

# Adaptive Blended Learning Platform based on the 4Cs Architecture

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**Keywords:** Blended Learning, Adaptive Learning, Platform's Architecture, Education, Bloom's Taxonomy, Developing 4Cs.

**Abstract:** In recent years institutions try to adapt their courses based on the students' needs. Research is focused on what data to extract from students and how to use them to provide personalized learning material. This article introduces the architecture of an Adaptive Blended Learning Platform that aims to help students develop 4Cs. The suggested platform is based on the principles of Bloom's Taxonomy, the Felder-Silverman Learning Styles Model and Blended Learning. A simple interface is provided to the teacher to create and manage courses and classroom material. Additionally, through the platform personalized worksheets for a selected course are created. For the creation of such worksheets an algorithm acts as an assistant to the teacher that suggests which learning objects suit each student better. Finally, the materials available to students consist of digital and non-digital tools to make them more active and to stimulate their interest, such as activities, exercises and games that can be practiced both at classroom and at home.

## 1 INTRODUCTION

Traditional methods of teaching in schools need to be modernized and adapted to the context of 21st-century society. Adaptive and Blended learning methods are some of the modern approaches in the field of education. Research shows that the use of different educational methods combined with technology creates a more positive attitude towards the learning process and at the same time motivates students to increase their grades (Abdul Latif & Lajiman, 2011). The curriculum often consists of a sole textbook that teachers are required to consult although many times this does not suffice to correspond to the diversity of a classroom. Nowadays we move away from the norm "one size fits all" and attempt to create courses compatible with the needs and preferences of each student.

As Kolb (1984) states, each person learns differently, so it is not appropriate to follow a specific learning sequence. Adaptive learning is characterized by the educational process of receiving data on the knowledge, learning style, learning tools, and of assessing each student. According to these data, this learning method tries to adapt the educational process

to the needs and preferences of each student (Morze et al., 2021). Teachers can contribute to the integration of educational theories and give directions for a more personalized learning process in order to improve the content and the quality of a lesson. The evolution of technology has enabled the creation of many adaptive e-learning platforms that support Learning Styles for the personalization of the learning process (Katsaris & Vidakis, 2021). A learning system tailored to each student's needs and learning style provides additional motivation to help them reach their full potential (Popescu et al., 2009).

Besides the educational theories, there are cognitive theories that can be incorporated in the learning process. Such a theory is the Revised Bloom's Taxonomy (RBT) that describes a framework for the classification of learning objectives (Krathwohl, 2002). This framework provides six cognitive levels which are used for the learning session design and guides students from lower order (remembering, understanding) to higher order (applying, analyzing, evaluating and creating) thinking skills.

For the development of the aforementioned higher order thinking skills the widely known 4Cs of 21st-

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century skills can be of assistance. These skills include:

**Critical Thinking and Problem Solving:** In this process, students discover hypothetical solutions to a problem and by processing those solutions they culminate in the most effective (Butler, 2012).

**Communication:** Communication constitutes an individual's ability to understand, share, and communicate thoughts, ideas, questions and solutions through written or oral speech (Pheeraphan, 2013).

**Collaboration:** It is an individual's ability to respect and cooperate with other individuals (Pheeraphan, 2013). Students work on a project towards achieving a goal while creating new knowledge through this process (Sharratt, L. & Planche, 2016).

**Creativity:** Creative thinking enables humans to be able to produce a variety of ideas, have flexibility, and be able to provide solutions to various daily life problems (Yuliati & Lestari, 2018).

According to the 'Partnership for 21st Century Skills' (P21, 2015b), every child in America, in order to succeed as an effective citizen, employee, or even a leader, should be equipped with the skills of the 21st century.

Pedagogical methods nowadays use technology to improve the learning process, combining both traditional methods and software and aiming at the involvement of students to a great extent (Nikolaos Vidakis et al., 2017). Blended learning consists of two main "components": face-to-face instruction and computer-mediated instruction to create a personalized educational process which will facilitate students' learning (Horn & Staker, 2011). The blended learning method provides several advantages such as increased flexibility in student learning and increased student control in their learning environment (Horn & Fisher, 2017). This can result in students becoming more actively involved in the lesson, more efficient, and discovering the teaching method that suits them best (Liu et al., 2016; Zaharah Hussin et al., 2015). An implementation of blended learning is the flipped classroom method that incites a student to study at home and solve questions and exercise the studied content in the classroom (Huang & Hong, 2016).

In a previous study about Adaptive e-learning systems through learning styles (Katsaris & Vidakis, 2021) we observed that most Adaptive systems do not follow a pedagogical theory and the majority of research is conducted in higher education. As a result and based on the main principles of the IOLAOS' architecture (Vidakis et al., 2015) we developed an educational platform incorporating the principles of

Bloom's Taxonomy, the Felder-Silverman Learning Styles Model and Blended Learning in order to mature the 4Cs of students, aiming to support the lower levels of education (primary school).

## 2 RESEARCH BACKGROUND

An important element of Blended learning is personalized education. As the teacher has acknowledged the difficulties and weaknesses of the students, he/she is capable of providing them with appropriate assistance through targeted exercises. The main goal of this method is to allocate personalized education to the students by means of home learning. Regarding the systems that will support the adaptive blended learning platform, many research proposals differ significantly from each other, but all of them offer personalized learning opportunities to the students and direct information to the teacher.

Modern blended learning platforms offer the ability to personalize education through targeted exercises and activities such as that of Mohamed & Lamia, (2018) which is focused on mathematics and logic subjects/lessons. The use of the flipped classroom enabled students to use their time at home to study key concepts and then the teacher managed to focus on developing 4Cs through the problem-based learning method. As a result, students performed better, needed less time and less mental effort to find solutions to problems.

In another attempt at higher education (Kakosimos, 2015) micro-adaptive instruction methodology was applied using behavioural data, self-assessment and performance information of students. Accordingly, the students demonstrated an increasing efficiency in the fields of perception, engagement, motivation and an overall improvement towards the control group.

Lai & Hwang, (2016) tried to explore the potential of the adaptive flipped classroom by initially assigning study material and quizzes for home study. Then, they created a self-regulated learning system that contains four (4) groups: an out-of-class learning system, a self-regulated monitoring system, a teacher management system and a database. The differentiation and the innovation they achieved is that each student can set his/her learning goals and evaluate his/her learning performance before and after the courses. Teachers can track their students' performance, while the platform provides them with analysis based on the teacher's criteria of self-regulation and the students' learning logs from the

out-of-class studying and the self-regulated monitoring system.

Respectively, in other efforts emphasis was given to the development of motivation of students such as in Lamia et al. (2019). The Flipped classroom method was invoked based on the Context-Aware mobile learning system (FC-CAMLS) on the English Linguistics module. The results of the study showed positive effects on students' learning outcomes, skills and motivation.

In addition, the study by Gunawan et al., (2020) created an Intelligent Tutoring System that supports blended learning to assist secondary science teachers in creating innovative course plans. Through this system basic skills are organized into a common learning theme, students develop higher order thinking skills and become more active in learning. Furthermore, it allows the development of higher-order thinking skills and perceived assessment patterns fitting in learning.

Finally, an interesting suggestion from Alsawat, (2016) is to differentiate the platform into two levels based on Bloom's taxonomy. The first is related to lower-order thinking skills and takes place outside of school, while the second concerns the higher-order thinking skills taking place inside school. As a result of their effort, students extended their engagement in the classroom and their overall satisfaction.

This study indicates that students prefer autonomous learning that involves technology over the traditional techniques. Additionally, it expounds that student activity in the classroom is derived through the way teaching is carried out.

### Objective

The main purpose of the platform is: (a) to create an innovative theoretical educational model combining the RBT, adaptive and blended learning theories; and thus, to provide teachers with a fast and flexible way of preparing courses and (b) the innovative theoretical educational model will be supported by a digital platform that will enable the teacher to create individual worksheets for each student based on his/her learning style and cognitive level. At the same time, the worksheets generated by the platform will help students to develop 4Cs in a Blended Learning environment.

Specifically, the objectives of the platform are:

- *Personalize* each student's worksheets based on their needs.
- *Provide* the opportunity for each student to develop new skills.
- *Allow* students to continue learning after school hours.

- *Assist* the teacher to create personalized worksheets based on a selected learning subject.
- *Monitor* the students' progress by the teacher.

## 3 THEORETICAL FRAMEWORK

The system aims for the creation of Adaptive Blended Learning Worksheets that will encourage learners to develop low and high order thinking skills. Figure 1 presents the basic concept of the platform. It is a student-centred approach that attaches importance to the abilities, inclinations and needs of each individual.

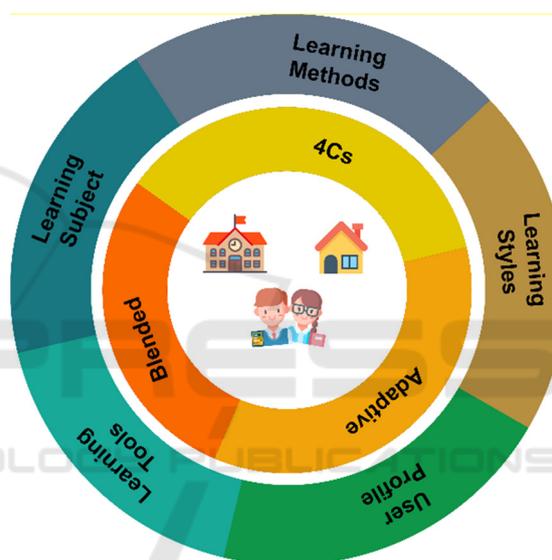


Figure 1: Theoretical Framework.

The framework allows the learning process to continue from school to home and vice versa. Finally, several parameters, methods and tools are used to produce personalized worksheets, like learning styles, user profile, learning tools and learning subjects.

The main features of the innovative theoretical educational model of the platform are Blended Learning, Adaptive Learning and 4Cs. Blended Learning was chosen to provide an agile approach to the lesson. The second feature is adaptability. A unique learning path containing a combination of exercises, activities and assessments reflecting the needs and preferences of a student can elevate the learning process. The third feature is the effort to develop 4Cs through teaching. Students should develop knowledge and be able to apply it to

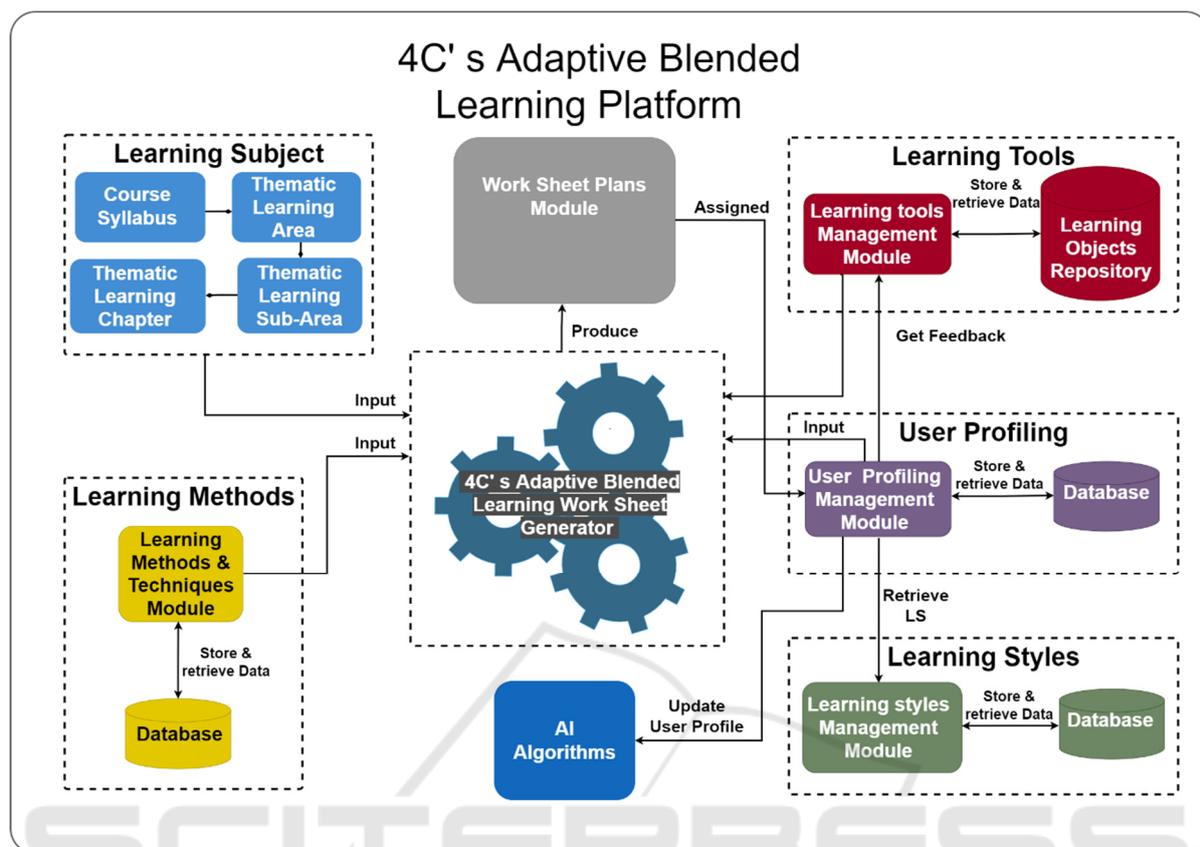


Figure 2: Architecture.

everyday problems. In this framework, 4Cs growth is achieved through high order thinking skills of RBT.

These principles will be implemented on a digital platform that students and teachers will use for an innovative personalized learning experience. The platform will provide a simple interface for the teacher to create worksheets and make suggestions about the learning objects each worksheet should include. Students will be able to access all their worksheets from a common interface that will allow them to complete their homework and collaborate with each other if necessary.

### 3.1 Platform Architecture Supporting the Theoretical Framework

Figure 2 illustrates the architecture of the platform. It is separated into five components that hold the information necessary for the creation of a worksheet, a component responsible for the generation of the worksheets, and AI algorithms that will be used for the student's user profile. In the following paragraphs we describe each component in detail.

#### 3.1.1 Learning Subject

This component is responsible for the information required during the creation and selection of a learning subject. Learning components includes the information of the learning syllabus, thematic learning areas, sub-areas and finally the learning chapter. This information is hierarchically organized in a manner that each learning syllabus contains the thematic learning areas, a subset of thematic learning sub-areas and so on. For instance, if teachers choose the course syllabus of the sixth grade they will have the option to select the thematic learning area of maths that corresponds to that grade; in the thematic learning sub-area, the decimal sub-area can be found as it is included on the sixth grade maths curriculum, and finally the subtraction of decimal numbers can be selected as the thematic learning chapter.

#### 3.1.2 Learning Methods

Learning Methods comprise the six cognitive levels of RBT (remembering, understanding, applying, analysing, evaluating and creating) and the types of activities each level contains. The purpose of this

component is to filter the Learning Tools based not only on the teacher's choices but also on students' preferences and abilities.

### 3.1.3 Learning Tools

Learning tools' component represents methods, types and assistance for the creation of learning objects. They are mainly divided into non-digital and digital. The former are related to traditional education and are connected to activities (In classroom) such as STEAM challenges, while the latter capitalizes on the advancements of technology (out-of-classroom). Each learning tool contains tags so that learning style preferences and cognitive level can be identified by them. Furthermore, learning objects have tags, indicating the learning subject, the difficulty level of the activity and necessary information that is required by learning objects (title, duration, and more).

Learning tools will be able to collect information about the student's progress and behaviour so that the platform can perform data analysis with the intention to update the user profile of the learner and provide better personalized content in the future. In case of non-digital learning objects the information retrieval will be field in by the teacher.

### 3.1.4 User Profile

User profile is maybe the most crucial component of the platform, as it includes the information about the user's preferences, performance and behaviour. This component provides the core features to assemble the adaptivity in the platform. The user profile will be updated each time the student completes a worksheet to ensure that the student will always receive worksheets that correspond to their current needs. An important element of the user profile module is to provide suitable material and feedback, after each activity, to the learner. The feedback is implemented in the form of a rating system in an effort to be short and easy to complete; a small form in which the learner can provide more information about the experience of the activities is also available as an optional step. As designed, the initiation of the user profile will contain demographic information about the learner (name, grade, etc.) while the learner is also invited to answer a questionnaire to set up the starting learning style preferences.

### 3.1.5 Learning Styles

In this component the characteristics of Learning Styles Theories and their respective questionnaires are defined. It is designed as a separate component

and not embedded in the user profile to support more Learning Styles in the future if necessary.

### 3.1.6 Worksheet Generation Engine

The first step of the worksheet generation engine is to shorten the search range to the learning objects that are compatible with the teacher's selection. For this, we query the learning objects (referred as LOs) and retrieve a subset  $N_{mc} \subseteq LOs$  where "m" is the Learning Method chosen by the teacher and "c" is the course.

The second step is to filter the retrieved learning objects ( $N_{mc} \subseteq LOs$ ) to denote the most possible matches for a user. In detail, we calculate the similarity of the learning style as well as the distance (dissimilarity) between 4Cs between each learning object and the user profile. It is worth noted that we prefer learning style similarity and 4Cs dissimilarity to be high as this means that the user is comfortable with the content of this learning object but needs to work more on the respected 4Cs.

The third step is to find what the ratings and scores other users similar to the user have for a learning object. This is calculated by using normalized cosine similarity between users. Furthermore, we calculate with the same method the ratings and scores the user to similar learning objects.

Each score retrieved from the previous steps is used to calculate the final score represented the suitability of the learning object to the user. We calculate this score with the following equation:

$$f_{score} = (c * w_c) + (l * w_l) + (s * w_s) + (u * w_u)$$

Where "c" is the 4Cs similarity, "l" is the learning styles similarity, "s" is the average score of suitability a learning object has from similar users, "u" is the average score of suitability obtained by similar learning objects completed by the user, and with a corresponding weight "w" each one.

After each learning object has assigned a suitability score, we group them based on the Learning Method level. Then we recommend to the user the learning object with the highest suitability score from each group.

## 3.2 Roles

The platform offers a gradation of classification levels into four roles (Figure 3) besides the administrator role. This allows the separation of functionalities into the qualified persons for each task. Each role and their responsibilities are described in detail below.

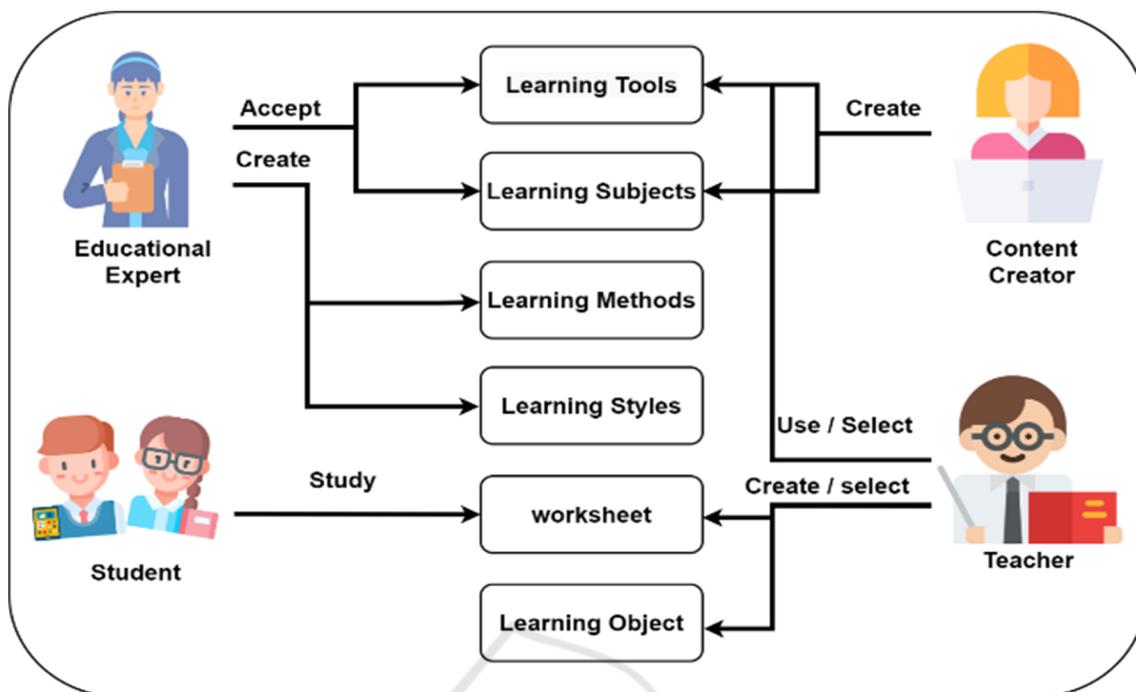


Figure 3: User roles.

**Student:** The role of a student is to study and complete worksheets. The student should be able to use the platform to receive worksheets and read their content as well as edit specific fields that the student is invited to fill. When a student completes a worksheet he/she should be able to provide feedback on how difficult and enjoyable the worksheet was.

**Teacher:** The teacher should be able to create worksheets or select from a list of predefined generic worksheets. Additionally, for the creation of a worksheet the teacher have permission to select and use Learning Subjects and Learning Tools. Through this process new learning objects can also be created.

**Content Creator:** The role of content creator is to create new learning tools and learning subjects for the platform. This role is filled by persons studying the literature to extract innovative educational techniques and to subsequently include them into the platform as learning tools. Moreover, this role undertakes the responsibility to check the updates on the course syllabus and update the learning subjects or add new ones accordingly.

**Educational Expert:** Educational experts should validate the content provided by the content creators and accept it as valid material for the platform or not. Another responsibility of educational experts is to create new learning methods and add new learning styles in the platform.

### 3.3 Scenario of Use

This section describes an indicative scenario of use based on the use case of figure 4 and the architecture illustrated in figure 2. Our scenario describes two core usage paths of the platform namely (a) Teacher set up a virtual classroom and select the constituents for the creation of individual worksheets for each student based on his/her learning style and cognitive level and (b) students logs in the platform to participate in the virtual classroom and complete the individual worksheet. In more detail:

Teacher Set Up a Virtual Classroom: When a teacher logs in the platform, he/she can create virtual classrooms and assign by invitation students to participate. Once students are assigned to the virtual classroom the platform’s procedure that communicate with the User profile module is initiated to collect the students’ individual characteristics to be used for the creation of the individual worksheets.

Teacher Selects the Constituents for the Creation of Individual Worksheets: The teacher, through a simple, step by step, predefined process selects the learning area, sub-area or chapter desired to be taught. Once this is selected the platform presents all suitable learning objects for the specific chapter. The teacher reviews the platform’s learning objects proposal for assigning to students and make corrections if desired.

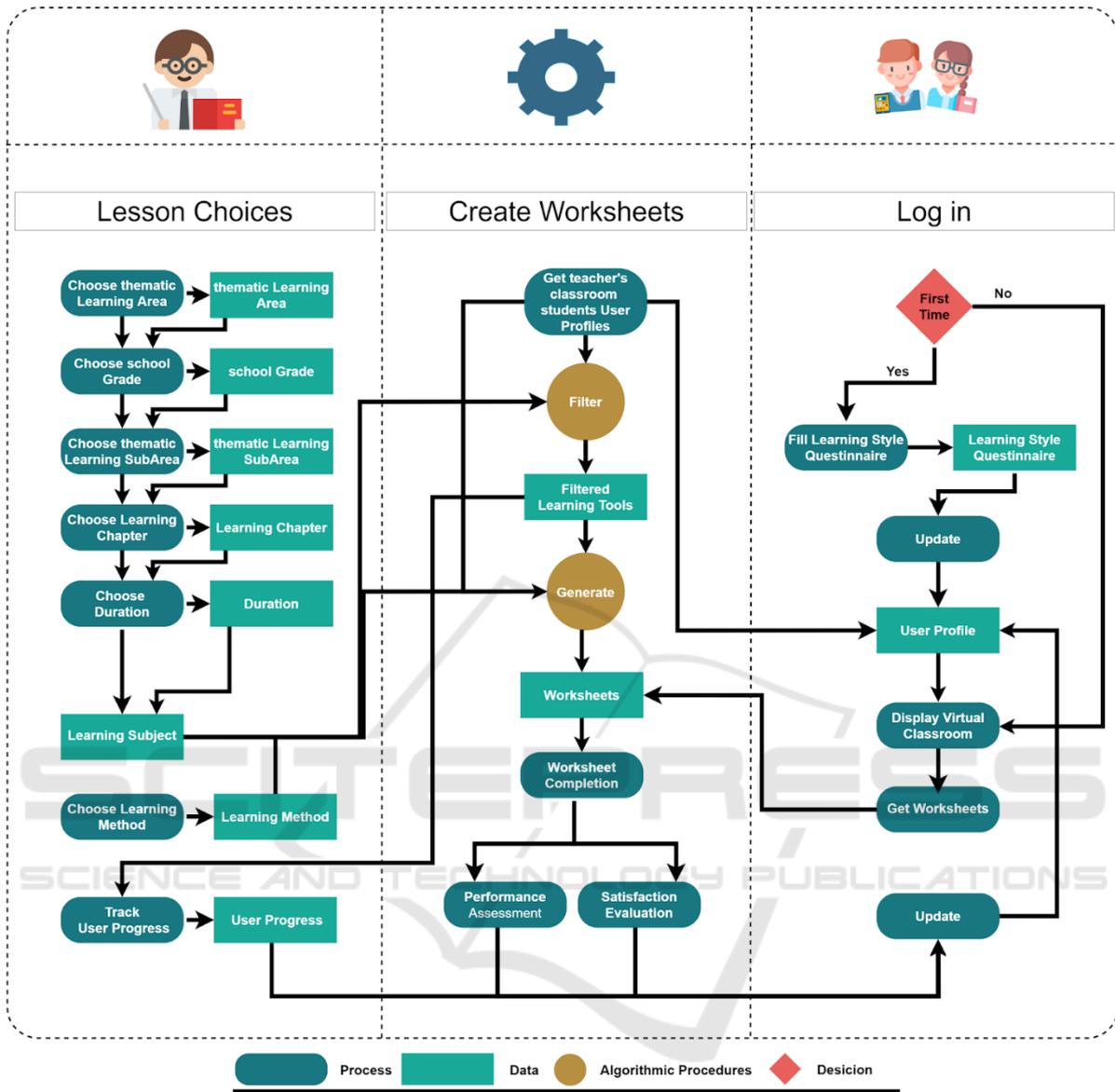


Figure 4: Scenario of use.

Students Logs in the Platform: When students log in to the platform for the first time the system uses collaborative student modeling by requesting the student to fill out an Index of Learning Styles (ILS) questionnaire in order to identify the student preferences learning styles, so that their user profile can be created. Students who have a user profile are navigated into a screen where their virtual classrooms are presented and currently active worksheets can be selected and completed.

Each time students complete a worksheet they are asked to provide feedback about how satisfied they are and how difficult they found it. Furthermore, while students are working on worksheets,

information about their performance is collected and calculated. This information helps to keep track of the students' progress and preferences to update their user profiles. Students' user profiles combined with the learning choices of the teacher are used for the creation of the personalized worksheets. Figure 4 shows the process of the core functionalities of the platform.

## 4 CONCLUSION - FUTURE WORK

The Adaptive Blended Learning Platform is an effort to create a useful tool for the teacher in the attempt to modernize education. The platform aims to develop 4Cs skills that are considered particularly significant for 21st-century students. The worksheet creation process has been designed to be simple for teachers to follow and review each step of the creation as they are considered the experts in the educational processes.

Moreover, we plan to support common educational learning tools such as GameHub (Barianos et al., 2021). It is important to have a plethora of learning tools not only to cover the preferences of students but also for the data that each tool can provide. Gamification techniques has been proven that can increase the quantity and quality of data (Kalogiannakis et al., 2021).

The platform is currently at its first pilot development phase and our goal is to be ready for evaluation within the year. The evaluation of the platform will be performed in primary and high schools of the region of Crete, Greece.

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