their progress). The users seldomly accepted the cookies upon being notified to do so; they navigated the platforms using contextual links and menus beyond the main menu, main pages and landing page; they showed more interest in exploring the labs and ILSs than the apps; they explored the platform's teaching resources without reading about the project or the platform in the Support, News and About pages; and teachers needed frequent support to update their software (browsers and operating systems) and to understand the technical requirements for using the ecosystem, such as browser and operating system versions, JavaScript support, and internet connection speed.

The results of the adaptation and localization of the first prototype highlighted the need to bring more visibility to the Collections page and to expand the resources suitable for the national curricula in the pilot countries. The Collections page was adapted to the curricular needs of the Republic of Benin, Kenya, and Nigeria, but only two out of the 13 teachers testing the platform actually accessed that page (recall fig. 4). This apparently surprising behaviour is justified by the fact that the teachers involved in the testing and validation of the prototype were new users who have not yet been introduced to the ecosystem and, so, they naturally explored the first subpages of the platform (Labs, Apps, and Spaces).

In addition, the testing and validation sessions provided a unique opportunity to identify a crucial technical limitation: the lack of stable and fast enough internet in many pilot schools. That lead to the decision of implementing performance improvement techniques and creating an offline version of the ecosystem, to allow for the implementation of the project where and when the internet was of poor quality or not accessible. Although it was not possible to make the full content available offline yet, key educational resources of the ecosystem (apps, labs and ILSs), reflecting some of the most important needs in terms of STEM education at secondary schools in the three pilot countries, were selected and made available offline.

Conclusion

The aim of the testing and validation presented in this paper was to gather a deep insight about users' behaviour and interaction with the Go-Lab ecosystem. The results contributed to better understand how new users interact with the platforms (Golabz and Graasp), they helped to identify the most important features, and to pinpoint elements that require attention during training and support. The process was not smooth, since pedagogical aspects, such as familiarity with IBL and using online labs, and extraneous factors during the sessions, such as unstable internet connectivity and outdated software, played an important role in the users' interaction with the ecosystem. Even though these factors reflect the everyday reality teachers face in their classrooms, most of them were controlled and taken into account in subsequent sessions.

Multiple techniques were employed to collect information: video recordings, questionnaires, observation forms, activities, open discussions, and scenarios. These methods targeted for feedback and better understanding on how users interact with the platforms. The collected data helped to adapt and shape the ecosystem to meet the users' needs and requirements, both from the technical and pedagogical viewpoints. Examples of improvements driven by the testing and validation of the prototype include the expansion of the digital educational resources suitable for the national curricula in the pilot countries, the adaptation of the ecosystem to work with low internet connectivity, and the offline availability of some virtual labs, apps and ILSs. The latter was motivated by the technological challenges and constraints faced during the testing and validation sessions. Without the offline version of Go-Lab that has been released since, it would have been impossible to bring additional schools throughout the participating countries, especially those that are far from the main urban areas, where the information and communication infrastructures and services are typically scarce. The next testing and validation sessions will study the effectiveness of these improvements, including the creation and adaptation of new content (apps and labs), will test the newly developed offline features, and will assess the planned technical implementations for better performance with low internet connectivity.

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