FORESIGHT

ADVANCED CYBER-SECURITY SIMULATION PLATFORM FOR PREPAREDNESS TRAINING IN AVIATION, NAVAL AND POWER-GRID ENVIRONMENTS

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D4.4

Online Innovative Curricula Tool (I)

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Executive Summary

This is the first version of the deliverable which reports the FORESIGHT online platform that will host the FORESIGHT innovative curricula framework and forms the preliminary work for final design and build the FORESIGHT Innovative Curricula tool (IC) which will be reported in the second version of the deliverable.

Contents

Figures

Tables

Acronyms & Abbreviations

Term	Description
AGPL	Affero General Public License
API	Application Programming Interface
app	application
CTF	Capture the Flag
CPU	Central Processing Unit
Ed	Education
GPL	General Public License
HCI	Human-Computer Interaction
HTML	HyperText Markup Language
IC	Innovative Curricula Tool
Inc.	Incorporation
iOS	iPhone Operating System
JSON	JavaScript Object Notation
JSONP	JSON with Padding
K-12	from kindergarten to 12th grade
LAMS	Learning Activity Management System
LMS	Learning Management Systems
PC	Personal Computer
PDF	Portable Document Format
PHP	Hypertext Preprocessor
RAM	Random-access memory
REST	Representational state transfer
SaaS	Software as a Service
SCORM	Shareable Content Object Reference Model
SOAP	Simple Object Access Protocol
SSO	Single sign-on
UI	User Interface
URL	Uniform Resource Locator
UX	User Experience
XML	Extensible Markup Language
XMLRPC	A Remote Procedure Call method that uses XML passed via HTTP as a transport

1 Introduction

1.1 Overview

The task aims to develop an online platform that will host the FORESIGHT Innovative curricula and the FORESIGHT certification program. To achieve this, the literature review on the contemporary online training, open-source and commercial platforms and Learning Management Systems (LMS) have been carried out and the initial design of the FORESIGHT Innovative Curricula tool (IC) is reported.

1.2 Relation to other tasks and deliverables

This deliverable is related to the following other FORESIGHT tasks and deliverables:

Receives inputs from:

Table 1. The list of input deliverable and task for D4.4

Deliverable/Task No.	Title of Deliverable/Task	Due
T4.5	Innovative Curricula	M32
D4.3	FORESIGHT Curricula (I)	M18

Provides outputs to:

Table 2. The list of output deliverables and task from D4.4

Deliverable/Task No.	Title of Deliverable/Task	Due
D4.6	Online Innovative curricula tool (II)	M24

1.3 Structure of the deliverable

The deliverable is structured into the following sections:

- Section 2 focuses on observing and critiquing contemporary literature on online training to ascertain the key features that should be considered when designing and building the FORESIGHT innovative curricula tool.
- Section 3 provides a review of the existing open-source and commercial platforms and LMS by taking into account the important elements such as the cost of implementation, the support of standards, scalability and adaptation along with the user base and the organisations that use them. A comparison of the key features offered by those platforms is provided to select the best suitable one for FORESIGHT.
- Section 4 presents the initial design of the FORESIGHT innovative curricula tool in detail in terms of the architecture, the APIs and plugins, the web service protocols, the registration and authentication process, as well as the user interface with the current development.
- Section 5 concludes.

2 Literature Review on Online Training and Platforms

2.1 Literature Review on Online Training

2.1.1 Overview

The HCI design for online training is an essential part of designing an engaging, efficient and comfortable experience for the learners. The innovative curricular tool for FORESIGHT should include an intuitive, clear and logical learning structure and interface. This will create an innovative and engaging approach to e-learning. Throughout this review we will focus on observing and critiquing contemporary literature to ascertain requirements that can be used to create the most usable, accessible and successful product from the perspective of HCI research.

2.1.2 Existing Online Training

To effectively compare online training platforms, we must first ascertain what factors make an effective training programme. A study conducted by Lim *et al.* [1] explores online training program design factors, with regards to improving learning performance and transfer performance. The study first makes a distinction between learning performance as the ability to complete the assigned tasks and absorb the relevant material; and transfer performance, the ability to apply the concepts learnt to further, non-contrived, problems. They assert that maintaining the learner's motivation is critical to improving both of these performance metrics. The learner's motivation is directly affected by several factors: the training content, trainer-trainee communication and ease of interaction process. The first of these factors, the training content, is conducive to online learning and must be taken into account when establishing the design of a platform. The design and delivery of the training material must be both engaging and focused in order to achieve learning objectives as marked progress, but also relevant to the actual work practices, and delivered in such a way that makes this applicable. For example, in a highly practical discipline such as cybersecurity, there must be a practical implementation of theory-based learning, both to maintain motivation and increase the relevancy to actual work processes. This has the added benefit of increasing both the learning performance and transfer performance of the learner. Secondly, the trainer-trainee communication must be taken into account when building the platform, as it is easy for online learners to lack the inter-personal relationship that face-to-face teaching brings, which breeds disengagement and lessens motivation. Therefore, considerations for two-way, direct communication between trainer and trainee as well as group or cohort communication must be addressed as features. This will allow easy response to questions, clarification on objectives and adds a social element to the learning process that also increases both performance metrics. The last point, the ease of interaction process, naturally lends itself to the discussion of HCI. This is a more general factor that includes both previous points, of facilitating communication and the delivery of training material, but becomes especially critical when considering the common geographic separation between learners. Ease of interaction design process must be employed to break down the learning process into logical subsections and have a user interface that is conducive to the delivery of these systems as an obstruction to learning or difficulty navigating a complex learning tool, can decrease motivation, thus lowering both performance metrics.

With this perspective, we can analyse a research paper by Fong *et al.* [2] during this study the authors explored the implementation of HCI design principles to workflow-based e-learning systems. This study

surveys the application of conceptual models, such as separating the course, person, queue and assessment aspects of learning into individual systems. By doing so, the study remarks the following key differences between a web-based workflow system and a linear system: “In a linear system, the study flow is in a fixed order. In a web-based workflow e-Learning System, it supports the concept of flexible learning pathways”. These flexible workflows tie in with the previous assertation of treating the course as a separate entity, comprised of modules. These modules in themselves are made up of learning activities. The paper reasons that breaking down these larger components into smaller, more manageable pieces that can be consumed gradually over time, these dynamic workflows allow the user to complete subsections out of order. This is achieved by having activities that vary between focused concepts and broader abstractions with concluding activities that tie these concepts together. Finally, testing of the user’s knowledge occurs in the assessment stage of this system, enabling quantifiable feedback. From this study, we can infer that having a linear pathway can be less engaging for the end-user, and a dynamic path can be better suited to consistent engagement. The consistency of this engagement is paramount to the factors of motivation explored by Lim *et al.*, therefore by increasing engagement the learning and transfer performance will be increased, improving the overall success of the tool. Therefore, we can say that the FORESIGHT interface must be conducive to the navigation of these entities: programs, courses, modules and activities in this hierarchy as well as to provide easily viewable user progression feedback in the form of progress bars or percentage completion to show user progress concerning each of these entities.

A similar viewpoint is argued by Mehlenbacher *et al.* [3], who draws on the work of Miller, Lehman, and Koedinger [4] to similarly deconstruct the relationship between navigation and progression of learner tasks and activities from an HCI perspective. They use the concept of e-learning “microworlds”, on a per-task basis. This mirrors the abstraction of Fong’s course dynamic- however they ascertain that no matter what level of navigation or progression the user is at, each activity - or “encounter”- must lead the user to naturally adhere to four preconditioned exercises. Firstly, to set and outline a goal- or point of progression and demonstrate this as the objective. Secondly, to provide an interface that allows navigation to new or related topics or to continue to progress. Thirdly, to allow the user to scan and absorb information and, critically, allow them to recognise that the displayed information is relevant to the outlined goal in step one. Finally, to enable the user to attempt to understand the information, which we take as providing a clear interface for actively learning - whether this is through an exercise, video or traditional written learning material. As noted in the paper, these activities must be structured, frictionlessly interfaced with and focused around “primary learning and task accomplishment”. We can infer from this that task completion to meet the learning needs of the end-user must be the primary focus of the user, there should not be distraction or hesitation of the user preventing them from continuing to access material or functionality as this will reduce engagement. Practically, these principles can be taken forward in the design of the FORESIGHT innovative curricula tool in that while the interface must provide essential information, such as progress and task material; things like quick navigation tools and interface elements must be logically arranged to maintain engagement and ease of use for the end-user.

Hassenzahl [5] furthers this concept while expanding the theory that the emotional response to HCI will affect the engagement and overall success of the learning experience. This stems from their reasoning that before people engage with the e-learning platform’s content, “people perceive the product's features”, meaning the emotional response to the characteristics of the platform’s interface

and useability inherently affect the learning outcomes. For example, the following process commonly occurs: confusion at navigation leads to momentary frustration which in turn leads to pre-emptive disengagement in the following activity. Furthermore, this research suggests that users will draw their opinion of the usability extremely quickly, based on the particular combination of product features and their personal standards and expectations. We can infer from this that, in accordance with the previous analysis, the less the user has to make a conscious effort to begin and continue to learn and therefore progress, the better the useability and success of the platform. We can apply this analysis to the development of the FORESIGHT innovative curricula tool by increasing the HCI's intuitiveness, so that the end user's focus is not on the navigation or functionality of the tool. Instead, the user should be able to successfully navigate menu, context and activity systems through visual cues, informative, but not obstructive, labelling and by avoiding overcrowding. This can be furthered by taking into account unambiguous labelling and positional design, such as having submitted options situated next to the relevant input boxes and the grouping of like menus into clusters. Both this and the previous work of Koedinger raise a critical observation in how an online training platform which the learner perceives to be easy to use increases the motivation of the user, which- according to the work Lim *et al.* simultaneously increases the learning and transfer performance.

Within this principle of engagement with the learning material is how the information and activities put forward by the tool are perceived and why. It is put forward by Zaharias and Panagiotis [6] in their research that to most successfully connect the user to the learning material and enable that user to stay engaged a focus must be placed on the "learner characteristics" such as the style of the user's learning, the user's emotional connection and, critically, the cognitive state of the learner. It is understanding and interfacing with this last part that is needed to "make e-learners more active and engaged in an e-learning course". This research, as well as supporting work such as Kinzie [7], introduce the concept of "effective differences" which are the engagement and reward factors that directly correlate the user's progression with the change in interface and material that is shown to the user. Practical applications of this concept would involve the ability of the user to see completion markers and change in material as they progress through each of the sections. This is in order to create and maintain a sense of pride and completion in order to encourage motivation, something that Martens, *et al.* [8] argue is a fundamental prerequisite for active learning and is something that e-learning platforms traditionally have trouble invoking due to the lack of inter-personal interaction, as explored by Schunk [9]. Therefore, we can apply this to the design principles of the FORESIGHT innovative curricula tool in that the design and compartmentalisation of each aspect of the content delivery and progression must be adequately segmented in order to allow for achievable completion. The ability for the learning platform to allow for compartmentalisation and logical subdivision of learning material ties back to the work of Lim *et al.*; whereby the use of an ease of interaction design process allowing closer representation of individual activities to broader learning objectives increases performance.

A study conducted by Shattuck and Anderson [10], extends these ideas. This study looked to evaluate to what extent the content, structure and instructional approach of an online, higher-education course affected the engagement, satisfaction and use of new knowledge and skills demonstrated by the learners. Notably, the study was conducted through interactive discussion boards supported by their chosen LMS, and from these interactions and feedback sessions results were acquired. A common result, with just over half of the surveyed participants noted that one major benefit of the assessed online learning system was how it enabled them to interact with their course mates who were

participating in the course with these interactions playing a large role in focusing and engaging in later practice and activities. This observation on communication and engagement feeds into another important finding on how the platform's instructional approach was designed in order to follow as similar of a pattern to curricula that are delivered in person. The researchers and participants noted that the process of assimilating to an online learning platform, especially when accustomed to in-person learning. We can take these results forward and apply them in the development of the FORESIGHT innovative curricula tool, by accommodating features that allow inter-user interaction, both within tasks such as the inclusion of whiteboard or scratchpad features, as well as messaging and forum functionality to compare ideas and promote social engagement between learners, in addition to engagement with the material. This links back to our first exploration of what makes a good training programme, in that the success of a learning platform's ability to allow inter-learner and learner-trainer communication is critical to maintaining motivation, and therefore increasing the success of increasing both performance metrics.

In a study by Bicen, Ozdamli and Uzunboylu [11] the importance of considering the use of multi-media when designing a blended, or entirely online learning platform is explored, with the participants of the study being asked what they perceived to be the most important parts of e-Learning during the course of the study. A common theme in these answers was the availability of on-demand audio and video material, which allowed the participants to quickly and easily engage with the material that had been developed for them. This was compounded by the fact that participants were able to repeatedly view the material on demand. Some participants noted that the use of multi-media material makes the learning more entertaining, thus increasing motivation and enthusiasm for the course. This is furthered by research by Park [12] who's research notes that this form of learning has unique benefit such as allowing the student to tailor their intake of material to them, and allow for learning that meets their preferred learning style. This in turn has the effect of causing the student to become more engaged, self-motivated and responsible for their learning. We can apply this to the development of the FORESIGHT innovative curricula tool by incorporating the ability to utilise multiple formats of learning material, including multi-media, as a core part of course learning material. In relation to this work by Fahy [13] explores that the effective organisation and sequencing of the learning materials, is key to effectively utilising multi-media material. In their research, a link between how and what a learner's attention can be focused on is explored within the context of ingesting learning material. They state that a learner's attention is fluid, in that it will shift naturally with teaching topics, and material- if the new material is able to be linked to the principles and goals of both the previous learning material and the general course learning objectives. Furthermore, that the learner's attention is selective in that it is focused on one thing at a time, with an emphasis on novelty, or new or particularly novel information. This can be applied to online learning, in that the use of multi-media learning material cannot be overused, or it will lose its effectiveness as a tool; whereby it loses its novelty and effectiveness to engage some users. We can apply this to the development of the FORESIGHT innovative curricula tool by including the requirement that each serialized learning element, must not be limited to only one type of learning material. In order to function effectively, this must not be a limitation for the module coordinator.

In accordance with this, we can draw on research by Adams and Makramalla [14] which considers the use of gamification to teach cybersecurity concepts and practices in a novel and engaging way. The support for gamification features allows teaching material to be designed in such a way as to include

interactive elements in the form of games, or using mechanics commonly found in games, in order to increase engagement. The inclusion of these features, such as progress or point acquisition mechanics, interactive problem solving and player controls can increase motivation and in turn benefit both performance metrics. However, the application of these benefits to a highly practical discipline such as cybersecurity are two-fold. This is because in addition to the previous benefits identified- by adding support for more features, such as support for integration with other immersive learning tools and practical exploratory scenarios for both red and blue team; a practical element is added to an already engaging workflow. This can provide increased benefits to the transfer performance of the learner and increase motivation and engagement with the learning material. Taking this research forward to the design and development of the FORESIGHT innovative curricula tool; we can integrate these concepts of gamified, practical learning through supporting features such as: progress mechanics, narrative-driven content, interactive problem solving and gamified assessments. The latter of which being critical for practical-based learning of cybersecurity concepts.

A work by McCarthy [15], explores students' attitudes towards online formative assessment feedback models. Feedback, as a part of the continuous assessment process, is a crucial tool in allowing the academic development of students, however as a part of an online learning platform it also serves not just as a performance indicator, but also a viewable mark of progress that allows the user, and their associated organisation and trainer, to view their progression through tasks, material and courses. In this research, it is outlined under what conditions feedback is most useful for students. Namely, these are when feedback is frequent enough and in enough detail on the completed task, this includes how it relates to the learning objectives in general and per the specific task. For this to be effective, assessment is required at multiple stages, such as before, during and as a consolidatory exercise at each step in the logical progression through the learning paths. Furthermore, the concept of receiving and viewing feedback should be built into the common workflows and user experience, so that the user can see their feedback and progress, as making feedback inaccessible means the user is less likely to review or act upon the performance feedback for each activity. This links to our previously explored points on user progress perception. We can apply this insight into how we will develop the FORESIGHT innovative curricula tool, as the platform must build in support for the aforementioned multi-stage assessment and testing as well as easily viewable and demonstrable actioning of feedback. Applying this to our original review of effective training programmes, the feedback process is another example of a feature set that must be included to facilitate communication between the trainer and learners, which was established to be a critical factor in maintaining motivation and thereby improving the learning and transfer performance of learners.

When considering the feature set needed for a next-generation online learning platform, a study by Violante and Vezetti [16] exploring the approach for the architectural design of an online learning platform breaks down the need for extensibility, ease of deployment and a component-based model of design. The features of a good online learning platform should allow for seamless communication between the LMS and each interfacing aspect of the system, whether it be the databases responsible for holding user data, administration portals or other provider-implemented systems for extensibility and flexible implementation. This empowers the provider to create and implement bespoke systems to service their needs, utilising the power of the underlying LMS. This can be used to simplify complex systems for learners or be used to create feature-rich performance analysis systems for trainers or organisations to better digest information. Similarly, the ease of deployment for each platform should

be considered- with an emphasis placed on support for containerisation and portability of components to allow for easy and scalable deployment for end-users. We can add these requirements to the list of preferable features that should be compared between LMS systems. Furthermore, from a resource usage standpoint- it is beneficial for each platform to be as light as possible, to allow for scalable deployment without needing unnecessarily high-cost on-premises hardware or incurring high cloud computing costs. Therefore, minimal CPU, RAM and storage hardware requirements should be treated as a good feature in an online learning platform.

A study on the introduction of support for time management and other organisation systems in online learning platforms was conducted by Nawrot and Doucet [17]. In this work, the researchers seek to explore and address one of the most prevalent issues faced by online learning platforms- providing support for student time management. This is critical in improving platform usability and allow optimisation of time used for the learner and training coordinators. The researchers assert that the novelty of online learning platforms and the lack of time management feature integration leads to a high withdrawal rate from programs. In response to this, they propose that online learning platforms should assist their users in scheduling and organising events relevant to their study. This includes not only critical time-based events such as assessments, submissions or completion deadlines but also provide the user with the ability to see such events easily and intuitively through the use of a calendar or timeline interface. We can take these findings forward into our development of the FORESIGHT innovative curricula tool, by ensuring that a requirement of the platform is to include the aforementioned time management features and display them prominently in the interface.

2.1.3 Key Features Required for an Online Training Platform

The outcomes from our overview of literature related to improving HCI for online learning platforms, allows us to inform a list of features as shown in Table 3 that we believe are required in any online training platform. The inclusion of these features' benefits both the user's perception of the platform, their interaction with the trainer, or other learners as well as the user's ability to engage with the learning material. All of these are imperative to increases the learner's learning and transfer performance and therefore the success of the platform.

Table 3. List of key features required for an online training platform

Category	Implementation	Feature
Assessment	Multi-Stage Assessment	Multiple Choice Quizzes
		Short Answer Questions
		Long Answer Questions
		Per-Topic Practical Exercises
	Consolidatory Assessment	Extended Examinations
		Group Project Setting and Submission
		Independent Project Setting and Submission
	Gamified Assessment	CTF-Style Challenges
		Red Team Interactive Challenges
		Blue Team Interactive Challenges
	Review	Automated Review
		Semi-Automated Review
		Fully Manual Review

Category	Implementation	Feature
Communication	Inter-User Communication	Forums
		Chatrooms
		Direct Messaging
	User-Trainer Communication	Direct Messaging
		Q&A Forms
Feedback	Visible User Progress Indicators	Progress Bars
		Status Tracking
		Completion Markers
	Individual Trainer Feedback	Submission Responses
		Grading
		Feedback Reports
Learning Workflow	Hierarchical Task Structure	Programs split logically into smaller sections: e.g., courses, modules and activities.
Navigation	Intuitive Inter-Feature Navigation	Quick-Navigation Menus
	Responsive Design	Adaptive Menus
	File Management	Interactive File Manager
Learning Material	Support for Traditional Learning Material	Text-Based Instructional Learning Material
	Support for Multimedia Learning Material	Video Learning Material
		Audio-Based Learning Material
	Support for Gamified Learning Material	Plenary Games
	Support for Practical Learning Material	In-Browser Simulations
		Web Console
Shared Interaction Tools	Collaboration Tools	Whiteboards
		Chatrooms
Organisation Tools	Scheduling Features	Calendar
		Timelines
		Notifications
Infrastructure	Extensibility	Multi-Format API Integration
		Accessible Database
		Accessible Environment Variables
		Plugin Support
	Deployment	Support for Containerisation
		Portable File Structure
	Hardware	CPU Usage (Light/Medium/Heavy)
		RAM Usage (Light/Medium/Heavy)
		Base Storage Required (Light/Medium/Heavy)

Using this table of comparison, we can put forward a set of required features that we should look for in the platform which will be used as the basis of the FORESIGHT innovative curricula tool.

Furthermore, as our findings have a direct impact on user satisfaction and performance, we can use it as a metric from which to assess the suitability of the platforms to achieve the best results for both of these factors.

2.2 Literature Review on Platforms

2.2.1 Overview

This section aims to briefly provide an overview of the platforms and learning management systems (LMS). Several platforms have been developed through the years in an attempt to help manage online material. There are various platforms in this category are various and provide similar sets of services and tools to help manage courses and learning contents. However, there are important differences that mainly concern the cost of implementation, the support of standards, scalability and adaptation along with the user base and the organizations that use them.

The above elements are particularly important, as the LMS that will be adopted will be one of the most important components of the overall solution that will support e-learning training processes.

2.2.2 Existing Platforms

Open-source Platforms

An open-source solution can provide several advantages over commercial solutions such as:

- Freedom of choice: Open-source software gives organizations the freedom to choose software based on its operational value, regardless of cost.
- Additional functionality: Open-source software allow the development of additional functionality required without having to contact the developers of the software.

Open-source applications are under close scrutiny and are constantly evolving and improving. When selecting open-source LMS software, an important criterion is the maturity of its version and the size of its user base that supports it. According to [18], the best LMS platforms for 2020, and [19] that provides a list for the top eight open-source LMS platforms, the platforms that appear in both lists include Chamilo, Sakai, Moodle, Canvas, LAMS and Dokeos. The open-source solutions are presented below, they support a large set of educational standards, are scalable and can support large user bases.

(1) Chamilo LMS

Chamilo, as shown in Figure 1, is an open-source e-learning platform, published under GNU/GPLv3+. Two different versions exist as of February 2021: Chamilo 1.0 and Chamilo 2.0; the latter is still in the development stage. Chamilo is built in PHP and requires a database such as MariaDB or MySQL [20]. Chamilo LMS has many features, which are aimed at the user experience to manage applications and other objects. Developers and teachers can fully customize the tool to their customers and beneficiaries. Chamilo does not include a built-in video conferencing system but allows connecting to BigBlueButton or OpenMeetings. Apart from the classic functionalities expected of an LMS such as course management, SCORM support, generation of advanced learning reports, the possibility of importing and exporting content freely, Chamilo also offers a plethora of advanced features, for businesses, educational institutions, and government organizations. Chamilo features include Courses, users and training cycles, advanced management, HTML5 support, mobile application for Android and

iOS, Google calendar integration, social media integration, timed exercises and exams, and progress graph reports [21].

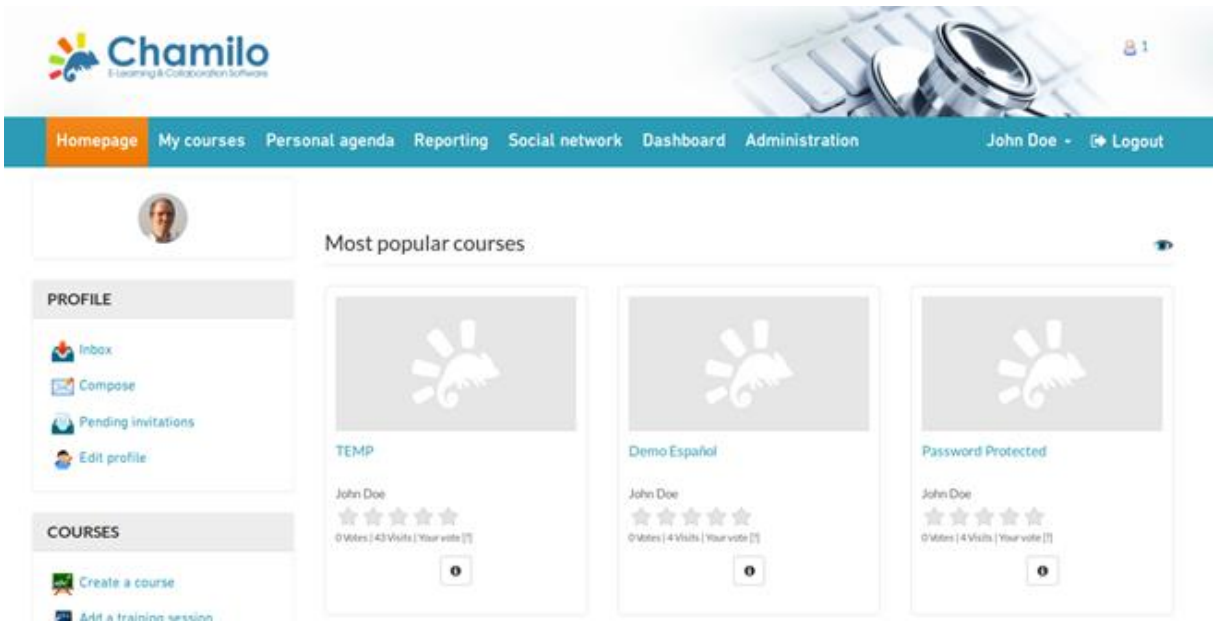

Figure 1. Chamilo Dashboard [20]

Support & Overview

Due to Chamilo's educational purpose, most of the community is related to the educational or the human resources sectors. The community itself works together to offer an easy-to-use e-learning system. The community of Chamilo is no longer active with most users being in a passive state while development is on stall [20], which indicates that it lacks proper support. Chamilo's main advantages include the fact that it provides a simple approach. It is light and uses less RAM than other LMS systems [21]. Also, Chamilo provides availability, could be optimized for the cluster [21]. Chamilo is not considered UI/UX friendly [22]. Learners find it difficult to fill in test questions and the scoring provided by Chamilo is not reliable to provide feedback such as whether each answer is correct or wrong [23].

(2) Sakai

Sakai, as illustrated in Figure 2, is an LMS platform with a group of open-source tools used in online learning environments. It was developed by the Sakai community [24]. Each educational institution can choose, from the set of tools offered, that meet their requirements [24]. Supported communication tools include chatrooms, email, Dropbox, forums, notification fields, and group chats. The instructor can maintain a gradebook with the grades of all trainees and comments on their progress. In addition, using the built-in statistical tools it allows drawing conclusions about the educational process for the whole class or each student individually. Teachers and learners have access to a shared diary, while each user has a personal page with the courses in which they participate and related emails. Regarding the learning tools, the trainee has at his/her disposal an assessment test, a glossary, tables and blueprints. New educational tools are constantly under development and offered by third party organizations such as SCORM, blogtool, multipoint audio services and shared whiteboard. Sakai can successfully support any activity that may require communication, collaboration and knowledge sharing among the platform users. Finally, it should be noted that emphasis has been given to be easy to use and accessible to people with disabilities.

Support & Overview

Sakai has an active community [25], with an appropriate level of documentation and guides. The codebase gets updated regularly. Support can be provided via the mailing lists, slack chat, wikis and forums. Sakai is considered a useful LMS [24]. It has features set to address the needs of the global academic community. It provides ease of use, ease of navigation but lacks integration with other software tools, e.g., gradebook loses form when downloaded in an excel spreadsheet. It does not provide built-in video conferencing software and the rich media types need to be handled in a better manner. Furthermore, Sakai requires improvements in standardising the tools and in the documentation provided.

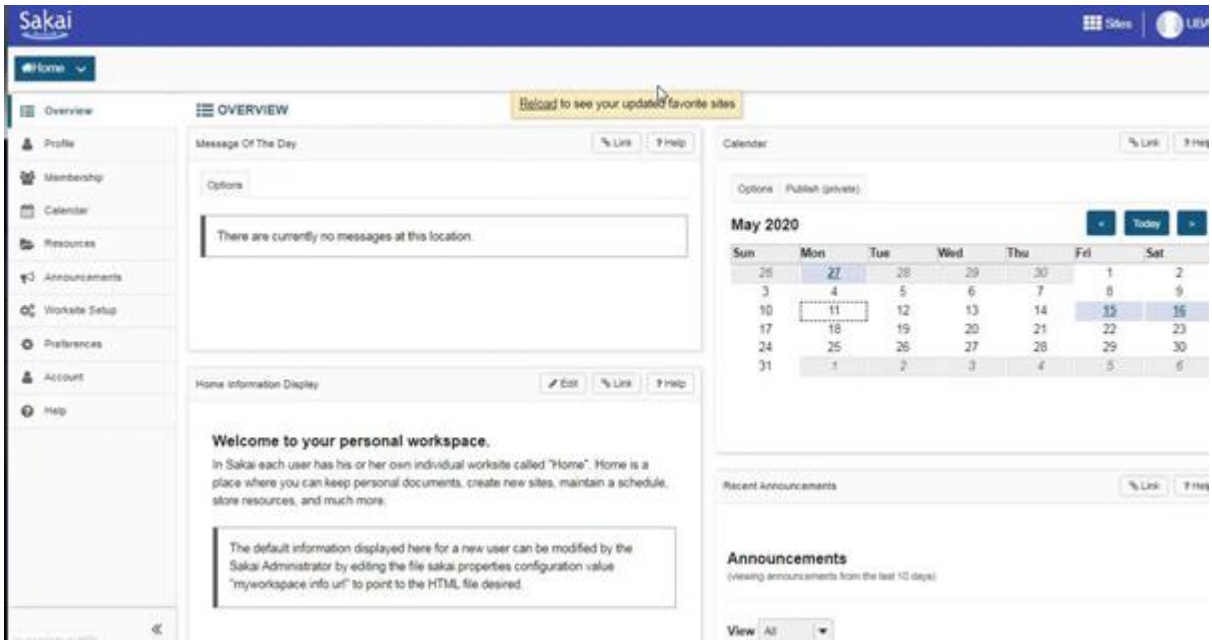

Figure 2. Sakai LMS Dashboard [24]

(3) LAMS

LAMS (Learning Activity Management System), as demonstrated in Figure 3, is an open-source JAVA-based E-Learning platform jointly developed by Australia Macquarie University, LAMS International Limited and LAMS Foundation. The learning activity management system is based on activity theory, adhering to the concept of learning design, and serializing learning activities. LAMS consists of environments such as student learning progress delivery, learner group management, educators' simultaneous supervision of student progress, and the most important learning sequence design and editing environment [26]. At present, the LAMS is being widely used in universities and middle schools in many countries around the world. LAMS is considered good for collaborative learning [26].

Support & Overview

LAMS does not have an active community to provide support although documentation is freely available. For support LAMS provides a paid service called Lams International. While LAMS is considered open-source, a number of its features need to be purchased [27]. Lams provides innovation in the design, management, and delivery of online collaborative learning activities tool, but lacks many custom features when it comes to course development. In a study [28] comparing LAMS with Moodle, it was identified that LAMS lacks flexibility, and it is more appropriate for young learners.

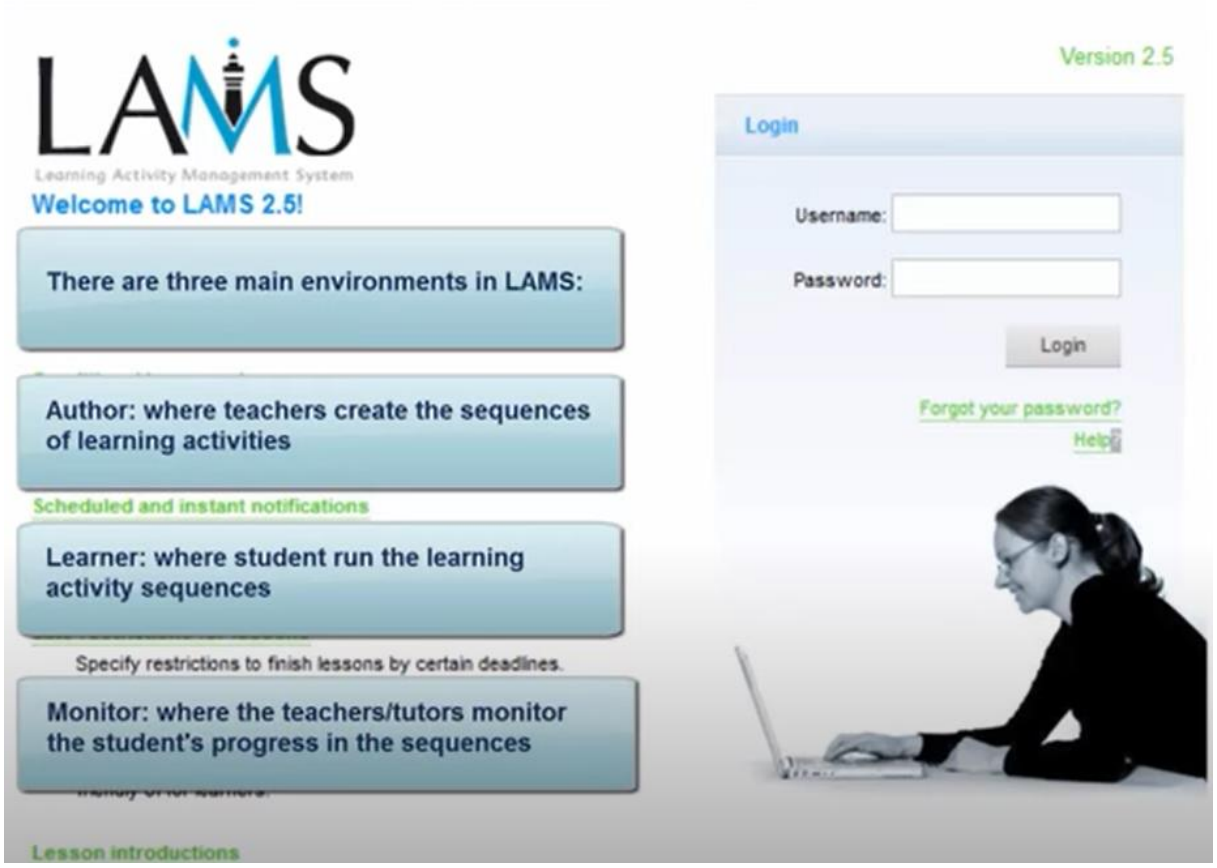

Figure 3. LAMS Dashboard [26]

(4) Dokeos

Dokeos, as shown in Figure 4, is an e-learning, online course management and collaboration tool. It is developed in PHP programming language and uses MySQL. Dokeos is cloud-based and is referred to as Software as a Service (SaaS) [29]. Dokeos features include the sharing of educational materials, maintaining lesson schedules, monitoring student progress, participation in text, audio and video chat sessions. It also allows conducting quizzes and examinations. The instruction can define a cognitive path within the material, which learners can follow to reach the educational goal faster and more efficiently. It supports all type of Documents and each lesson has a digital mailbox to which the student can send the coursework. The Dokeos app has discussion forums, bulletin boards, hyperlinks to other websites, and training opportunities for trained groups. Finally, Dokeos offers video conferencing, auto-evaluation via PC, writing an educational blog, and creating educational games. Instructors can organize the lessons based on some pedagogical standards. It should be noted that video conferencing services are only available for a fee.

Support & Overview

Dokeos comes in Community edition which is the open-source and commercial edition which requires a fee. While the support of the commercial edition is outstanding, the Community edition of Dokeos lacks documentation and an active support community. Some documentations exist but are mostly outdated and non-functional.

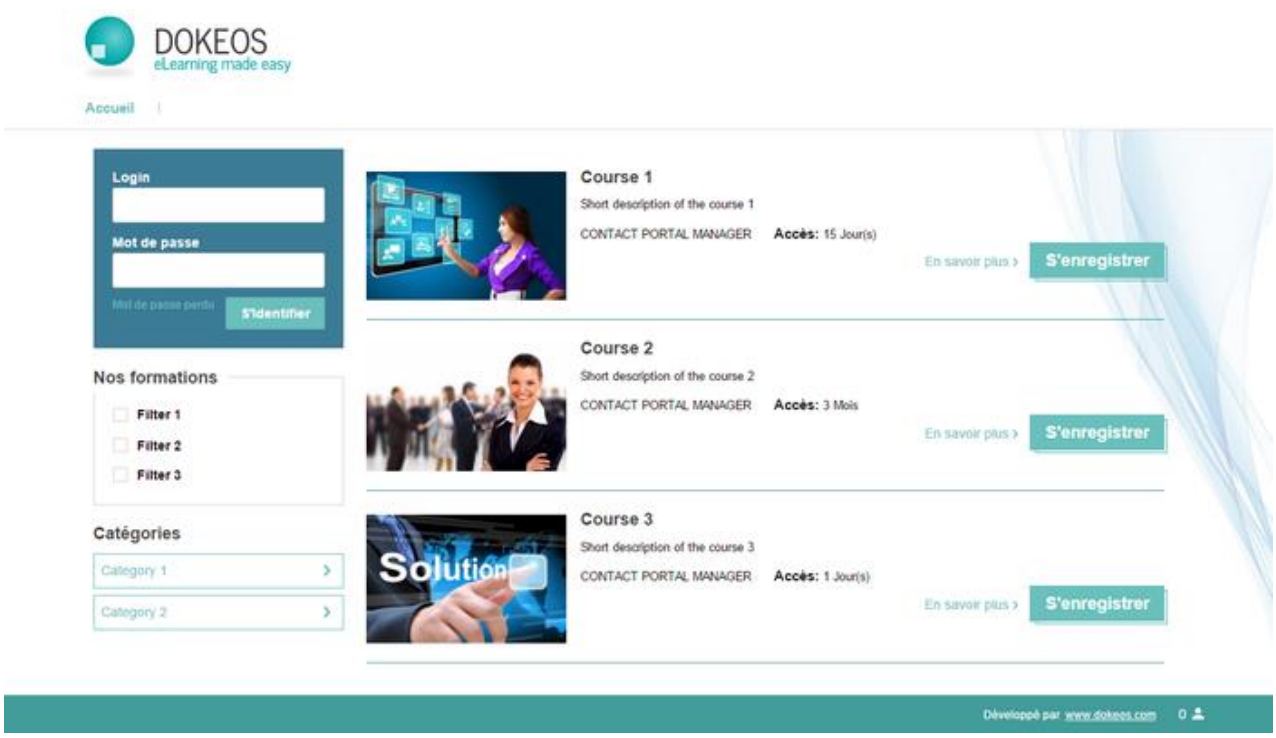

Figure 4. Dokeos LMS [29]

(5) Moodle

Moodle is considered by Moodle community as the de facto online learning platform [30]. It is an open-source course management system used by many institutions and organizations worldwide. It has two different names: learning management system and virtual learning environment [30]. Moodle's platform interface is simple, allowing platform users to adjust it and add or delete content according to their needs. There is an introduction to each course. The platform offers compatibility and ease of use. Moodle can be installed on any environment that supports PHP [30].

Overview of Moodle

The Moodle platform provides learners with rich and diverse learning resources. The course guidance module can be used to introduce learners to the learning objectives, process, and related requirements of the course. The teaching material is presented in a bottom-up manner, allowing learners to grasp the required principles. Animation displays that can be configured in Moodle assist learners to understand more abstract concepts. Discussion areas and chat rooms provide a good platform for communication. Feedback and survey sections can better help obtain feedback to further improve methods and content.

Moodle is highly suitable due to its flexible course and training pathways and is generally preferred by teachers designing courses for mature learners due to the student-directed learning it offers [28]. Moodle obtained the best results as an overall LMS platform [31]. It received a higher ranking when it comes to adaptivity and personalization that can be supported as well as for the ease of adaptation [32]. A comparative study [33] between Moodle and other similar platforms such as the ones specified previously, evaluated each platform in terms of architecture such as learners' tools and support tools, and technical aspects such as authentication and registration. It was identified that Moodle is the most suitable eLearning platform in both architecture and technical aspects [33]. Moodle was built with pedagogical models in mind, it accentuates knowledge construction with the use of interactive learning

through multimedia [34]. It promotes collaborating interaction between learners [35]. The modular design that Moodle offers increases flexibility and usability making it the best overall platform, compared to other open-source platforms [36].

Basic characteristics

Moodle is similar to many learning management systems. It can manage content components, but it is mainly designed for education and learning. It provides a record of learners' learning process, which is conducive to teacher's supervision and analysis of learners' learning process. Its main features and functions have three main aspects: overall design, website management, and user management.

Main functions

Moodle, as shown in Figure 5, offers course management. Teachers can control the course settings. It provides a flexible course configuration that includes forums, tests, resources, and so on. In the homework module, teachers can set the deadline and maximum score for assignment submission and make timely evaluations of the assignment uploaded by learners. The chat module supports the inclusion of text and pictures, which is helpful for communication between learners and between learners and teachers. The conversation records can be saved. The voting module can be used to vote on something or to conduct opinion surveys and polls. In Moodle, there are different types of forums to choose from such as forums to express opinions, and forums to share learning. In the test module, the detection of learning effects can also be effectively carried out through the Moodle platform. Teachers can choose a question bank and questions can be automatically graded, which is very helpful for the detection of learners' progress. The resource module supports the display of various electronic documents, as well as video and sound, it can connect to external resources, and can also transmit data to external applications. The questionnaire survey module can be used as an effective way to analyze online courses. The results of the questionnaire can be viewed at any time, and it can also be downloaded through forms and texts. Moodle offers Interactive evaluation, in which learners can evaluate sample documents given by teachers, and teachers can manage and score the evaluations made by learners.

Figure 5. Moodle Dashboard

Commercial LMS Platforms

Commercial platforms are generally preferred by large scale organisations as maintenance and developing fuss can be avoided. Developers of Commercial LMS claim that their LMS is easier to use than an open-source LMS. To be able to identify whether a commercial or an open-source solution would be suitable for FORESIGHT, commercial LMS platforms have to been overviewed as well.

(1) Blackboard Learn™

Blackboard Learn, as illustrated in Figure 6, is a commercial platform, which was created at Blackboard Inc [37]. It was intended to support teaching and is now used for online teaching. In 2006, the company took over the rights to the WebCT platform, which was popular at the time, and changed its name to Blackboard. The system can be installed on local servers as well as on servers provided by the manufacturer with the latter option being recommended. It provides the possibility to integrate with other systems operating within a given university [38]. The platform is used, among others at the Open University of Cyprus together with Moodle. Blackboard Learn acquired tools such as Elluminate for online live tutorials and collaborative communication with tools such as blogs and wikis. It has the characteristics of an intuitive and easy-to-use interface, customized courses, background monitoring, etc. Blackboard Learn is one of the most widely used platforms in the field of education and teaching. The flagship of Blackboard Learn LMS is for conducting and managing courses. It includes a material repository, a teaching and supporting portal and creating an online university community.

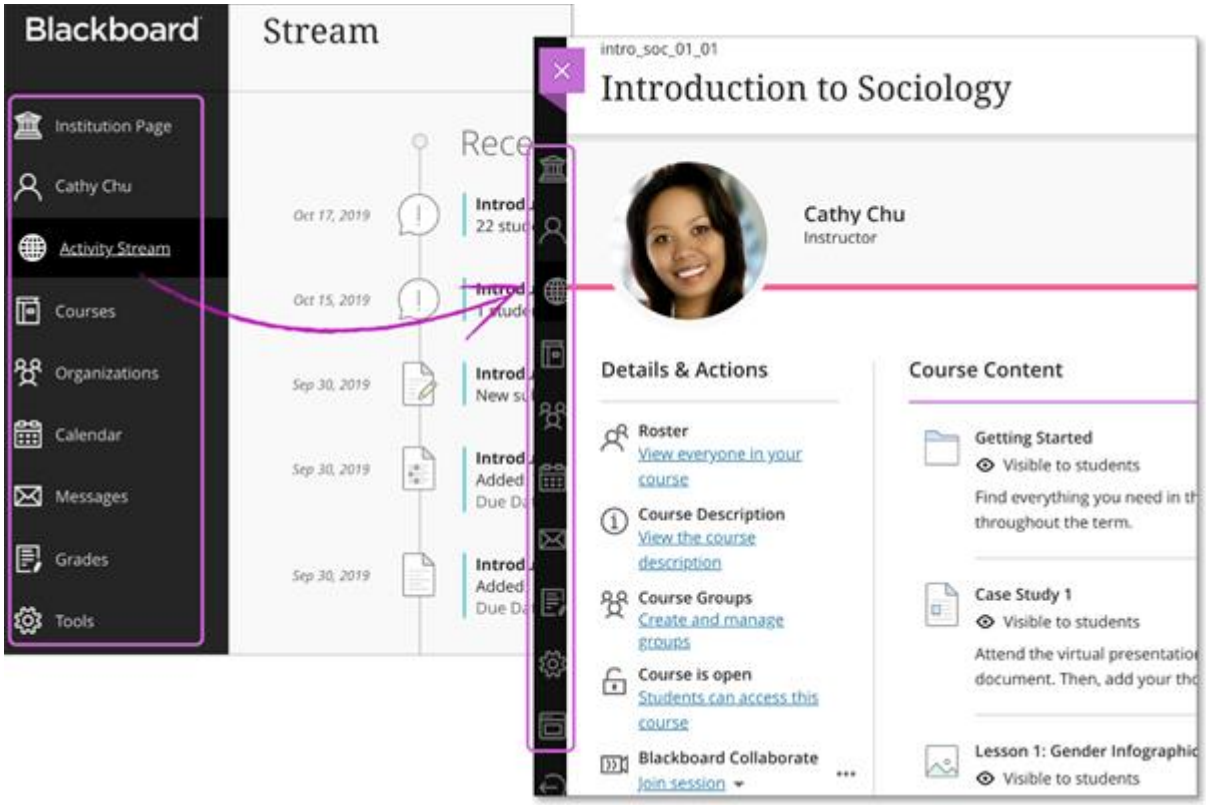

Figure 6. Blackboard Learn™ [37]

Support & overview

Since Blackboard Learn is a commercial LMS, the support is provided based on the price and fee. The interactive learning tools that it offers are the highlight of Blackboard Learn, which both learners and teachers enjoy based on research conducted in [38]. In terms of accessibility and course materials navigation blackboard is preferred to other commercial alternatives. Nonetheless, Blackboard Learn does not support mathematical equations [39], even though developers provide a set of alternatives the issue with equations cannot be ignored. Furthermore, according to a pilot study [40] users preferred Moodle in terms of usability compared to Blackboard.

(2) Canvas Instructure

Canvas, as demonstrated in Figure 7, is a modern, free for trial LMS developed and maintained by Instructure Inc. It is released under the AGPLv3 license for use by anyone interested in learning more about or using learning management systems. Canvas consists of LMS for K-12, Higher Ed LMS and LMS for Business [41].

Features of Canvas include Outcomes, MasteryPaths, Canvas Data and Canvas Commons. Outcomes describe what a learner should be able to do and are used to measure knowledge and ability. MasteryPaths is a tool that allows course content to automatically be released to a learner based on performance, providing differentiation to learners. Canvas Data allows instructors to parse Canvas-generated data quickly and Canvas Commons is a repository that lets users easily share content. It also includes a Speedgrader app for iOS and Android, teachers can preview student submissions, provide feedback, and annotate homework submissions in a single frame. Furthermore, it includes Integrated Media Recorder, Web conferencing, Mastery GradeBook, Canvas Parent, Canvas Polls and MagicMarker.

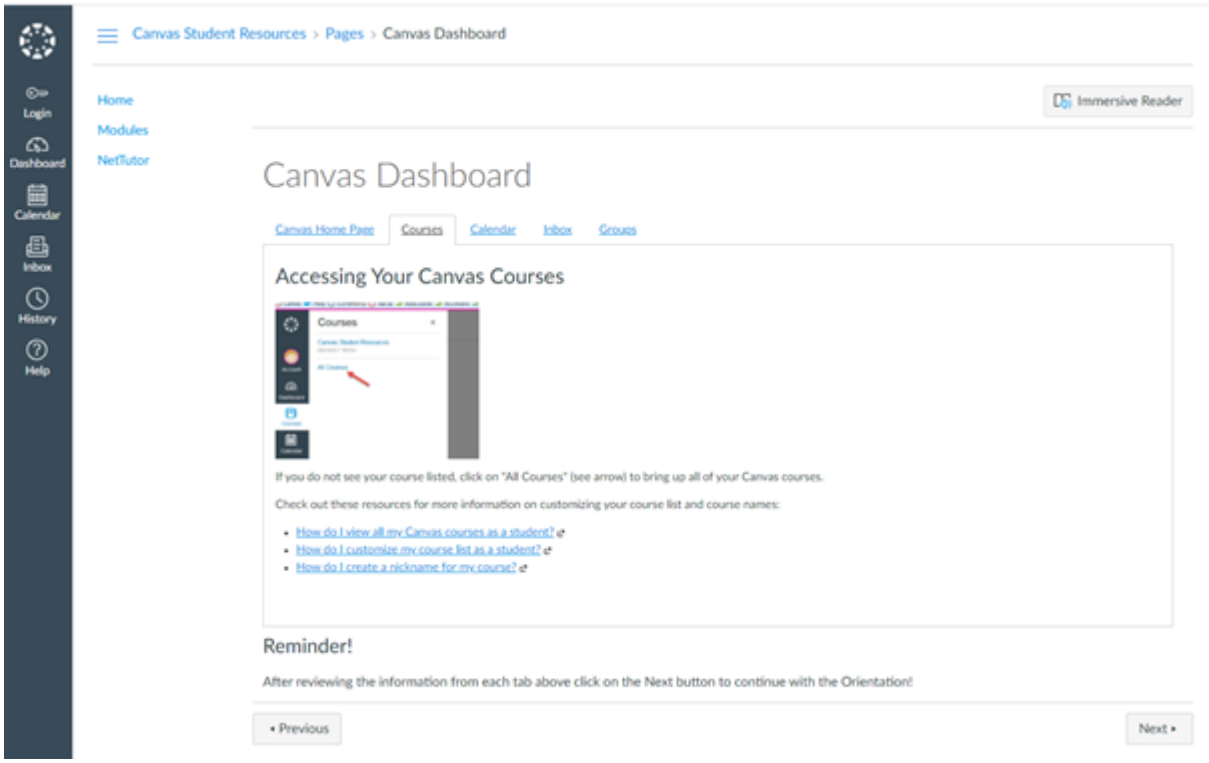

Figure 7. Canvas Dashboard [42]

Support & overview

Instructure was founded in 2008 with the mission to create software that makes people smarter. Building on this goal, the vendor launched Canvas in 2011, which is now used by over 2,000 universities, school districts and institutions globally. Canvas received several awards such as the 2016 Best Learning Management System and E-Learning Platform — "Gold" choice [41]. Previously Canvas was open source, while nowadays it does not provide a community version. Moreover, when it comes to teaching, assessing, and learning tools, Canvas is less powerful than Moodle on the tools that it offers, it especially lacks content authoring tools [43].

(3) Adobe Captivate Prime

Adobe Captivate Prime, as shown in Figure 8, is a commercial cloud-based LMS with a trial version for 30 days. It claims to be focused on user experience and allows managers to easily create courses without investing an increasing amount of time. The built-in LMS function feature allows keeping modules organized. Adobe Captivate Prime includes a player which adds interactivity to online training courses. It supports all multimedia formats, from standard videos to PDFs. It includes two types of dashboards, the standard dashboard for eLearning professionals and a lighter user-friendly dashboard for corporate learners [44]. Even when learners cannot access the internet, they are still able to participate using the prime app which lets them access the course offline. All the phases of the online training course are tracked from user interactions to performance assessment scoring. It also offers a gamification system with supervised leaderboards. With badges earned per learner, it increases engagement from earners [45].

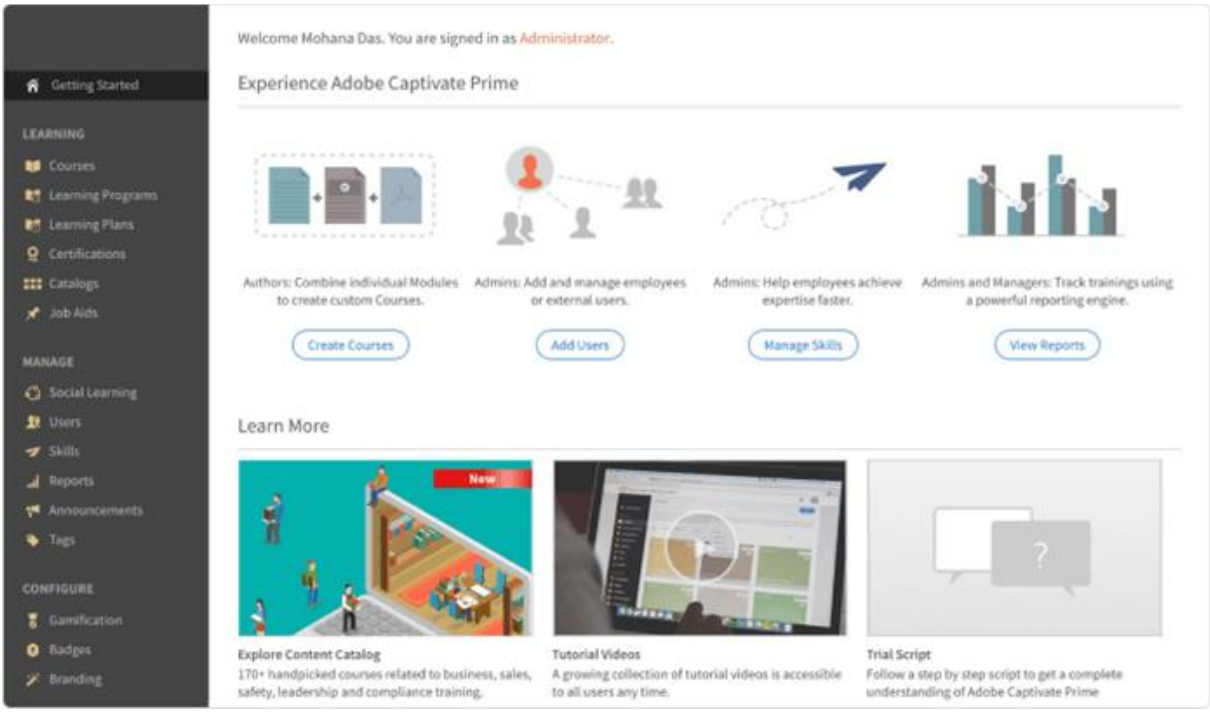

Figure 8. Adobe Captivate Prime [45]

Support & Review

Adobe Captivate Prime is ideal for business organizations for training personnel especially in case an organization has an abundance of learning material or certifications [46]. It provides customer support to subscripted users, but a number of its features are not included and have to be purchased separately [44].

2.2.3 Comparison of the key features

The comparison of the identified key features between the platforms is listed in Table 4. The result shows that Moodle is the best candidate to accommodate those features.

Table 4. Comparison of the key features required in the selected platforms

Feature	Chamilo	Sakai	LAMS	Dokeos	Moodle	Blackboard Learn	Canvas	Adobe Captivate Prime
Multiple Choice Quizzes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Short Answer Questions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Long Answer Questions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Per-Topic Practical Exercises	Yes	No (Has issues with mathematical equations)	Yes	Only with the use of interactive slides	Yes	Does not support mathematical equations	Yes (with the use of practical quizzes)	Yes (with the use of question slides- interactive slides)
Extended Examinations	Yes	Yes	No	Yes	Yes	Yes	Yes	Does not specify
Group Project Setting and Submission	Yes	Yes	Yes	Not entirely	Yes	Yes	Yes	No
Independent Project Setting and Submission	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CTF-Style Challenges	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Red Team Interactive Challenges	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Blue Team Interactive Challenges	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Automated Review	No (Can only be achieved using question banks)	No	No	No	Can only be achieved using specific tools such as plugins	No	No	No
Semi-Automated Review	No (Can only be achieved using question banks)	No	No	No	Can only be achieved using specific tools such as plugins	No	No	No
Fully Manual Review	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Feature		Chamilo	Sakai	LAMS	Dokeos	Moodle	Blackboard Learn	Canvas	Adobe Captivate Prime
Forums		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chatrooms		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Direct Messaging	**Inter-User Communication**	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	User-Trainer Communication	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q&A Forms		Not specified	No	No	No	Yes	Yes	Yes	No
Progress Bars		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Status Tracking		Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Completion Markers		No	No	No	No	Yes	Yes	Yes	Yes
Submission Responses		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Grading		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Feedback Reports		Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Programs split logically into smaller sections: e.g., courses, modules and activities.		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quick-Navigation Menus		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adaptive Menus		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Interactive File Manager		Yes	yes	Yes	Yes	Yes	Yes	Yes	Yes
Text-Based Instructional Learning Material		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Video Learning Material		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Audio-Based Learning Material		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plenary Games		Yes	Yes	No	No	Yes	Yes	Yes	Yes
In-Browser Simulations		No	No	No	No	Yes (with specific tools)	No	No	No
Web Console		Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Whiteboards		Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Chatrooms		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Calendar		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Timelines		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Feature		Chamilo	Sakai	LAMS	Dokeos	Moodle	Blackboard Learn	Canvas	Adobe Captivate Prime
Notifications		Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Multi-Format API Integration		No	No	No	No	Yes	Yes	Yes	No
Accessible Database		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Accessible Environment Variables		Yes	Yes	Yes	Yes	Yes	No	Yes	No
Plugin Support		Yes	Yes	No	No	Yes	Yes	Yes	Yes
Support for Containerisation		Yes	No	No	No	Yes	No	Yes	Yes
Portable File Structure		No	No	No	No	Yes (with proper tools)	No	No	No
Hardware Requirement	**Light** (CPU: 1 Core RAM: 1GB Recommended HD: 1GB> Usage)	X		X		X			
	Medium (CPU: 2 Core RAM: 4GB Recommended HD: 2GB > Usage)				X		X	X	X
	Heavy (CPU: 4 Core RAM: 8GB Recommended HD: 4GB > Usage)		X						

2.2.4 Synthesis

Through the literature review on the HCI design for online training which focuses on observing and critiquing contemporary literature, a list of key features has been identified to ascertain the requirements that can create the most usable, accessible and successful product from the perspective of HCI research. The implementation of those key features will benefit the user's perception of the platform and their interaction with the trainer or other learners, as well as the user's ability to engage with the learning material, which is imperative to improve the user's learning and transfer performance and therefore the success of the platform.

The literature review on existing platforms has been carried out and a selection of platforms has been investigated, which includes open-source platforms (Chamilo LMS, Sakai, LAMS, Dokeos and Moodle) and commercial Learning Management System platforms (Blackboard Learn™, Canvas, Adobe Captivate Prime). The identified key features have been compared between those platforms and the result shows that Moodle is the most suitable platform for FORESIGHT to host the FORESIGHT innovative curricula framework.

The literature review on the contemporary online training, open-source and commercial platforms and Learning Management Systems forms the preliminary work to design and build the FORESIGHT innovative curricula tool which will be further reported in the next section.

3 FORESIGHT Online Innovative Curricula Tool

3.1 Viewpoint of the Architecture

Figure 9 shows the overview of the architecture of the FORESIGHT Online Innovative Curricula tool (A – Innovative Curricula Tool, B – Learning Interface). To clearly depict the architecture, it has been split into the following nine sections with annotations and descriptions respectively: ① Learning Paths ② Dashboard ③ Courses ④ Modules ⑤ Video Library ⑥ Downloads Library ⑦ Team System ⑧ Gamification Module ⑨ Authentication System. Different categories of the objects in the architecture are explained in Table 5.

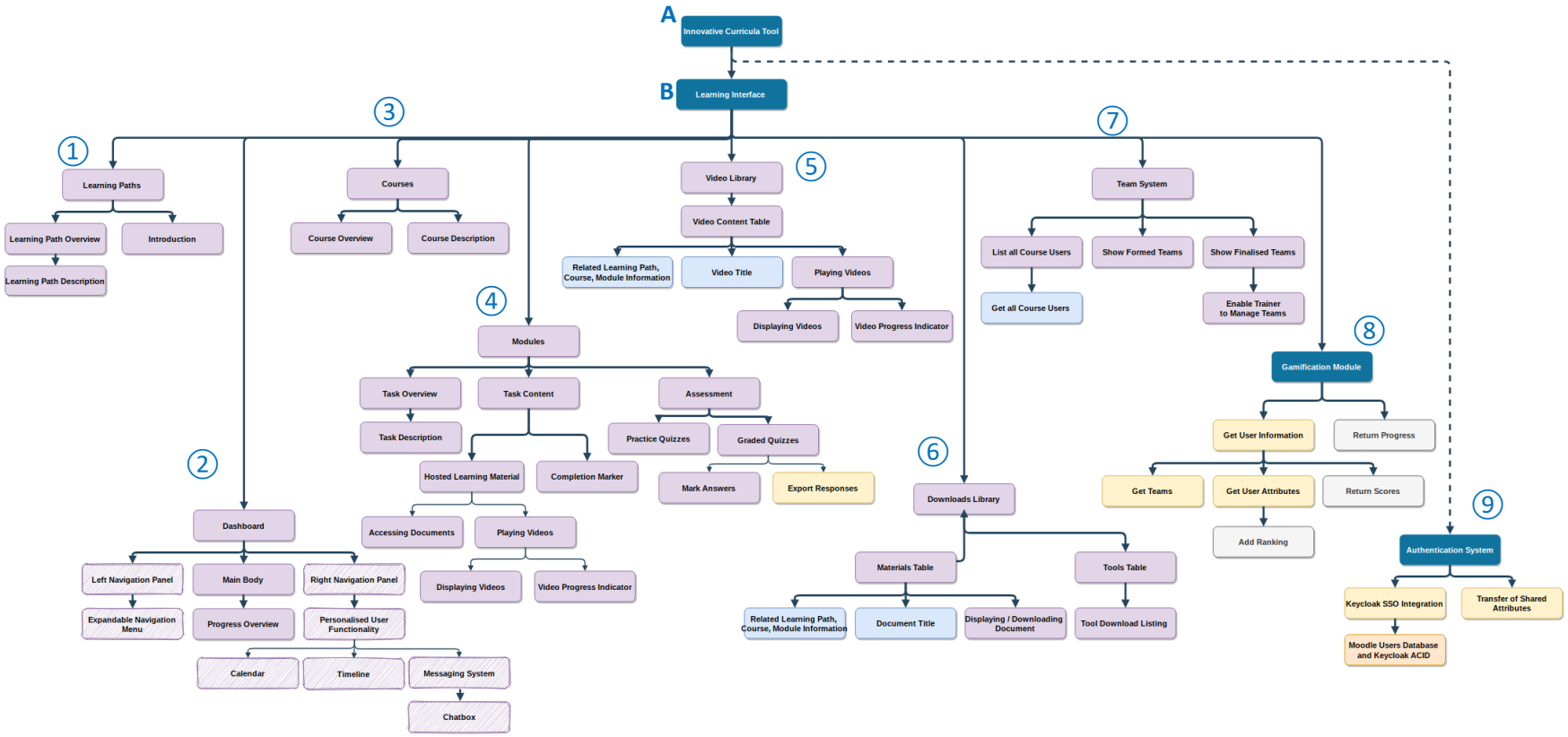

Figure 9. Overview of the Architecture of FORESIGHT Online Innovative Curricula Tool (IC)

Table 5. Objects in the architecture of FORESIGHT online innovative curricula tool

Object	Explanation
Component	Represent elements of the Innovative Curricula Tool (IC) that are related to, or dependent on integration with other components on the FORESIGHT project to function, e.g., the authentication system which is dependent on both the IC and the Keycloak authentication server.
Moodle Plugin	Moodle plugin objects are aspects of the IC that are comprised of integrated Moodle components or can be added in using pre-existing plugins.
Moodle API	Using the Moodle API infrastructure provided by Moodle in order to provide information to other components or to inform the UI.
Site-Wide Component	Primarily aspects of the UI that need to be persistent elements, such as quick navigation buttons, sidebars or menus.
Database Direct Communication	Relate to actions or information that can be retrieved from the Moodle database directly, by either the IC or the Moodle APIs.
Component API	Aspects of the IC that are related to or expected to support and utilise API integration with other components.
Direct System Functionality	Relate to operations that need to be configured directly between systems, e.g., database atomicity or other system-specific operations.

3.1.1. The Architecture of Learning Paths

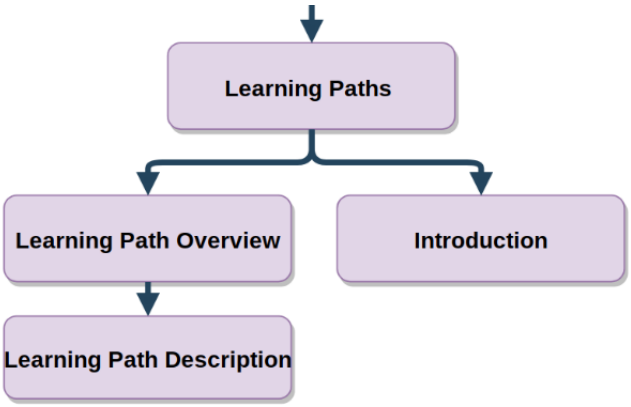

Figure 10. The Architecture of Learning Paths

This architecture workflow in Figure 10 shows the learning paths, which are broken down logically into each component of this section. The overview, a brief description and the introduction - a short preamble which will explain the learning objectives of that path. The Innovative Curricula tool must display each of these elements in order to successfully show the learning paths. This will be completed through the use of standard Moodle features, with the possibility of including plugins to adapt the layout of the Learning Paths overview to closer match mock-ups.

3.1.2. The Architecture of Dashboard

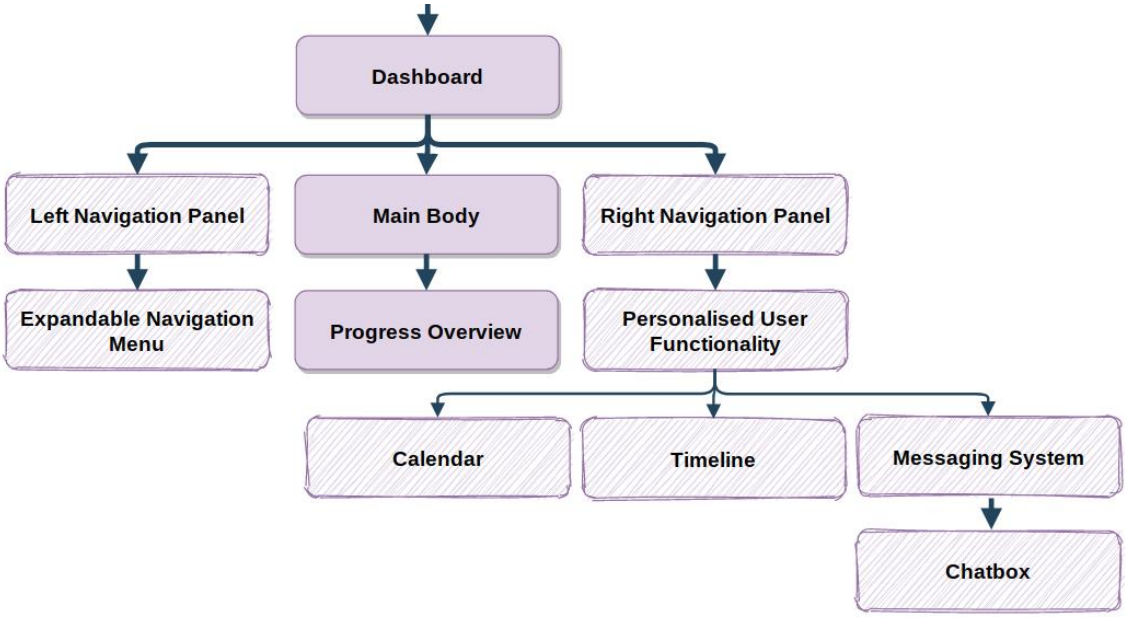

Figure 11. The Architecture of Dashboard

This architecture workflow in Figure 11 shows the features of the IC dashboard, and how each of these features will be implemented. The dashboard is a critical component of user navigation and as such it is the basis of several important site-wide components, such as the left and right navigation panels, which each contains sub-features such as quick navigation menus, messaging systems and organisational tools such as calendars and timelines. Each of these features is supported by Moodle natively, or with plugin integration. This will allow for a featureful but clean dashboard that presents persistent UI elements without a need for non-native functionality to be integrated.

3.1.3. The Architecture of Courses

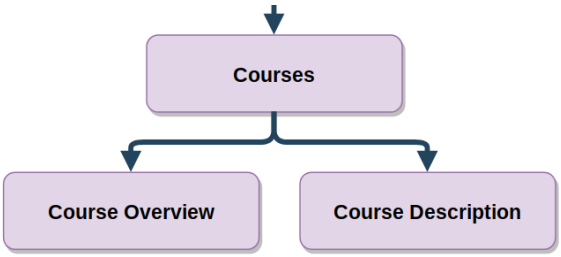

Figure 12. The Architecture of Courses

The courses display section shown in Figure 12, is important, as it shows the user what course they are enrolled on, and what it will entail from a simple introductory screen. For this subsection, the courses, which depend on the enrolled learning path, can be displayed. For example, the beginner's learning path of "Awareness" and "General Cyber Security" can be displayed, along with a brief overview and more detailed description.

3.1.4. The Architecture of Modules

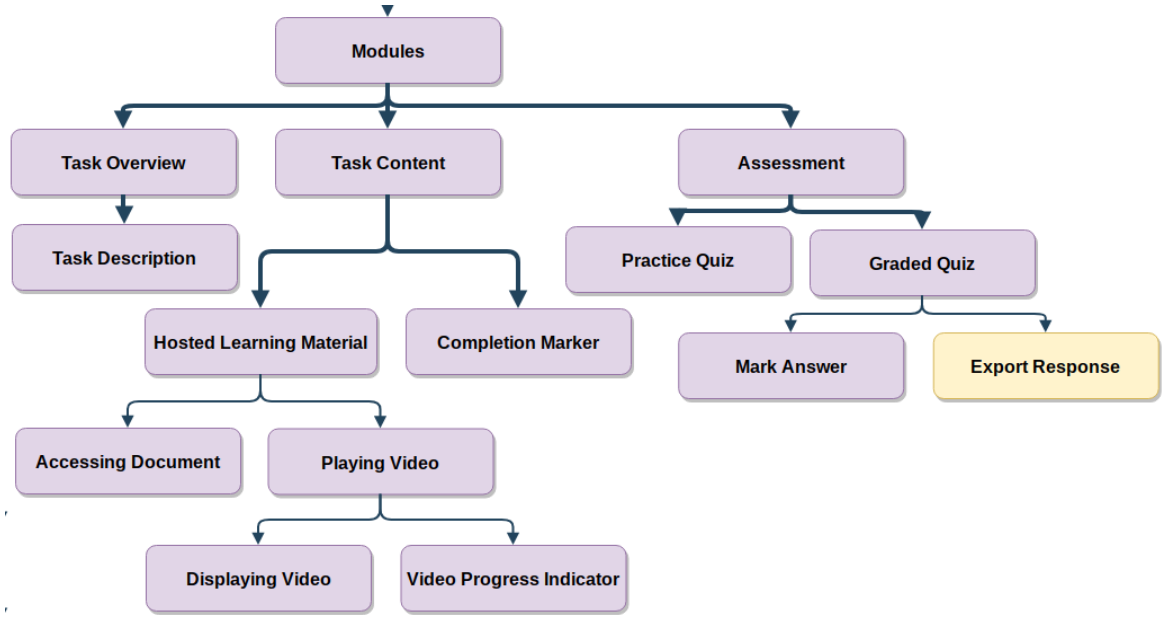

Figure 13. The Architecture of Modules

Modules are the core of the learning material delivery system for Moodle. The diagram in Figure 13 shows specific units to be set relating to specific learning objectives. These can be created by trainers and have sub-tasks assigned to them, which can be released all at once, for self-paced learning or incrementally. Critically, these tasks need to be multi-purpose and allow for learning material to be viewed, accessed or downloading. This requires integration with multimedia hosting and replaying features. For each activity that the user completes, completion indicators should be easily visible to show completed, partially completed and pending tasks. Tasks should also be able to function as assessments, introducing needed support for the practice, and graded quizzes. All of these features are capable of being handled by Moodle directly; except for the API system that allows querying of Students' performance for all of these tasks for other components to access and analyse student performance and progress. This will be handled by Moodle's built in API system, specifically the grading module, which has support for multiple API formats.

3.1.5. The Architecture of Video Library

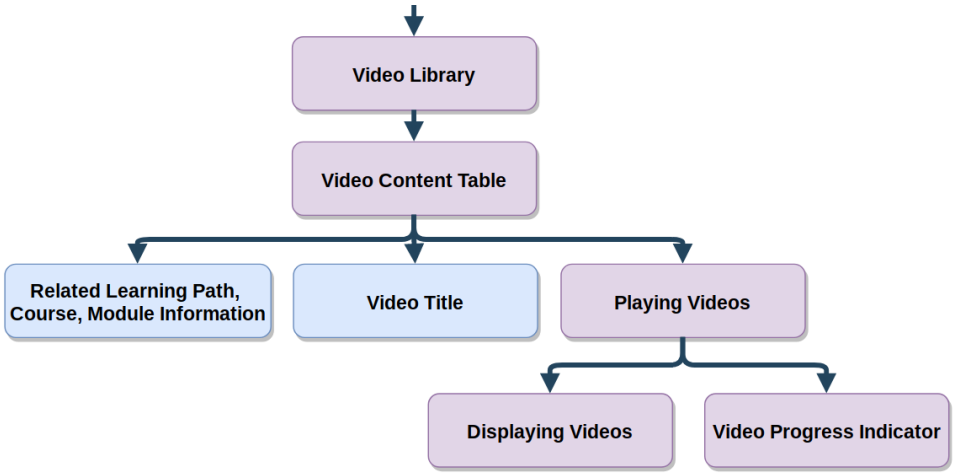

Figure 14. The Architecture of Video Library

Figure 14 shows an architecture breakdown of the video library. To provide support for later viewing of video content without navigating through the tasks directly, a central video library will be implemented to act as a repository for task videos. As there is not support for the implementation of this feature directly within Moodle, this will be added by using database queries to the main Moodle database to provide direct links to view the content.

3.1.6. The Architecture of Download Library

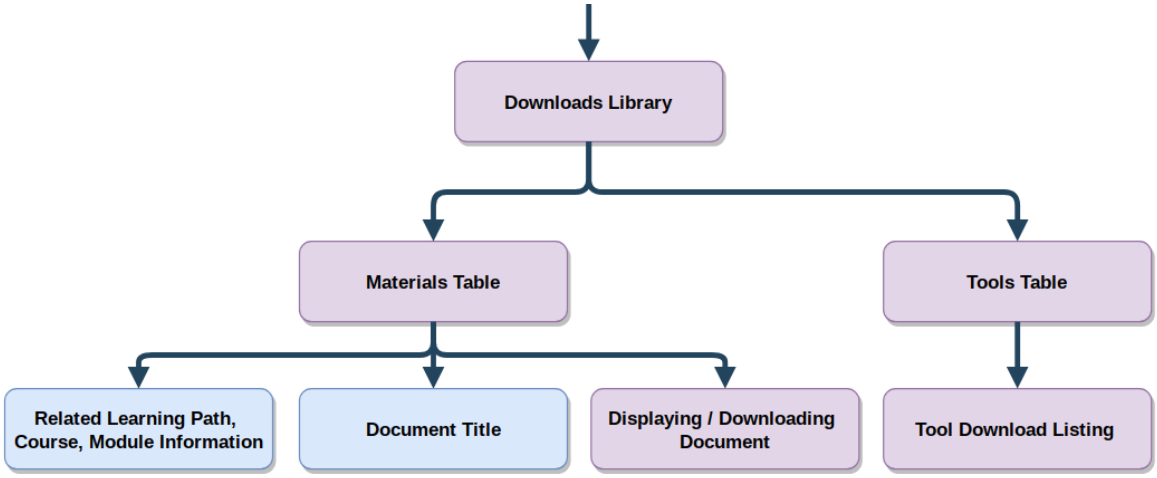

Figure 15. The Architecture of Download Library

Figure 15 shows an architecture breakdown of the download library. Similarly to the video library, it provide a central repository for downloadable materials, which include practical - such as tools or scripts, learning materials, and documents that contain theoretical information that can later be referred back to. Again, Moodle does not natively support collating these resources out in a table- so this will be added by using database queries to the main Moodle database to provide direct links to access or download the content.

3.1.7. The Architecture of Team System

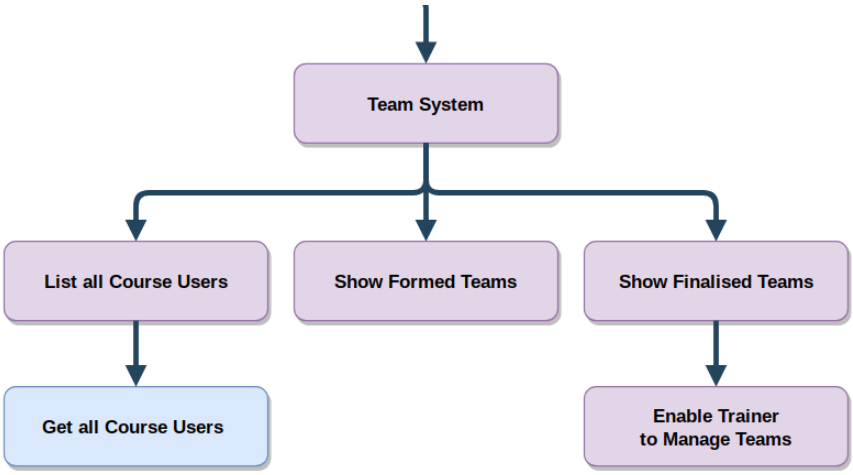

Figure 16. The Architecture of Team System

The implementation of teams allows for the grouping of the users according to different factors within courses. The functionality shown in Figure 16 shows that doing this is already supported within Moodle, however, the ability to fetch the total information on users per course is not a feature that has been integrated into Moodle, therefore we will acquire the entire list of users per course through database queries, which can then be used to inform the user selection through the IC.

3.1.8. The Architecture of Gamification Module

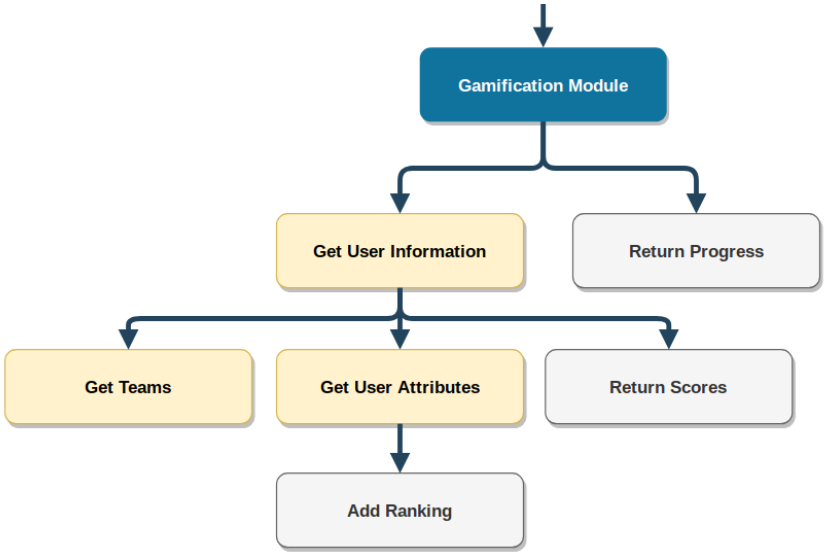

Figure 17. The Architecture of Gamification Module

The FORESIGHT platform will also interact with T9.5 and T9.6 to be regularly updated with scenarios align with the state of the art in vulnerabilities for an optimal learning experience. The Gamification module, shown in Figure 17, will exist as a plugin within the Moodle platform that the IC uses. It will utilise both internal Moodle API functions and objects, as well as exporting data such as the rankings, scores and progress of users to external REST API objects.

3.1.9. The Architecture of Authentication System

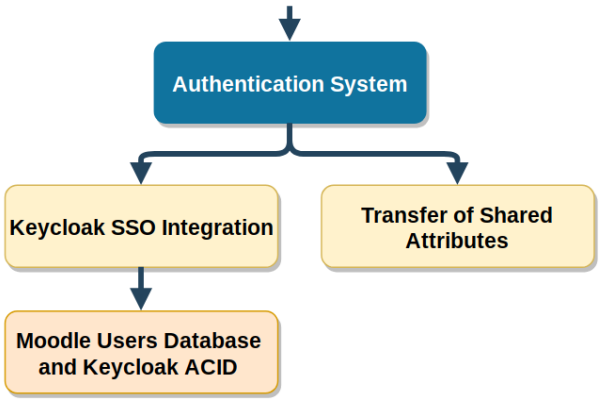

Figure 18. The Architecture of Authentication System

Figure 18 shows the architectural breakdown for the authentication of each user to access the IC. This will be handled through SSO integration with the Keycloak module using OATH2 integration with Moodle. This is a directly Moodle compatible component, but it has been marked as direct system functionality due to its dependency on the Keycloak module and the integration between the two. This communication will be encrypted using SSL.

3.1.10. The Architecture of API

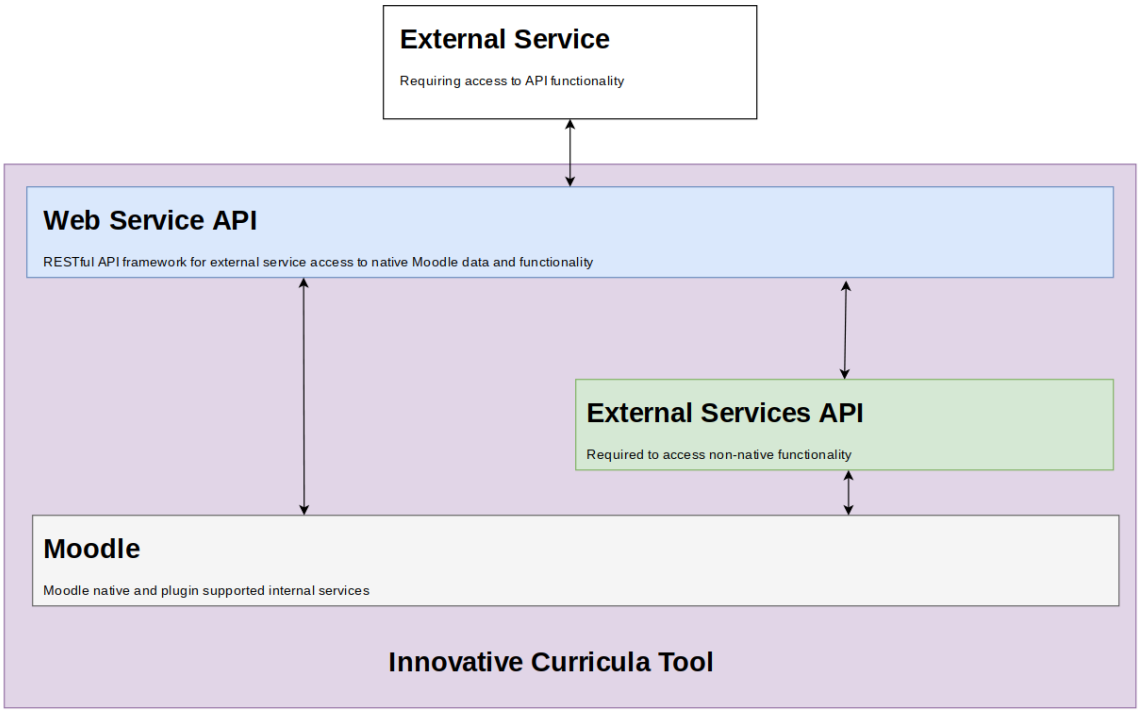

Figure 19. The Architecture of API

The API system has two levels, shown in Figure 19. First- Moodle supported API systems that allow for the operation of the Moodle API, served through the Web Service API system that supports multiple API protocols, as detailed in the 3.2.3 section below. Secondly, there is the external services API that supports the building of bespoke API calls for any features that are not able to be served by the main Moodle API system; which is again exposed through the Web Service API. This will be used to query

the information needed, before transfer being transferred to the RabbitMQ message broker bus for communication with other components.

3.2 APIs and Plugins

3.2.1 APIs

Primarily, data will be retrieved from the Moodle API systems according to the operational model above, this will involve two API systems; firstly- the Moodle API system. We will utilise components of this to retrieve the relevant data, before serving it using another component of this broader API specification- the Moodle Web Service API.

3.2.2 Plugins

While the IC has the capability for later extension utilising plugins, at the moment it is not utilising any third-party plugins to deliver the features that have been specified. Development has been achieved using first-party Moodle components and extensions, as well as code and configuration that has been developed and implemented specifically for the purpose.

3.2.3 Web Service Protocols

Application requests towards the core Moodle API will primarily be sent via the RabbitMQ message broker which will be provided on the platform for inter-communication between partners, Moodle has support for multiple different API protocols, both RESTful and not; in multiple different formats. This allows the direct component to component data query and transfer when applicable, as shown in Table 6.

Table 6. Web service protocols [47]

Name	Moodle Ver.	Description	CORS	Issue
REST (returning XML)	2.0	XML data accessed through a REST API (not restful)	Supported (3.0 and onwards)	
REST (returning JSON)	2.2	JSON data accessed through a REST API (not restful)	Supported (3.0 and onwards)	MDL-29242
REST (returning JSONP)	2.X	Would be very useful for client-side JavaScript	Not supported	MDL-29913
JSON	2.X	JSON server receives a JSON encoded params and return JSON encoded values.	Not supported	MDL-21341
SOAP	2.0	Very important for interoperating with Java and .Net applications. There was a partial implementation JAVA/.Net in Moodle 2.0, but it does not work for anything but the most trivial functions. It is fully working with PHP clients.	Not supported	MDL-20804, MDL-28988, MDL-28989
XMLRPC	2.0	XML remote-procedure call.	Not supported	

Interaction with the webserver is done in a very specific format during web requests which can only be requested in either XML or JSON message formats as follows:
{fullcomponent}_{methodname} - example: core_user_get_user_preferences
Where:

- {fullcomponent} is the full short name or the component such as core_users
- {methodname} is the name of the method in the form of {verb}_{noun} such as get_user_preferences
  - {verb} - preferably one of get, create, delete, update or eventually other that well describes the action
  - {noun} - moodle objects, usually plural such as user_preferences, or e.g., posts, discussions, users, courses etc.

Using these naming conventions alongside the core web service functions that can be found at https://docs.moodle.org/dev/Web_service_API_functions allows for the querying and posting of all Moodle data across the RabbitMQ BUS.
Interaction to the REST API of Moodle will require authentication in the method of an authorization token in order to request data from the Moodle service.

3.3 The Registration and Authentication Process

Authentication of the Moodle site is handled via OpenID integration between the Moodle and Keycloak services, this authentication method will handle the handling of user account creation and access to the IC service. This compatibility with OpenID natively integrated within Moodle and will allow for the user to select Keycloak as an authentication method. On selecting this, it will redirect the user to the Keycloak SSO screen which they can enter their username and password. On successful login, the user will then be displayed their personal Moodle dashboard. Through this, the users that are registered as users on the Keycloak domain will have a Moodle account created on first sign in, needing no direct Moodle registration.

3.3.1 The User Registration

The user will be registered through the Keycloak main domain where they are to be assigned the username and password by the domain administrator.

3.3.2 Authentication Process

When the user signs in with the Keycloak, they will be taken to the Keycloak sign-in portal as shown in Figure 20, where they can enter the credentials that have been allocated by the network administrator, if further factors such as 2FA or One Time Passcodes wish to be implemented, this can be done through the Keycloak configuration.

All authentication to the Moodle site is handled by an OpenID integration between the Moodle components and the Keycloak server. This is encountered when attempting to visit the IC - Moodle site http://foresight.eurodyn.com/ic.

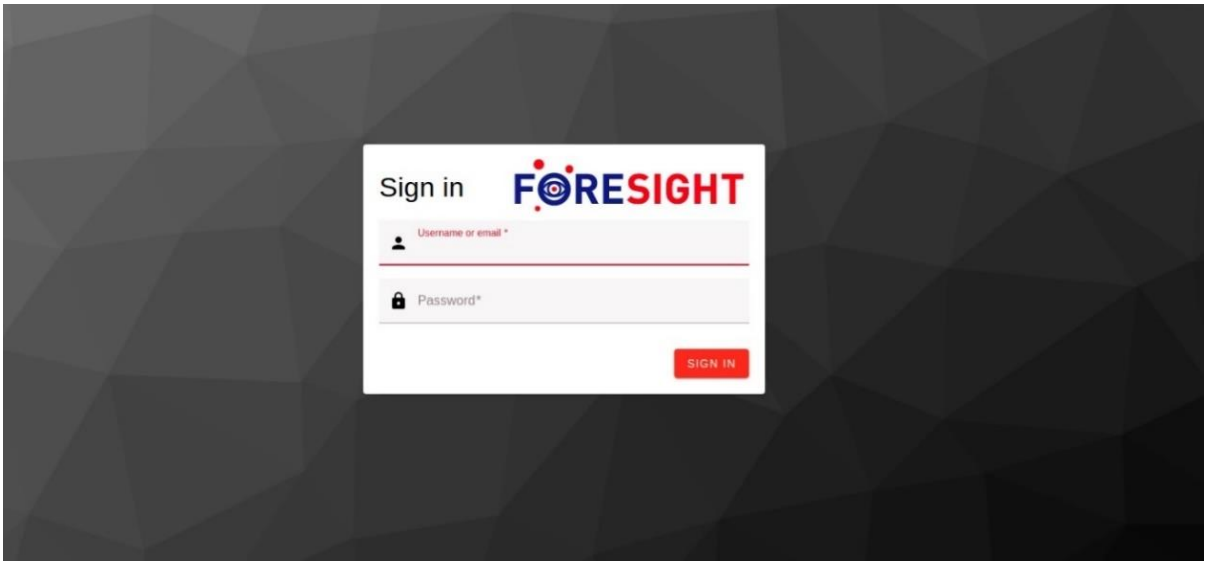

Figure 20. User Sign in through Keycloak

3.4 The User Interface

The user interface of the FORESIGHT platform has been designed with HCI principles as discussed in section 2 and it will be extended through modules to support professional certification assessment. The classic theme is currently used in the design as advised by Moodle, and the further UI implementations are to be changed as development progresses to improve the aesthetic for user interactions, focusing on the UX/UI (User Experience and User Interface) of the IC. This section will describe the initial design of the platform from the users view.

3.4.1 Home Page, Learning Paths and Exploration

John Smith is a trainee who has registered at the Beginner level. After the successful login, his home page on the FORESIGHT innovative curricula tool is displayed as in Figure 21:

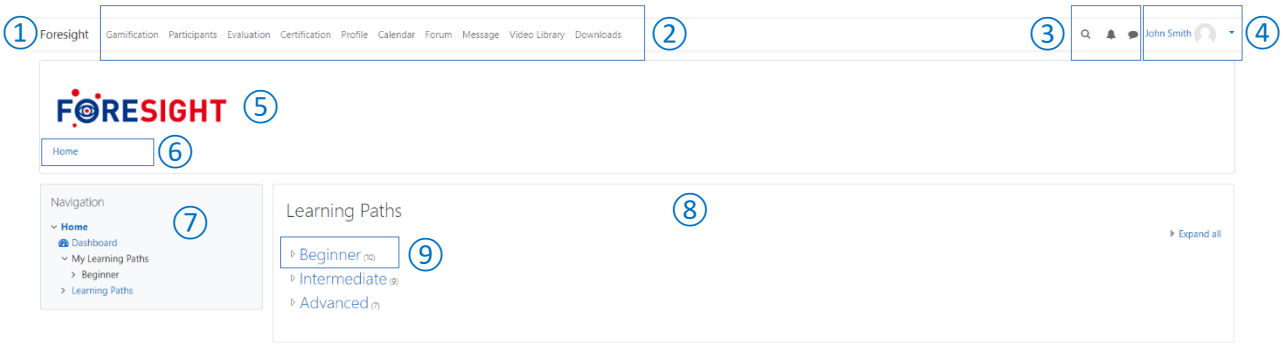

Figure 21. The user interface - Home page and available learning paths

- Any text showing in blue colour represents a link that can be clicked on.
- The header block includes
  - Short name for site ①
  - Navigation links ② to “Gamification”, “Participants”, “Evaluation”, “Certification”, “Profile”, “Calendar”, “Forum”, “Message”, “Video Library”, and “Downloads”.
  - Toggle icons ③ for the following functions:
    - Global Search to explore the content
    - Toggle notification menu showing the list of all notifications and access the settings for notification preferences.
    - Toggle messaging drawer for (1) people and messages search, (2) list of contacts (3) personal space to save draft messages, links, notes etc. to access later, (3) list of conversations with *Starred/Unstarred contacts*, *Group*, or *Private*.
  - The toggle menu ④ showing the user’s full name – John Smith, his ID and a dropdown arrow symbol. Clicking on any part of this area, a dropdown menu will allow the user to select collapsed topics in “Dashboard”, “Profile”, “Grade”, “Messages”, “Preferences”, or “Log out”.
- FORESIGHT logo ⑤
- The navigation bar ⑥ shows the current context path, with links to the higher contexts.
- The navigation block ⑦ provides navigation links associated with the current page and available content in a hierarchical display and will appear on every page of the site. It contains an expanding tree menu which includes the following links:
  - “Dashboard”

- "My Learning Paths -> Beginner" to access what John is currently registered.
- "Learning Paths" which lists all the available learning paths offered by FORESIGHT.

- The Learning Paths block ⑧ lists all learning paths offered by FORESIGHT IC – "Beginner", "Intermediate" and "Advanced", allowing one-click access to any chosen path.
  - Each learning path ⑨ has a title with the number of courses in a bracket, e.g., "Beginner (10)" means there are 10 courses in the learning path "Beginner".
  - For any unregistered path, e.g., intermediate or advance, a list of the courses in this path will be provided in this block. But registration will be required to go further for any of the courses. For example, John clicks the path 'intermediate' and chooses one of the courses - "Domain 3: Naval", a message ⑩ will appear in the block to remind him that the registration is required as shown in Figure 22.

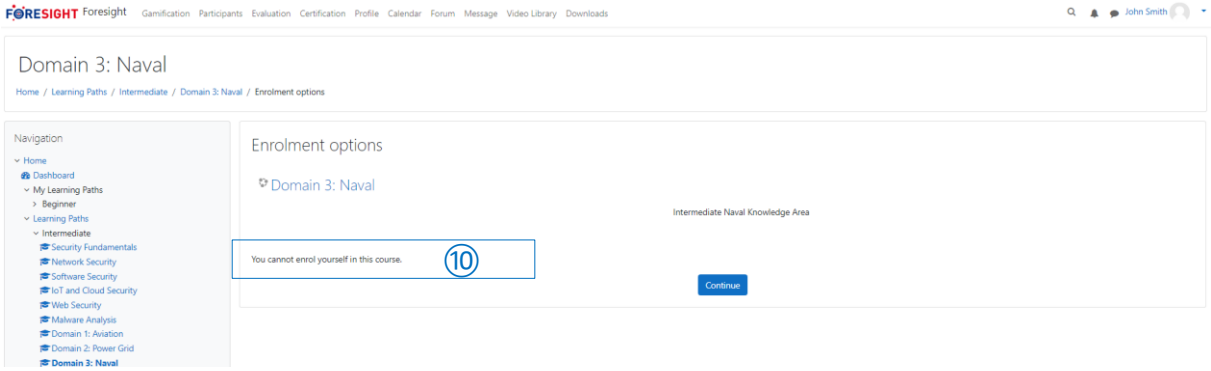

Figure 22. The user interface - Choosing a course in unregistered learning path

3.4.2 Curricula Dashboard and Courses

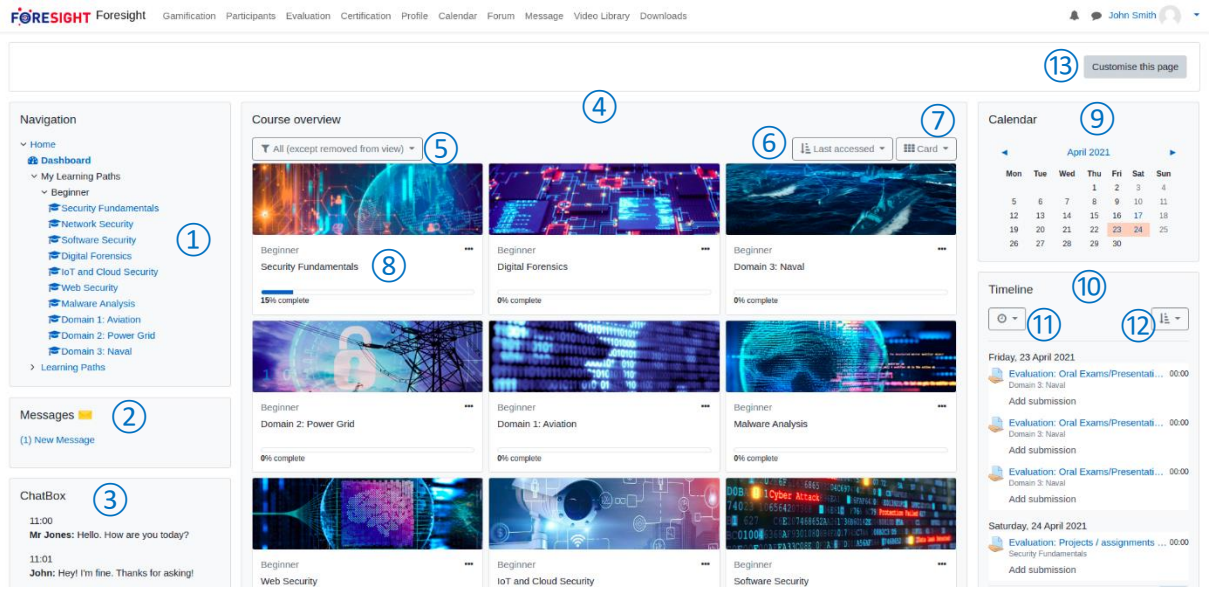

Figure 23. The user interface - Curricula Dashboard

When John selects 'Dashboard', his curricula dashboard will be shown as Figure 23 with the following items:

- In the navigation block ①, the tree menu of his registered learning path – "Beginner" expands automatically and shows the list of courses in this learning path.
- Incoming message notification box ②

- Online Chatbox ③
- In the course overview block ④, all of the courses in this path are listed in the card view by the order of last accessed. The view of the courses in this block can be changed with the following options:
    - Toggle menu ⑤ - "All (Except removed from view)", "In progress", "Future", "Past", "Starred", or "Removed from view".
    - Toggle menu ⑥ - "Course Name" or "Last accessed"
    - Toggle menu ⑦ - "List" or "Summary"
- Each course block ⑧ shows the following:
    - The learning path which the course belongs to
    - The title of the course
    - The progress of the course in the percentage of completion, e.g., the security Fundaments course is showing 15% complete.
    - A brief introduction of the course will appear when the option of ⑦ is "Summary".
    - Toggling the icon "…" allows to either 'star' or 'remove' the course from view.
- The Calendar block ⑨ displays a small version of the current month's calendar and is added to every Moodle course page by default.
    - Events and due dates are colour-coded to distinguish event type from the *site*, *category*, *course*, *group*, *user* or *other*.
    - Day 23rd and 24th are examples of *course* events in April. When hovering the cursor on the day, a list of events on that day will pop up.
- The timeline block ⑩ (displayed by default on the Dashboard) provides an overview of deadlines.
    - Deadlines can be sorted by "All", "due dates" or "Overdue" in ⑪, or sorted by due dates per course in ⑫.
- The user can click "Customise this page" ⑬ to move those blocks around, or choose "Reset the page to default".

3.4.3 Modules and Tutorials

Figure 24 show the page when John selects one of the courses in his registered learning path "Beginner" - "*Security Fundamentals*" with the following items:

- The title of the course ① - Security Fundamentals
- The current context path ②
- The navigation block contains the expanding tree menu under "My learning Paths -> Beginner -> Security Fundamentals" ③ with the following branches:
    - Participants:
        - "Course blogs" – showing blog about this course
        - "Participants" - list of participants in the same course with search function.
    - Badges: can be awarded either manually or using activity completion settings in a course and are a popular way to motivate students. Students may be awarded badges at different stages of the course for different levels of progress.
    - Competencies: describe the level of understanding or proficiency of a learner in certain subject-related skills. Competency-based education (CBE), also known as Competency-based learning or Skills-based learning, refers to systems of assessment and grading where students demonstrate these competencies.

- Grades: Every course has its own *Gradebook*. Some activities such as Assignment and Quiz send grades back to this gradebook. It is also possible for teachers to enter grades directly into the gradebook.

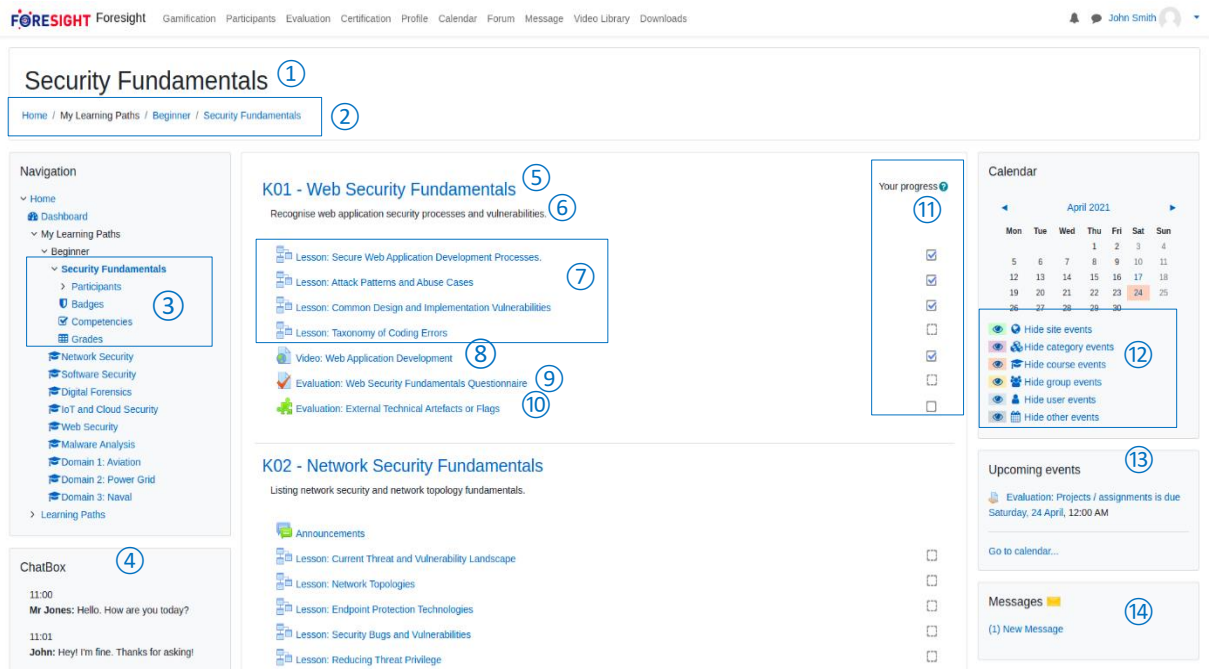

Figure 24. The user interface - Modules and tutorials

- ChatBox ④ - enabled in every page.
- Module block:
  - ID and Module title ⑤
  - Learning objectives of the module ⑥
  - A list of lessons and tutorials in this module, can be offered in different formats, e.g., PDF files to read ⑦ or a video to watch ⑧. Clicking on the item will open a new webpage that contains the relevant information.
  - Tests for evaluation, e.g., questionnaire ⑨
  - Practical evaluation, e.g., start a challenge, lab, or exercise etc. ⑩. Clicking on it will open a new webpage that contains the relevant information. When team forming is required, the user can either be invited or invite other members via messages, forum, or Chatbox. In "Your progress block" ⑪, a tick next to an activity name may be used to indicate when the activity is complete.
    - The box with a dotted border means that a tick will appear automatically when the activity is completed.
    - The box with a sold border can be ticked by John when he thinks he has completed the activity, and it can be removed by clicking it again.
- The calendar block displays the events related to this course, and showing all the colour-coded event types ⑫ which can be hidden or shown by John.
- Upcoming events block ⑬:
  - Clicking on the event will show more details of this events in a pop-up window, include the event *title*, *date and time*, *type*, *related course*, *related file submission*.
  - "Go to Calendar" allows to explore the events in the following ways:

- Present the detail of event(s)
- Sort event(s) by Upcoming events', 'Month', 'Day', or by "All courses" or different "Course ID",
- *Export calendar*
- *Manage subscriptions* of calendar or import calendar
- *A new event* to add

- Messages block ⑭ showing the number of new messages, and clicking on to access the message.

3.4.4 Video Library

The video library provides a central repository for finding and viewing video content. Future video content that gets uploaded as learning material can be sourced by users from this library.

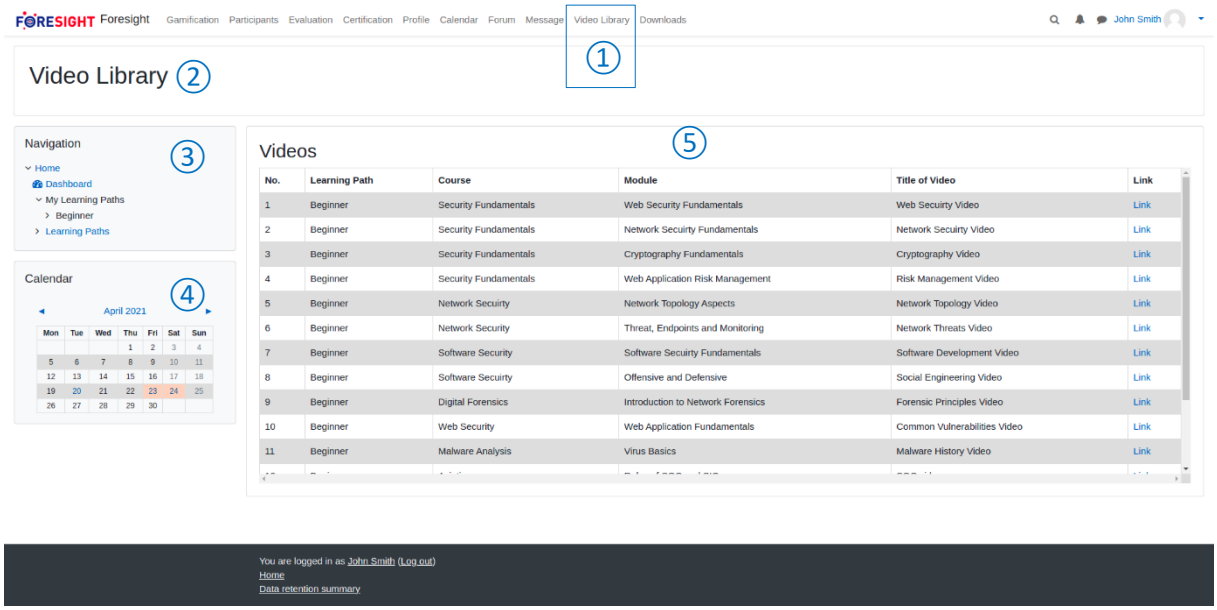

Figure 25. The user interface - Video library

As shown in Figure 25, the Video Library can be accessed by clicking ① and showing the following items:

- Title of the webpage ②
- Navigation block ③ - unexpanded tree menu same as at Home page.
- Calendar block ④ - showing all the events in this learning path, same as in the curricula dashboard page.
- List of videos ⑤ in the category of *Number*, *Learning path*, *Course*, *Module*, *Title of Video*, and *Link* that are associated with. This allows the user to easily access a video by any of the categories.

3.4.5 Downloads

Similar to Video Library, the downloads library provides a single source for learning materials and tools that have been uploaded to FORESIGHT online innovative curricula tool. As shown in Figure 26, the downloads library can be accessed by clicking ① and showing the following items:

- Title of the webpage ②
- Navigation block ③ - unexpanded tree menu same as in the Video Library page.
- Calendar block ④ - showing all the events in this learning path, same as in the Video Library page

- List of learning materials ⑤ in the category of *Number*, *Learning path*, *Course*, *Module*, *Title of material*, and *Link* that are associated with. This allows the user to easily access a learning material by any of the categories.
- List of tools ⑥ in the category of *Number*, *Tool name*, and *Link* that are associated with. This allows the user to easily find and download a tool.

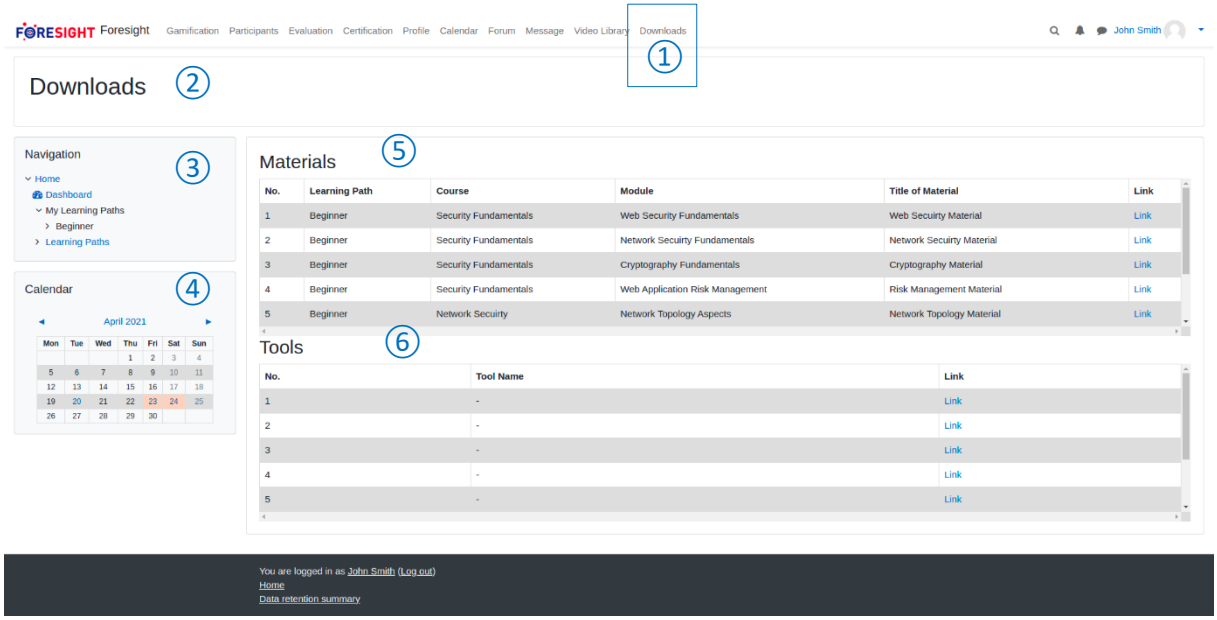

Figure 26. The user interface - Downloads

4 Conclusion

The literature review on the contemporary online training, open-source and commercial platforms and Learning Management Systems has shown that Moodle is the best choice to hold the FORESIGHT innovative curricula tool. The initial design of the FORESIGHT innovative curricula tool has been presented in detail in terms of the architecture, the APIs and plugins, the web service protocols, the registration and authentication process, as well as the user interface with the current development. These form the preliminary work to design and build the FORESIGHT innovative curricula tool, which will be fully developed and reported in the second version of the deliverable.

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