Lappeenranta University of Technology
School of Industrial Engineering and Management
Degree Program in Computer Science

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DESIGN OF PERSONALIZATION OF MASSIVE OPEN ONLINE COURSES

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ABSTRACT

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Design of Personalization of Massive Open Online Courses

Master's Thesis

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Massive Open Online Courses have been in the center of attention in the recent years. However, the main problem of all online learning environments is their lack of personalization according to the learners' knowledge, learning styles and other learning preferences. This research explores the parameters and features used for personalization in the literature and based on them, evaluates to see how well the current MOOC platforms have been personalized. Then, proposes a design framework for personalization of MOOC platforms that fulfills most of the personalization parameters in the literature including the learning style as well as personalization features. The result of an assessment made for the proposed design framework shows that the framework well supports personalization of MOOCs.

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LIST OF ABBREVIATIONS

ADL	Advanced Distributed Learning
AMOL	Adaptive Mobile Learning
AMDF	Adaptive MOOC Design Framework
ARCS	Attention, Relevance, Confidence and Satisfaction
AWS	Amazon Web Service
CTM	Cognitive Trait Model
FSLSM	Felder and Silverman's learning style model
ILS	Index of Learning Style
IO	Information Object
LO	Learning Object
LS	Learning Style
MOOC	Massive Open Online Course
PST	Pacific Standard Time
SCORM	Sharable Content Object Reference Model

1 INTRODUCTION

1.1 Background

In 2012, some of the most prestigious universities of the world, such as MIT, Harvard and Stanford launched courses in an open approach known as Massive Open Online Courses, or MOOCs (the list of all abbreviations can be found before the introduction chapter of the thesis). Coursera [1], edX [2], Udacity [3], are examples of these platforms. Oxford dictionaries define MOOC as a "a course of study made available over the Internet without charge to a very large number of people" [4]. It has been reported that "The number of courses offered has grown from about 100 MOOCs in 2012 to almost 700 starting in 2013, with an average of nearly two new MOOCs starting every day [5]". Figure 1 shows the growth of MOOC from 2012:

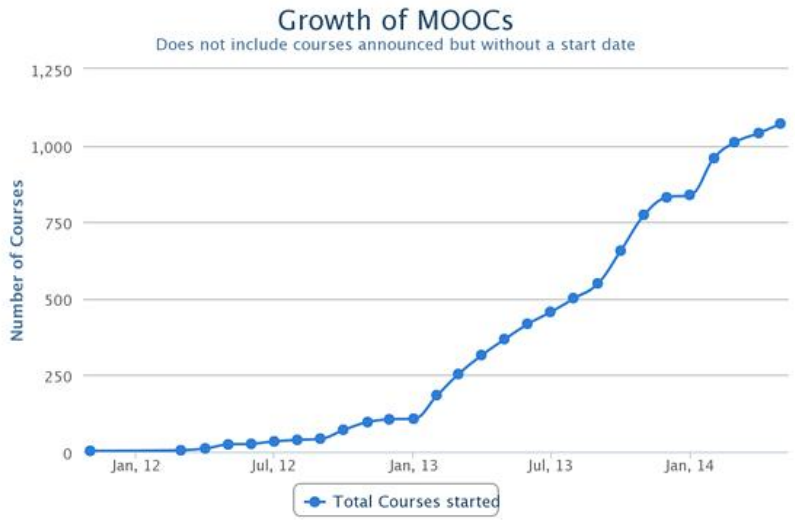

Figure 1: growth of MOOCs [5].

It has also been mentioned in Open Education Europa that belongs to the European Commission that "The European MOOCs Scoreboard has been updated for February 2014, showing 10% growth in the MOOCs offered from European institutions and 12% growth in the rest of the world" [6].

As a result, currently MOOCs are in the center of attention related to eLearning to the point where the New York Times had called the year 2012 as the "year of MOOCs" [7]. The significant attention to MOOCs is because of the benefits it offers [8]:

1. **Scalability:** courses provided in open learning environments have been designed to support an unlimited number of participants.
2. **Accessibility:** Learners can access the learning resources easily and flexibly which gives opportunities to learners in rural areas with limited technical capabilities to access learning resources and communicate with learning communities with a very low cost.
3. **Openness:** MOOC provides free to access learning materials over the Internet for whoever that is interested. Therefore, knowledge is shared with everyone around the globe, which leads to having more informed societies.
4. **Self-organization:** the learner of a MOOC gets to be in the center of decision making of the course; the pace to do the course, learning according to his or her interest and motivation. In addition, it has been found that providing learning materials online accelerates the learning process.

There has been a significant amount of investment to the limit that edX and Coursera started with the initial funding of 60 and 43 million Dollars, respectively [9, 10]. In return, Coursera is receiving more than $1 million per month in revenues from its verified certificates [11]. However, the downside of MOOCs is that as far as March 2014, no evaluation on the efficiency of them has been conducted [8]. A particular fact that suggests the inefficiency of MOOCs is an average completion rate of 7% [12]. Although this poor completion rate might be due to different factors like lack of motivation of the learner [13], the question still remains to be deeply investigated: “What could be done to make MOOCs more usable?”

1.2 Goals and delimitations

The way to make MOOCs more usable might be dependent to many different fields and

topics but the main problem with online learning environments in general, is their lack of personalization [14]. George Siemens a prominent educator of the MOOC, was recently quoted saying in New York Times that, “the next challenge will be scaling creativity, and finding a way that even in a class of 100,000, adaptive learning can give each student a personal experience” [15]. There are two conclusions to this statement; first, he is saying that a massive number of students should not prevent the system from being adaptive. Second, he is also confessing that the lack of adaptation is the challenge that needs to be solved next. At first, the issue of “Massive Open Online Courses” seems in contradiction with personalized learning but because of the importance of the issue, a lot of research [16] and also some workshops [17] have been done to find solutions to have these two concepts aligned.

On the other hand, supporting personalization based on the learner’s learning preferences might not have been affordable before MOOCs. This is due to the fact that to do this, the teachers had to provide multiple contents for each of the learning preferences for exactly the same concepts. For example, for supporting the learners’ learning style, they had to provide diagrams and pictures for the visual learners and textual description for exactly the same content for the verbal learners, which would take a lot of time, money and effort. This could be the reason why most of the eLearning systems have ignored the individual difference that exists in learners, such as the ability, background, goal, knowledge foundation and learning style [18]. Instead, they send the unified teaching material to all learners. However, the ultimate goal of web-based education like MOOC platforms is not only to increase the learning opportunities, but also to promote the learning efficiency and being adaptive is the way to this [18].

Fortunately, supporting personalization in MOOCs in possible. Research shows that a MOOC typically takes over a hundred hours before being used for the first time by recording online lecture videos and doing other preparations, and another 10 hours while being run [19]. Therefore, a large investment is already being made in time for running MOOCs. In addition, the huge amount of investment has financially been made [9, 10] on MOOCs, and also its very large number of participants [8], make it much more worthy of designing MOOCs personalized for each of the learners. However, discussions around

MOOCs during the last years have been focusing on the potential, social, institutional, technological, relevance, and marketing issues and less on the quality design of MOOC environments [20].

Therefore, because of the importance of personalization of learning and also the focus that has been on MOOCs, it had to be investigated to see how well the current MOOC platforms have been supporting personalization. However, in an attempt for this investigation, no results were found in the literature and thus, became the first research gap to be covered in this thesis. Furthermore, the second research gap that was found was that no design framework had been proposed for MOOC platforms for supporting personalization. Hence, in order to fill-in these two research gaps, the following steps were made:

1. identify all the metrics related to personalization in the literature also known as personalization parameters
2. evaluate to see how these popular MOOC platforms have been personalized based on these personalization parameters
3. identify the MOOC platforms that have already been developed to fulfill personalization and also evaluate them to see how much they have fulfilled the personalization parameters
4. find the features that were used for the purpose of personalization
5. investigate how MOOC platforms have used these features to see how close they are to personalization
6. study which learning style model best fits MOOCs
7. study how eLearning platforms have been designed to support the chosen learning style model
8. propose a design framework to explain how MOOCs should be designed to support personalization parameters
9. make mock-ups for the design framework
10. Interview Educational Software professionals and MOOC designers to refine the design framework
11. Conduct an assessment to evaluate the design platform

1.3 Research methodology

The first research gap was filled with deductive research approach according to [21]

1. deducting a hypothesis from the theory by identifying a list of personalization parameters
2. expressing the hypothesis that the existing MOOC platforms are not passing most of the personalization parameters
3. using observation method for data collection regarding how many personalization parameters do the existing MOOC platform fulfill
4. examining a table that shows how many parameters the MOOC platforms fulfill

Then the second research gap was filled with constructive research. [22] defines this research approach as a problem-solving method that a set of different research tools are used in combination for producing constructions. This approach of research was divided into the following six phases according to [22]:

1. Finding the research gap.
2. Obtaining a general and comprehensive understanding of the topic.
3. Innovating, and constructing a solution idea by making a set of mockups.
4. Demonstrate that the innovation with mockups.
5. Showing that the design framework was proposed based on the personalization parameters introduced in the literature.
6. Examining the scope of applicability of the solution by discussing with the interviewees

1.4 Structure of the thesis

The structure of the thesis is as follows: in the second chapter, some of the basic concepts that were used throughout the research were explained. The third chapter covers the literature review related to personalization. The forth chapter is about how personalization has been used in MOOC platforms. Furthermore, the fifth chapter elaborates on the design framework that has been proposed in this research to apply personalization in MOOCs. Finally, the research has been concluded with suggestions for future works in this field.

2 BASIC CONCEPTS

One of the challenges related to this research was the large number of concepts and terminologies that were mentioned in the literature. Furthermore, some of these concepts and terminologies were very close or even identical according to some definitions. So in this chapter these concepts and terminologies will be explained to have a clear understanding of what this research is about. However, throughout this thesis some other short concepts have been defined but since they were not related to the topic of this thesis from a general perspective, they have been defined in the place it has first been used. Furthermore, since this research was in the conjunction of personalization and MOOCs, each of these fields and their related concepts will be explained separately; first personalization and then MOOCs.

2.1 Personalization and adaptivity

The concept of personalization is very close to some other concepts like individualization, differentiation and adaptivity. Therefore, the first that needs to be done is to differentiate it from each other to have a clear understanding of what this thesis will focus on.

Individualization, Differentiation and Personalization

The general concept behind words like individualization, differentiation and personalization is that they are the alternatives to the old "one-size-fits-all" model of teaching and learning. The following is how [23] defines each of these words:

- **Individualization:** refers to instruction that is paced to the learning needs of different learners. Learning goals are the same for all students, but students can progress through the material at different speeds according to their learning needs. For example, students might take longer to progress through a given topic, skip topics that cover information they already know, or repeat topics they need more help on.
- **Differentiation:** refers to instruction that is tailored to the learning

preferences of different learners. Learning goals are the same for all students, but the method or approach of instruction varies according to the preferences of each student or what research has found works best for students like them.

- **Personalization:** refers to instruction that is paced to learning needs, tailored to learning preferences, and tailored to the specific interests of different learners. In an environment that is fully personalized, the learning objectives and content as well as the method and pace may all vary

Therefore, personalization encompasses differentiation and individualization[23]. However, the main term used in this thesis is personalization.

Personalization parameters

A personalization parameter defines some divergent characteristics and needs of learners such as learners' prior knowledge, their motivation and learning styles while the combination of a set of personalization parameters is called personalization strategy [24].

Therefore, the learner's learning style is one of the personalization parameters that is going to be covered next.

Learning style

While style in educational psychology has been known to be a key construct in the area of individual differences in learning [25], learning style is a component of the wider concept of personality [26]. Learning style is the method an individual uses to concentrate and to process and retain new information [27]. In other words, it is the characteristic strength and preferences in the ways the learner takes in and process information [28]; some students learn better with facts and data, others with images and diagrams, others with theories and some with actively doing. Learning style falls into the categories where there are differences across individuals but there are groupings of individuals who have common or similar learning style characteristics [26]. These differences for example, could be due to cultural background of the learners [29].

Although some researchers refute the influence of learning styles [30], [31] has experimented two groups of students, one with using their personalized platform and one without using it. They have then stated that the group that was using the platform completed the course in less time and continuously completed more lessons successfully. In addition, [32] has stated that students that are taught according to their learning style tend to learn more.

It is worth mentioning that, researchers have also noted that learning styles are dynamic, meaning that learners might adopt new styles when required [33] or as they grow older [34].

However, learning style should not be confused with cognitive style and individual traits.

Cognitive style

An individual's consistent approach to organizing and processing information during learning [35]. Therefore, it is much more pervasive, stable and deep seated than learning styles [36].

Individual traits

The user's individual traits are the aggregate name for user features that together define a user as an individual. Examples are personality traits, cognitive styles, cognitive factors and learning styles [37]. Therefore, even though some researchers use cognitive and learning style interchangeably [25], learning style is more narrow in scope due to its focus on human learning [37]. Therefore, throughout this thesis, the two terms will be differentiated.

Learning style model

[38] Has identified 71 models of learning style, like Kolb [39], Felder and Silverman [28] and Dunn and Dunn's learning styles [40], each proposing different descriptions and classification of learning styles [41]. Furthermore, [31] has stated that more than 1000 publications have been written about the Kolb learning style and the Dunn and Dunn learning style model. On the other hand, Felder and Silverman's learning style model (FSLSM) has been recognized as the most suitable learning style for eLearning or web based learning platforms because of its adaptability to learning differences and individual needs [42]. In addition, the original paper related to Felder's model has been the most frequently cited paper in articles published in the Journal of Engineering Education over a 10 year period [8].

In the next section, FSLSM will be covered which is the learning style model that have been used in chapter 5 for the design framework that supports learning styles.

Felder and Silverman learning style model

Felder and Silverman learning style model, FSLSM has four dimensions where every learner is characterized by a specific preference in each of these dimensions [41]:

1. **Active-Reflective:** active learner like to try things out, learn in groups to be able to discuss with people, communication with others, while the reflective learners like thinking and reflecting the material, work alone and maybe in small groups.
2. **Sensory-Intuitive:** Sensing learning style likes learning by facts and concrete learning material, solve problems with standard ways and are more patient with details. They are more realistic and sensible and are more practical compared to intuitive learners and enjoy relating the learned material to the real world. Intuitive learners prefer to learn abstract learning material like theories. They find possibilities and relationships better and are more creative and innovative compared to sensory learners.
3. **Visual-Verbal:** As the naming implies, visual learners are those who remember what they have seen better while verbal learners remember textual content whether they are spoken or written.

4. **Sequential-Global:** sequential learners learn in small incremental steps and have a linear learning progress. They like following a logical stepwise paths for finding solutions to problems and details. Global learners on the other hand, have a holistic learning process and learn in large leaps and like the overview in a broad knowledge.

Table 1 summarizes the four dimensions of Felder and Silverman learning style model:

Table 1: four dimensions of Felder and Silverman learning style [43].

	Active	**Reflective**
Definition	Learn by trying things out and enjoy working in groups.	Learn by thinking things through, working alone or with single familiar partner.
	Sensory	**Intuitive**
Definition	Concrete thinker, practical, oriented towards facts and procedures.	Abstract thinker, innovative, oriented towards theories and underlying meanings.
	Visual	**Verbal**
Definition	Prefer visual presentations of presented material such as pictures, diagrams and flowcharts.	Prefer to written and spoken explanations.
	Sequential	**Global**
Definition	Linear thinking process, learn in small incremental steps	Holistic thinking process, learn in large leaps.

The difference between Felder and Silverman learning style model and other learning style models is that most other learning style models classify learners into a few groups, whereas Felder and Silverman describe the learning style of a learner in more detail, distinguishing between preferences on four dimensions. Another main difference is that Felder and Silverman learning style model is based on tendencies, meaning that learners with a high preference for certain behavior can also act sometimes differently [41].

Index of learning style

The Index of Learning Styles (ILS), developed by Felder and Soloman, is a 44-item English questionnaire for identifying the learning styles for the Felder and Silverman learning style model [41]. These preferences have been expressed with values between +11 to -11 per dimension as shown in Figure 2:

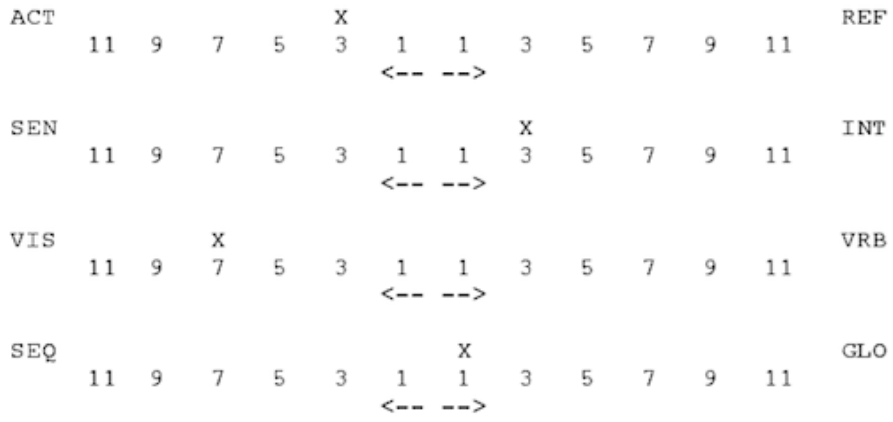

Figure 2: an example of the result of index of Felder and Soloman learning style.

After submitting the answers, the learner is provided with the Learning Style Results. If his or her score is [44]:

1. 1 to 3: the student's learning style is fairly well balanced on the two dimensions of that scale.
2. 5 to 7: the student has a moderate preference for one dimension of the scale and will learn better in an environment that favors that dimension over that opposite dimension.
3. 9 to 11: the student has a very strong preference for one dimension of the scale and is classified as a purely single style learner which may struggle and suffer if the learning environment does not support their preference.

It is worth noting that as Figure 2 shows, in this learning style model a learner cannot be for instance a highly verbal learner and a highly visual learner at the same time. A study conducted by [44] with 132 students indicate that students do vary in their preferences for

a particular learning style as shown in the Figure 3 and Figure 4:

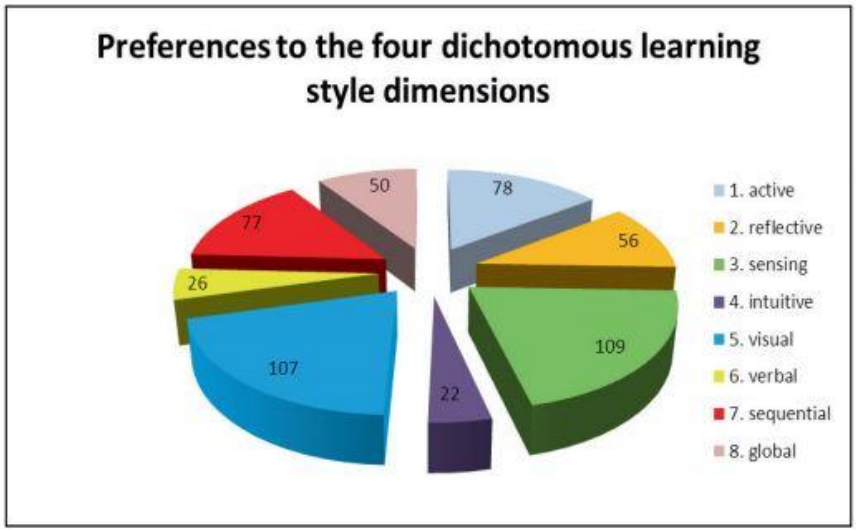

Figure 3: Overall preferences of Felder and Silvermen's learning style model [44].

It also can been seen from Figure 4, there is a big difference in sensory-intuitive and also visual-verbal learning styles among learners.

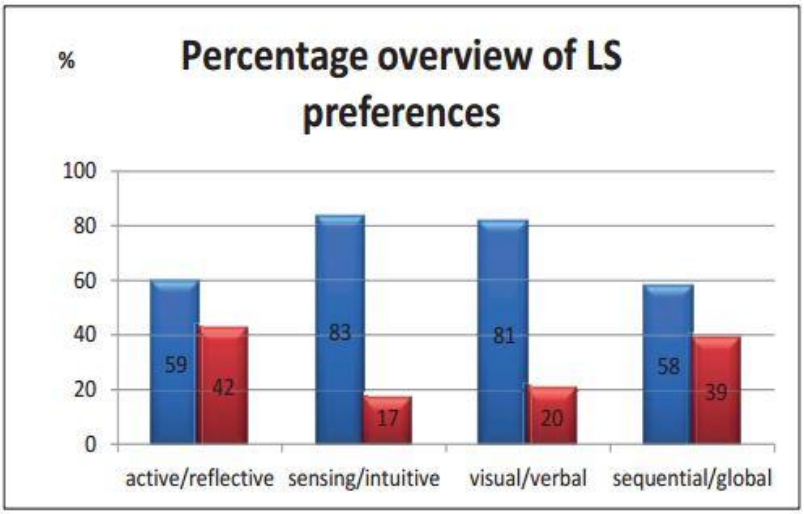

Figure 4: percentage overview of learning style preference of the Felder and Silverman's learning style model [44].

Adaptivity, adaptability and adaptive learning

Adaptivity is “the capacity of the instructional systems to modify lessons through using specific parameters of the learner needs” [30]. This is different from adaptability that is “the possibility for the learners to choose certain parameters of the learning experiences by themselves” [30]. The definition given is very close to the definition of adaptive learning which is: “an effective way to improve the learning outcomes, that is, the selection of learning content and presentation should be adapted to each learner’s learning context, learning levels and learning ability. Adaptive Learning System can provide effective support for adaptive learning” [45].

In general, adaptive learning and personalized learning differ in that adaptive learning continually takes data from students and adapts to their learning [46], therefore, also take the parameter of time into account meaning that when the learner’s learning it repeatedly evaluated, the learner’s status adapts to the learner. So if a system repeatedly evaluates the personalization parameters, it will become adaptive.

Throughout this thesis, the term personalization is used for parameters since the parameter alone does not decide whether it would be repeatedly evaluated or not. This could be the reason that in the literature the word “personalization parameter” has been used. However, when the discussion is regarding the platform, the word adaptivity will be used because not only this is how the term has been used in the literature, the platform should consistently “adapt” to the learner’s learning preferences based on these “personalization parameters”.

Adaptation techniques

A wide range of different adaptation techniques are used in current adaptive learning environments. Figure 5 shows the general process of adaptive learning systems; the adaptive learning system collects the data of the learners, then it processes the data to learn about learner’s abilities, goal, learning style so forth. Then based on this analysis and the learner model, it adapts to the learner. Learner modeling “aims at obtaining sufficient valuable information in order to provide the system with adaptivity [47]”. For example, it

processes the data of the learner and notices that this learner is a visual learner, then since the learner model used suggest using mind-maps for visual learners, it shows a mind-map of the concept to the user.

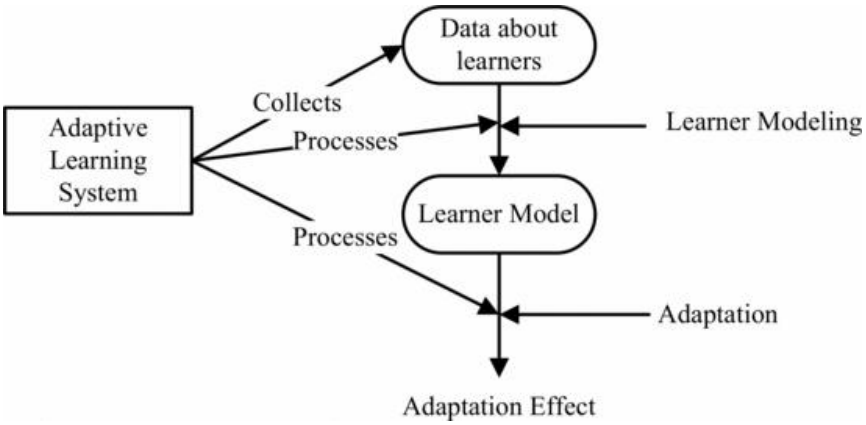

Figure 5: Adaptive process in adaptive learning system [18].

Types of learner modeling

Student modeling can be done in two ways [48]:

1. **Collaborative way**: such as asking the learners to fill out a questionnaire
2. **Automatic way**: in which the behavior of the learners are tracked when they are using the system

Although the majority of methods of measuring learning style use some sort of a collaborative way, learners are less motivated to respond to them. This is why automatic student modeling has been found to be successful in identifying learning styles in analyzed studies [30]. Aside from the way that student modeling is done, there are also two types of student modeling, static and dynamic, depending on how frequently it is done: static modeling means the student modeling is done only once whereas in dynamic modeling, the information in the student model is updated frequently [30]. Dynamic student modeling is especially valuable since research shows that learners have different learning styles depending on the task or the learning content [31].

Types of interface-adaptation

In this section the types of adaptation will be covered. In chapter 5, the research's proposed design framework will be evaluated to see how many of these interface-adaptation types it covers. 5Burgos et al, have categorized into eight types:

- **Interface-based:** the elements and options of the interfaces are positioned on the screen and their properties are defined.
- **Flow-based learning:** the learning process is dynamically adapted to an individuals' needs to explain the course in different ways.
- **Content based:** resources and activities dynamically change their actual content.
- **Interactive problem solving support:** guides the learner to get the right solution of the problem.
- **Adaptive grouping:** allows *ad hoc* group creation and collaborative support on carrying out specific tasks.
- **Adaptive information filtering:** showing appropriate information retrieval that provides only relevant and categorized outputs to the learner.
- **Adaptive evaluation:** that can change depending on the performance of the student and the guide of the tutor. This could be done with the following technologies.
- **Changes on-the-fly:** modification or adaptation of a course on-the-fly by a tutor or author in runtime.

However, in this research, Burgos's definition of interface-based adaptation has been extended so that it also includes the user interfaces that have found to be useful for adaptation to the learners' learning style.

2.2 MOOCs

The word MOOC was used in 2008 for the first time to describe a course that was held in Canada in which it was open and online and more than 2000 learners had signed up of the course [44]. The same kind of course was held by Stanford University in 2011 where close to a 250,000 people had signed up for it [44]. It this section, some brief explanations

related the types of MOOCs will be given as it is the main focus of this research.

Types of MOOCs

We should first take a brief look at the types of MOOCs that currently exist. According to [49], MOOCs are mainly further divided into two categories:

1. **xMOOC:** a highly structured, content-driven course, designed for large numbers of individuals working mostly alone, guided by pre-recorded lectures, assessed by automated or peer-marked assignments. xMOOCs aim to provide access, at scale, to established higher education subjects as presented by authorities in various fields where authority is signaled by affiliation with elite educational institutions. Examples of xMOOCs are Coursera [1], edX [2], Udacity [3] and Khan Academy [50]. xMOOCs more closely resemble traditional educational models; the courses are divided into several lectures and the lectures are delivered with a YouTube style videos [44].
2. **cMOOCs (connectivist MOOCs):** designed on what are described as "connectivist" principles, and involving a networked and collaborative approach to learning that is not primarily curriculum-driven, and does not involve formal assessment. The emphasis of cMOOCs is placed on distributed, self-led exploration of topics, rather than on the expertise of authorities. For example, a set of students decide to study about some topic, then they fstart writing Blogs and Tweets and the supervisor of that course selectively collects some of the information and send that to every student via email.

It should be noted that, Clarke has further defined other types of MOOCs entitled: “taxonomy of 8 types of MOOC” [51]. However, in the literature, the first two types of MOOCs, namely xMOOCs and cMOOCs are mainly discussed [44]. There is also a type MOOC called adaptive MOOCs or aMOOCs that is directly related to this research:

Adaptive MOOC

“The courses are one-size-fits-all and depend heavily on the video lectures and discussion boards. A MOOC course that adapts to the learning preferences of individual learner using

brain-based adaptive learning with learning strategies … can lead to much higher completion. The adaptive MOOCs, where the content is presented with differentiated learning strategies and real time intelligent feedback can significantly improve completion rates" [16, 52].

"The pedagogy and technology developed for the adaptive MOOC shows great promise for the future creation and conversion of the one-size-fits-all MOOC into effective adaptive MOOC" [16]. The Gates Foundation, founded by Bill Gates and Melinda Gates, has highlighted this approach as key for future online courses [53]. AMOL and CogBooks are two of the first Adaptive MOOC solutions to be released [53].

3 LITERATURE REVIEW

In this chapter, the main theoretical findings of the thesis including the identified personalization parameters, the use of personalization parameters in the popular MOOCs and adaptive MOOCs and the features that are needed for adaptivity of eLearning platforms will be provided. The list of personalization parameters and the personalization features gathered in this chapter will be used in chapter 4, to evaluate the currently developed MOOCs to evaluation their level of personalization.

3.1 Identification of Personalization parameters

In order to identify the personalization parameters, the literature was studied to find authors that had utilized the term “personalization parameters” in their research. The result of this study has been classified in Table 2. The table consists seven different publications: Essalmi et al 2010 [24], Pallas[54], Essalmi et al 2007 [55], Riad et al [56], Chen et al [57], Tseng et al [58] and Verpoorten et al [59]. In order to have the correct understanding of the meaning of these terms, exact definition of some of them had to be examined. In Table 2, the terms with similar or close meaning were inserted in the same row so that they could later on be merged into one parameter. For instance, if Riad et al has parameter called “Learner’s level of knowledge” and Verpoorten et al has a parameter called “skills”, these two parameters were inserted in the same row of the table and in the next step merged into ta parameter called “Level of knowledge”.

Table 2: list of personalization parameters by different authors. The parameters with identical or close meaning were inserted into the table in the same row so that they would be merged together to get list of all personalization parameters in the literature.

Essalmi et al, 2010	Pallas	Essalmi et al, 2007	Riad et al	Chen et al	Tseng et al	Verpoorten et al
Information seeking task						
Level of knowledge	Skill level and experience	prerequisite	Learner's level of knowledge	levels of learner knowledge		skills
Goals & plans						intention
Media preference or presentation styles		media preference	Media preference	learner/user preferences of media based on learning styles		
Language preference	Navigation language	language preference				
Kolb learning cycle		learning style				Kolb's Learning Style Inventory
Honey–Mumford learning style						
Felder–Silverman learning style			Felder–Silverman learning style			
La Garanderie learning style						
Neil Fleming's VARK learning style			VARK learning style			
			Unified Learning Style Model			
Participation balance						
Progress on task						
Waiting for feedback						
Motivation level	Interest	motivation		interests	concentration and willingness	
Navigation preference			Navigation preference	browsing behaviors		
Cognitive traits						
Pedagogical approach		Pedagogical approach				
	Location					location
	Weather					
	Date and time					
					patience	duration

After merging the same or close concepts that are in the same row in Table 2, the following 17 personalization parameters were classified:

1. Information seeking task
2. Level of knowledge
3. Goals & plans
4. Media preference or presentation styles
5. Language preference
6. Learning style
7. Participation balance
8. Progress on task
9. Waiting for feedback
10. Motivation level
11. Navigation preference
12. Cognitive traits
13. Pedagogical approach
14. Location
15. Weather
16. Date and time
17. Patience

3.2 Description of personalization parameters

In the following section, each of the 17 personalization parameters will be briefly described:

Information seeking task: used to facilitate information searching from a vast amount of information [24]. For example, if it was evaluated by the system that the user is trying to find information that would help her in a project-planning task, all the information which is irrelevant to project-planning will become hidden by the system. Thereby, attempting to get at the underlying needs of users rather than only focusing on their knowledge, as well as making quite robust and useful adaptations [60].

Learner's level of knowledge: used for taking the learner background when communicating learning materials to the learner into account [24].

Learning goals: used to plan the learning and to communicate the learning materials which satisfy the learner goals [24].

Media preference: enables the learner to be provided with the form of learning materials he/she prefers most for example text, graphic, video, audio [24].

Language preference: allows the presentation of learning material in the learner's preferred language for example English, French, Arabic, German, etcetera [24].

Learning style: Characteristic strength and preferences in the ways they take in and process information [28].

Participation balance: enables monitoring of group dynamics concerning the balance in learners' participation. In other words, it controls the desired balance in participation. More specifically, participation balance itself consists the following parameters [61]:

1. **Maximum Standard Deviation:** determines the desired level of participation of each student compared to his or her teammates. If this parameter is high, the coach will encourage students to participate only when there is a large difference in their participation level. If this value is too small, the coach will interrupt students almost after every action they do.
2. **Maximum Consecutive Contributions:** determines the maximum number of consecutive contributions that the student can do before the coach suggests that he or she let others participate.
3. **Minimum Listen Advice:** indicates the minimum number of 'listen' advice for example 'listen to others', or 'let others participate' that the coach should use to encourage the student let others participate before the coach takes the control of the group area from him or her.

Progress on task: encourages students to devote adequate time to the task of constructing the shared solution. In other words, it takes the maximum period of inactivity in the group that the system waits before suggesting that the student take an action in the group workspace. Having such parameter helps to ensure that students are not just chatting for a long time, but are also working on the construction of the group diagram [61].

Waiting for feedback: allows the system to make decisions when certain period of time has passed and the student has not pressed any opinion button for example "OK," "not OK," or "unsure", or when certain period of time has passed and the student has not received any feedback. In this case, an 'Ask For Feedback' suggestion is considered [61].

Motivation level: the ARCS model which identifies four essential components for motivating instruction (Attention, Relevance, Confidence, and Satisfaction) [62].

Navigation preference: allows the navigation in the learning material in the learner's preferred order (in breadth-first or depth-first) [24].

Cognitive traits: [63] defined the Cognitive Trait Model (CTM) that offers the role of 'learning companion', which can be consulted by and interacted with different learning environments about a particular learner. Current implementation of CTM is composed of four cognitive traits (working memory capacity, inductive reasoning ability, information processing speed, associative learning skills).

Pedagogical approach*:* [55] introduced the pedagogical approach as a personalization parameter and identified three pedagogical approaches (objectivist approach, competency based approach, collaborative approach) [24].

Patience: determines the use of features that the learner with less patience can quickly go through the learning material.

Location: takes the location of the user into account.

Weather: aimed to be used outside of the classroom and may help in suggesting appropriate activities for the learner [54].

Date and time: takes the date and time into account.

3.3 Identification and description of personalization features

Since the personalization parameters are generally based on human psychology, they need to be connected to computer science and IT. This way we can see what kind of features are needed to make MOOCs more personalized. So the features used for personalized learning in the literature related to eLearning were identified. For example, adaptive quizzes were used to evaluate the level of knowledge of an individual so that the eLearning platform can give more content to a learner that has problem understanding a concept.

Below the description of each of the personalization features have been given:

- **Dynamic student modeling:** dynamically detect the learners learning style by examining their behavior. For example, the visual learner tends to check out the diagrams and mind-maps more.
- **Quiz:** quizzes were embedded into each concept to evaluate the level of competency that the learner has achieved [16].
- **Adaptive feedback:** after each quiz, the learner is provided a quiz and then provided a feedback immediately through the adaptive learning system [16]. Johnson et al have used a similar technology; they have used an intelligent tutoring system to assist students in learning the course with the use of artificial intelligence. This system provides instruction and feedback that is tailored to each individual student and addresses not only problem-solving outcomes but also problem-solving processes [64].
- **Graded assessment:** a weekly assessment was taken at the beginning of each week and a grade was given accordingly. The weekly assessment could not be retaken [16].
- **Hands-on simulation experience:** the learner is provided a visual lab like MATLAB

to derive the answers of the weekly questions. This lab was available with no cost for the registered participants of the course [16, 65].

- **Adaptive link hiding:** a tool that hides links that would be unlikely chosen [66].
- **Content navigation tree:** implemented based on Windows Explorer tree metaphor with expandable and collapsing submenus and content leaves; the more units the learner learns, the more complex the tree becomes [66]. Knauf et al have also used the same idea calling it storyboarding to model student curricula and to follow student progress in their studies [67].
- **Note-taking tool:** a tool for taking notes that would be useful for reflexive and visual learners [66].
- **Adaptive educational hypermedia:** systems that personalize the learning experience based on the learner's learning preferences and knowledge [68] that are able to make the learning process more efficient [69].
- **Social learning:** by using discussion triggers and discussion threads, include many perspective on the same topic which is possible with high number of participants in MOOCs. This technology is especially useful for diverging learning style in Kolb's learning model [65].
- **Collaborative grouping:** learners with the same learning style tend to have more interactions with each other during their learning period of time. Therefore, grouping learners with similar learning profile and styles in order to achieve a better learning experience [70, 71].
- **Real-time course adaptation:** the possibility to modify or adapt a course on-the-fly by a tutor or author in run-time [72].
- **Mind-maps:** a mind-map highlights were in the lecture the student is at the moment in the content structure of the module. It also shows the previous and the next section useful for global learners [8, 66]. It has been stated by that students that use mind-maps are able to recall more critical and central concepts than students who use texts [73]. Moreover, mind-maps are found to decrease student's anxiety and to increase motivation [74].
- Gamification: for increasing awareness to enhance active participation and social judgment and motivation [65]. "Gamification is the use of game design elements and game mechanics in non-game contexts" [75].

4 PERSONALIZATION OF MOOCS

Until this chapter, the personalization parameters in the literature have been identified. In this chapter, the existing MOOC platforms were evaluated to see how many personalization parameters they support to fulfill the first research gap introduced in chapter 1. Furthermore, the adaptive MOOCs that have already been developed were identified and they were also evaluated to see how much they have fulfilled the personalization parameters. The evaluation was taken in place by either personally trying the MOOCs or studying the MOOC platform's own websites or other websites that had written about these platforms.

4.1 Personalization parameters in MOOCs

In this section, first the popular MOOC platforms as well as the already developed adaptive MOOC providers were evaluated to see how well they fulfill the personalization parameters. Therefore, in this part of the research, the was each of these platforms fulfill personalization parameters will be explained. Thus, the personalization parameters that are not explained here are the ones that have not been supported.

4.1.1 Coursera

Goals and plans

In Coursera, courses were offered in multiple levels of engagement. For example, in the "Programming Cloud Services for Android Handheld Systems" course, there were two levels of engagement:

1. Normal track: estimated to take 3 to 4 hours per week. learners at this level were assessed by weekly auto-graded standalone quizzes. This track was designed for those who wish to engage the material by taking the auto-graded quizzes and participating in the online discussion forums, but who may not have the time or interest to complete the programming assignments.

2. Distinction track: estimated to take 8 to 12 hours per week. In addition to completing the auto-graded weekly quizzes from the normal track, learners in this track had to complete the required programming assignments. This track was designed for those students wishing to achieve mastery of the course and to understand its application in realistic project context.

Therefore, the learner's goal is taken into account because based on his or her level of engagement the tasks the learner has to do and the grading varies. Furthermore, some of the lessons are optional. The optional 4 weeks of material will not be included in the grading at all and it will not provide bonus credit.

Media preferences

The following items could be noted regarding the multimedia of Coursera:

- Video have been provided and broken into small chunks
- The subtitle was available

Language preference

The learner can search for courses based on their language and some of the courses provided subtitles in variety of languages. Thus, the language preference was fulfilled.

Motivation level

The motivation parameter was also overall passed since:

1. **Attention:** the videos were short and the embedded quizzes inside videos were helping the learner to pay attention.
2. **Relevance:** in the beginning when the learner wants to register for the course, fair amount of information was provided.
3. **Confidence:** the confidence of the learner was raising after giving a correct answer to the quizzes
4. **Satisfaction:** although the courses were in high quality, there was no particular

technology or feature like user rates that would pass this item.

Patience

The patience parameter was passed since the learner can make the video play faster (0.75x, 1x, 1.25x, 1.5x, 1.75x, 2x) if he or she is bored with the content.

Location

Coursera had a feature to match learners in the same location to have a face-to-face group discussion.

4.1.2 edX

Media preferences

The following items could be noted regarding the multimedia of edX:

- Videos were provided
- The transcript were written beside the videos and the sentences were highlighted when the lecturer was saying them
- Slides were shown and the lecture were not provided for the learner

Motivation level

Some of the videos may contain integrated "check-yourself" questions so for the same reasons given for Coursera, edX passes the motivation parameter.

Patience

The learner can make the video play slower or faster (0.5x, 1x, 1.25x, 1.5x, 2x), so edX passes this parameter.

4.1.3 Udacity

Language preference

Similar to Coursera, the learner can search for courses based on their language and some of the courses provided subtitles in variety of languages. Thus, the language preference was fulfilled.

Motivation level

Like edX, some of the videos were containing integrated "check-yourself" questions. However, it was providing a chatting system with experts. The experts were answering the learners'' questions about course material, or working with them to debug their code. They were available to chat on Monday to Thursday 10AM to10PM PST and Friday to Sunday 10AM to 5PM PST [76]. So for the same reasons given for Coursera, it was passing the motivation parameter.

Patience

The learner could make the video play slower or faster (0.25x, 0.5x, 1x, 1.25x, 1.5x, 2x), so Udacity fulfills the patience parameter.

4.1.4 Khan Academy

Media preference

In Khan Academy, while the videos were playing, the transcript was written beneath the videos and the sentences were highlighted when the lecturer was saying them.

Languages preferences

The learner could set the preferred language for example, English, Spanish, French, and Portuguese for the menus but not the lectures.

Navigation preference

The learner can navigate through the course by using the course structure available that is a set of connected nodes, where each node represents a lesson of the course.

Patience

The learner can set the pace of the videos (0.25x, 0.5x, 1x, 1.5x, 2x)

4.1.5 AMOL

Nishikant Sonwalkar, Adjunct Professor of University of Massachusetts, Boston, has developed the first adaptive MOOC also known as aMOOC [16]. The platform is called Adaptive Mobile Online Learning, AMOL and a course called "Molecular Dynamics for Discoveries in Computational Science" has been taught on this platform. It has incorporated adaptive technology so that students can be taught according to their own individual learning styles. They have used a scalable cloud architecture that marries Amazon Web Services (AWS) with AMOL adaptive learning architecture to support the dynamic rendering of web pages leveraging service-oriented architecture of the AWS servers. The data obtained in their research indicate that "even with large loads and stress applied to the system under load-testing conditions the throughput and response time remains within acceptable limits for the adaptive learning platform, with the auto-scaling of the AWS instances that add computational power as the stress linearly increases with the increase in the number of connections [16]".

Media preference

AMOL was providing a combination of text, videos, subtitles, picture and diagrams and slides. It also had an interactive glossary of words.

Learning style

In AMOL, content presentation was done based on the learner's learning style. More precisely, AMOL conducts an assessment on the learning style then changes the sequence of the content depending on that learning style [16]. The learning style model used in the

system was the “learning cube” [77] with five learning strategies: apprentice, incidental, inductive, deductive and discovery.

Patience

The learner could set the pace of the videos (0.25x, 0.5x, 1x, 125x, 1.5x, 2x).

Motivation level

Research shows that when learners are presented with their optimal learning strategy, with immediate feedback and true adaptability, it takes less time to master a given concept, master concepts in a more comprehensive way, leading to a deeper learning experience as well as the chance for continuous self-improvement, with immediate feedback motivates learners to complete courses and degree programs [78]. On the other hand, taking less time increases the level of attention, mastering the course more deeply and completing the course enhances the learner’s confidence and satisfaction, therefore, more motivation for the learner. So since AMOL supports learning styles, it is also capable of passing the motivation level parameter even though these two parameters have been separated in the literature.

4.1.6 CogBooks

The CogBooks adaptive learning platform personalizes web-based learning so that each individual receives the learning and support she needs, at every step [79]. Even though CogBooks is an adaptive learning platform, a MOOC called Citizen Maths have been developed by it [80]. Therefore, the platform is capable of hosting MOOCs and this is why it has been evaluated in this research. Citizen Maths’ online applications allow learners to try out new ideas through hands-on activities, discuss the learning material, and share problems and solutions with other like-minded learners [81].

Level of knowledge

CogBooks adapts to the individual learner at each step, identifies the ideal learning path or

sequence for the learner at each step, tailors the learning sequence to the needs of the individual and based on their responses and knowledge profile [82].

Media preference

- Citizen Maths was providing videos with subtitles in English only. The translation of the captions were available in many languages but since it was translated with a software, for example the Persian translation it was not at all understandable.
- It has an interactive application for helping the learner understand concepts like proportion in mathematics.

Navigation preference

The learner could navigate through the course by using the course structure available that is a set connected nodes where each node represents a lesson.

Patience

The learner can set the pace of the videos (0.25x, 0.5x, 1x, 125x, 1.5x, 2x).

4.1.7 MOOCulus

MOOCulus [83] was designed by Jim Fowler and his colleague Thomas Evans from Ohio State University to give their Coursera course some adaptivity. It has been bolted on to Coursera's MOOC platform and is designed to feed students progressively harder questions based on previous answers. As of November 2013, the course had 147k students enroll enrollments that led to millions of attempts, and over two million correct answers, being submitted to MOOCulus. The adaptive learning tool sits at MOOCulus.osu.edu and runs external to Coursera servers, but students seamlessly log in using Coursera credentials. MOOCulus is written in JavaScript and the open source Web application framework Ruby on Rails [84].

Level of knowledge

In MOOCulus a student works through a problem, hints are available. The software weighs the hints used and the amount of time taken to answer the question and depending on the student's answer, whether it was right or wrong, the system determines which question to display next and keeps on providing activities that are at the appropriate level. Interestingly, "the level of understanding of the current concept is displayed to the student on a color-coded progress bar that inches along from red to green, indicating mastery" [84].

Media preference

MOOCulus had videos with subtitles in English only. The courses were also provided in an ebook.

4.1.8 Instreamia

Instreamia [85] is sponsoring the first-ever language MOOC, for college-level Spanish students. The course is a combination of recorded video instruction, conversation practice with other students, and homework assignments given and evaluated through the integrated Instreamia learning platform. While learning from authentic videos, Instreamia will periodically probe the learner's comprehension with simple knowledge checks, such as a fill-in-the-blank listening problem. The accuracy of the learner's response in combination with other information in her learning profile helps Instreamia evaluate the learner's overall level, the types of problems she needs to work on most, and which vocabulary she needs to practice more. By iteratively adjusting questions to the learner's level, Instreamia adapts to meet her needs and help you learn faster and more effectively [86].

Media preference

- The transcript were written beneath the videos and the sentences were highlighted along with the video
- The videos had subtitles
- When the learner hovers her mouse over a work, a box pops out showing the word,

its translation and an audio sound that reads the word.

Language preference

The learner could set the languages for the menus.

Motivation level

The gamification used in the system raises the motivation level of the learner [75].

In Table 3 the summary of the use of personalization parameters in MOOCs have been shown. In this table, the check sign indicates that the personalization parameter was applied in at least one of the courses. The cross sign shows that the platform is not supporting this parameter at all.

Table 3: use of personalization parameters in MOOCs.✓: at one course was found in the platform that supports the parameter, ✖: the platform does not support this parameter. V: video, S: subtitles, Te: text, Sl: slides, D: diagram, G: interactive glossary, B: ebook, Tr: translation

	xMOOCs				aMOOCs			
Personalization parameters	**Coursera**	**edX**	**Udacity**	**Khan Academy**	**AMOL**	**CogBooks**	**MOOCulus**	**Insreamia**
Information seeking task	✖	✖	✖	✖	✖	✖	✖	✖
Level of knowledge & skills	✖	✖	✖	✖	✖	✓	✓	✓
Goals & plans	✓	✖	✖	✖	✖	✖	✖	✖
Media preference or presentation styles	V, S	V, S	V, S	V, S, Te	V, Te, S, Sl, D, G	V, S	V, S, B	V, S, Tr
Language preference	✓	✖	✓	✓	✖	✖	✓	✓
Learning styles	✖	✖	✖	✖	✓	✖	✖	✖
Participation balance	✖	✖	✖	✖	✖	✖	✖	✖
Progress on task	✖	✖	✖	✖	✖	✖	✖	✖
Waiting for feedback	✖	✖	✖	✖	✖	✖	✖	✖
Motivation level	✓	✓	✓	✖	✓	✖	✖	✓
Navigation preference	✖	✖	✖	✓	✖	✓	✖	✖
Cognitive traits	✖	✖	✖	✖	✖	✖	✖	✖
Pedagogical approach	✖	✖	✖	✖	✖	✖	✖	✖
Patience	✓	✓	✓	✖	✓	✓	✓	✖
Location	✓	✖	✖	✖	✖	✖	✖	✖
Weather	✖	✖	✖	✖	✖	✖	✖	✖
Date and time	✖	✖	✖	✖	✖	✖	✖	✖

It can be concluded from the Table 3 that most of the evaluated MOOCs were not supporting most of the personalization parameters such as information seeking task, participation balance and weather. It can also been seen that most adaptive MOOCs are supporting the level of knowledge parameter and only one is supporting learning styles. The other conclusion is that Coursera supports the most number of parameters compared to other MOOC platform with 6 supported parameters while edX and Khan Academy support the least number of parameters with 3 fulfilled parameters.

4.2 Personalization features in MOOCs

In addition to the evaluation of the personalization parameters in MOOCs, another evaluation was conducted to see how the MOOCs collected in this research have used the penalization features listed in section 3.3. This approach gave the chance to see how close the MOOC platforms are to personalization. This evaluation was done by either personally trying the MOOCs or by studying their website or other related websites about their platform.

Table 4 shows the summary of this evaluation. The check sign indicates that the MOOC platform takes advantage of the feature and the cross sign means it does not. Since these features have already been specified in section 3.3, the meaning of each item in the table is trivial and therefore, they will not be explained here. For example, if the quiz feature has been checked for Coursera, it is clear that the Coursera has this feature. But note that, the hands-on simulation feature was not applicable for Instreamia since the purpose of this platform was to teach languages but they do not require this feature.

Table 4: evaluation of MOOCs based on a list of personalization features in eLearning. ✓: the MOOC platform does has this feature. ×: the MOOC platform does not have this feature.

	xMOOCs				aMOOCs			
Features	**Coursera**	**edX**	**Udacity**	**Khan Academy**	**AMOL**	**CogBooks**	**MOOCulus**	**Instreamia**
Automatic student modelling	×	×	×	×	×	×	×	×
Quiz	✓	✓	✓	✓	✓	✓	✓	✓
Adaptive feedback	×	×	×	×	✓	✓	✓	✓
Graded assessment	✓	✓	✓	×	✓	×	✓	✓
Hands-on simulation experience	✓	✓	✓	✓	✓	✓	✓	Not applicable
Link hiding	×	×	×	×	×	×	×	×
Content navigation tree	×	×	×	✓	×	✓	×	×
Note-taking	×	×	×	×	×	×	×	×
Hypermedia system	×	×	×	×	×	✓	×	×
Social learning	✓	✓	✓	✓	✓	✓	✓	×
Collaborative grouping	×	×	×	×	×	×	×	×
Real-time course adaptation	×	×	×	×	✓	×	✓	✓
Mind-maps	×	×	×	×	×	×	×	×
Gamification	×	✓	×	✓	×	×	×	✓

5 ADAPTIVE MOOC DESIGN FRAMEWORK

In chapter 3, the personalization parameters referred to in the literature were identified and in chapter 4, some of the main MOOC platforms and some other adaptive MOOCs were evaluated based on these parameters. According to this evaluation, the MOOC platforms were not so personalized to this date. Thus, as an extension to this research, it is worthwhile to propose a design framework for adaptive MOOCs that fulfills most of the personalization parameters in the literature, especially the learning styles. Furthermore, designing this framework will fulfill the second research gap of this thesis mentioned in chapter 1.

However, developing an adaptive MOOC based on learning styles was not so straight forward as it had challenges such as selecting the most suitable learning style model, creating course content consistent with the various learning styles and the appropriate personalization technologies. Furthermore, massiveness and low teaching involvement during the delivery stage is one of the biggest challenges of MOOC design [87] that had to be taken into account while designing the framework. Therefore, in this part of the research, an Adaptive MOOC Design Framework, AMDF, was proposed to support the following design criteria:

1. the design principals suggested in general for MOOCs in the literature
2. most personalization parameters including the most appropriate learning style for web-based online learning

5.1 AMDF's learning style model

The main purpose behind AMDF, was to show how a MOOC should be designed in order to fulfill most of the personalization parameters. Furthermore, as learning style is one of the personalization parameters, FSLSM was chosen to pass this parameter because of the following reasons:

1. It has been successfully implemented in previous studies [88-90].
2. It has been approved by its author and other researchers [43, 91].
3. It is user-friendly and the results are easy to understand [92].
4. It has been recognized as the most suitable learning style for eLearning or web based learning platforms [28].

In this section, some adaptive learning systems that were based on FSLSM in the literature have been evaluated. The idea behind this evaluation was to see what kind of media elements they have used for their framework for each of the dimensions of FSLSM to get some ideas of what media should be used in AMDF.

Parvez et al [93]

Parvez et al have presented a design framework that supports Felder and Silverman's learning styles model. It has the following media elements:

1. **Definition:** contains definitions of domain concepts and is useful for many learning style dimensions including verbal, sensor, intuitive
2. **Example:** contains examples that can illustrate a given concept useful for almost any learning style, especially the sensor style
3. **Question:** contains questions which is very useful in making the learner think about his problem solving and very important for reflective learners
4. **Suggestion:** suggests to a learner who might be lost. It helps in pointing the student in the right direction.
5. **Picture**: contains images that illustrate a concept for the visual learner
6. **Relationship:** contains information that provides the relationship of a given concept to the big picture useful for global learners
7. **Facts**: contains facts about a concept that extends beyond the concept definition useful for sensory learners but can also be used for other types of learners

Flexi-OLM [25]

Papanikolaou et al have investigated the design of Flexi-OLM which is also designed

based on the Silverman's learning styles model. It has the following seven views to support different dimensions but does not have any view for the active-reflective dimension:

1. Hierarchy of concepts
2. Lecture structure
3. Concept maps
4. Pre-requisites
5. Alphabetical index
6. List ranked according to performance
7. Textual description

Algorithms course [94]

The algorithms course designed for a C programming course had done the adaptation by providing different representations for each student and using different types of resources [92]. For example, it was showing different interfaces for visual and verbal learners; pictures and tables to visual learners and plain text to verbal learners. For other dimensions like active-reflective learners, it was showing very similar material [94].

Franzoni et al [95]

In a comprehensive study on how to choose the appropriate electronic media for FSLSM, they have suggested to use media such as:

1. forums and chat for active and slideshows for reflective learners
2. text and sounds for verbal and visual representations and diagrams, forums, slideshows for visual learners
3. forums, laboratory and experiments, pictures and graphics for sensory learners and theoretical and abstraction for intuitive leaners
4. media that allow to see everything as a whole, forums, chat for global learners and media that allows content to be shown in steps and slideshows for sequential learners

The summary of the information above could be found in the table below:

Table 5: summary of the elements used to fulfill FSLSM other adaptive learning systems.

	View					View			
Style	**Parvez et al**	**Flexi-OLM**	**Algorithms course**	**Farnzoni et al**	**Opposite style**	**Parvez et al**	**Flexi-OLM**	**Algorithms course**	**Farnzoni et al**
Active				Forums, chat	**Reflective**	Definition, question			Slideshows
Verbal	Definition	Textual description	Plain text	Text and sounds	**Visual**	Picture	Concept map, pre-requisite, lecture structure, Hierarchy of concepts, index, list	Picture, table	Visual representations and diagrams, forums and slideshows
Sensory	Definitio, example, facts	Index, List	Examples with little explanations	forums, laboratory and experiments, pictures and graphics	**Intuitive**	Definition	Concept map, pre-requisite	Examples with little explanations	Theoretical and abstraction
Global	Relationship	Hierarchy of concepts		Media that allow to see everything as a whole, forums, chat	**Sequential**		Lecture structure		Media that allows content to be shown in steps, slideshows

5.2 Terminology

Before proceeding to the design framework, the main terminologies used in this design framework will be explained. These terminologies have been used according to the literature regarding eLearning.

5.2.1 Stakeholders

First and foremost, [96] has suggested a MOOC framework has four stakeholders; course designers, managers, tutors and learners. Therefore, the same terminology has been used in this research but with the following roles:

- **Learner:** the student who is taking the course

- **Tutor:** the person who is responsible for designing the contents of the course. For example, the tutor should provide separate material for visual learners and the verbal learners.
- **Course designer:** the person who has a higher-level perspective to the course than the tutor. The course designer is the person responsible for defining the framework of the course. In other words, the course designer has to define what should be covered in the course and what should not from a general perspective. For instance, she defines that in the second lecture in the "Introduction to Python programming" course, Python's "arithmetic operators" should be taught. Then, it is the tutor's responsibility to provide the content for teaching this subject.
- **Manager:** the person responsible for designing the MOOC platform's settings in general.

In AMDF, separate views were designed to show how an adaptive MOOC should support each of these stakeholders.

5.2.2 Modular Content Hierarchy

In this section, the terminology used for the content will be covered. So, as Learning Objects are the core of AMDF, it should be defined precisely.

Learning Objects are "a collection of content items, practice items, and assessment items that are combined based on a single learning objective [97]". Learning Object is especially important since it is a key concept in many standards and specification, such as SCORM [98]. SCORM that is an abbreviation for Sharable Content Object Reference Model, is a set of technical standards of the Advanced Distributed Learning, ADL, initiative for eLearning software products and it is the de facto industry standard for eLearning interoperability [99, 100].

Furthermore, the hierarchy of modular content has been divided into 5 levels according to the terms used in [101]:

1. **Raw Media Contents:** the smallest level in this model, consists of raw media elements including media types such as text, audio, illustration, animation.
2. **Information Objects:** sets of raw media elements. They describe a certain procedure, process or structure, define a concept, present a fact, or provide an overview on some subject. The plan is to generalize the concepts to deal with more advanced and innovative content.
3. **Application Specific Objects:** Based on a single objective, information objects are then selected and assembled into the third level of Application Specific Objects. The "learning objects" defined above reside at this level.
4. **Aggregate Assemblies:** deal with larger objectives which corresponds with lessons.
5. **Collections:** aggregate assemblies are themselves assembled together to form collections like courses.

Figure 6 shows the above mentioned hierarchy in a diagram:

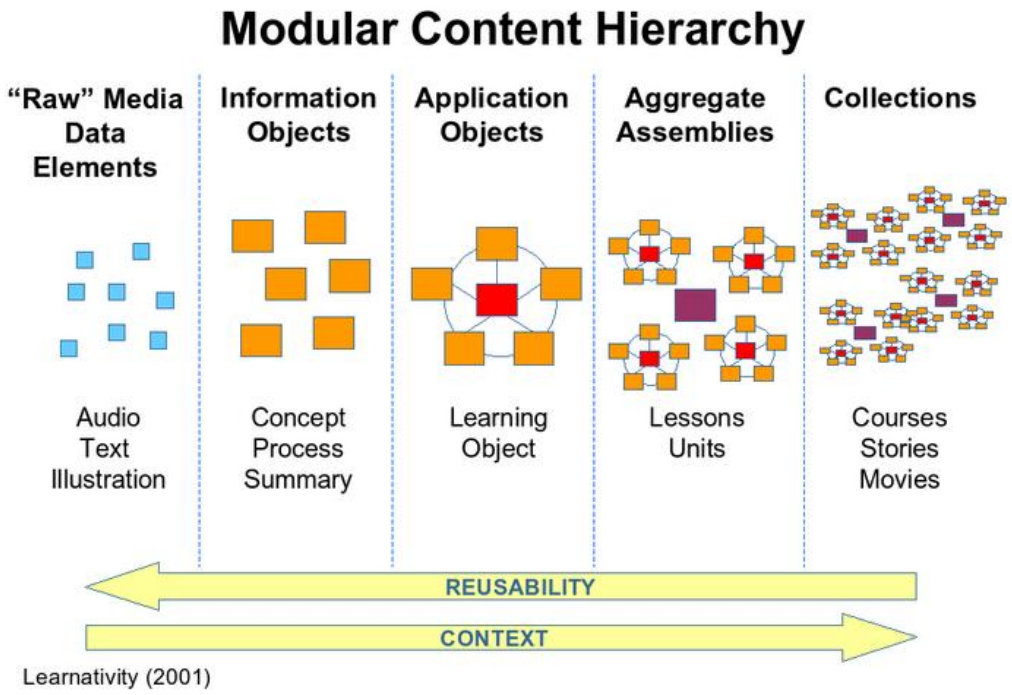

Figure 6: Modular Content Hierarchy [102].

Therefore, in AMDF, each course is composed of a sequence of lessons and each lesson is a combination of Learning Objects where these Learning Objects are called “lesson nodes” or simply “nodes”. The nodes are themselves combination of information objects and the information objects are a set of media elements. Table 6 shows the summary of the terminology used in AMDF:

Table 6: the terminology used in the literature for the modular content hierarchy and their corresponding terminology in AMDF.

Terminology in the literature	Corresponding terminology in AMDF
Raw Media Content	Media element
Information Object	Information Object
Application Specific Object	Lesson node or node
Aggregate Assembly	Lesson
Collection	Course

5.3 Course design

Now that the terminology of AMDF has been clarified, it is time to go through the details regarding the design framework of AMDF. Therefore, first, the structure of a lesson has been explained.

Lesson structure

In AMDF, each lesson node has been composed of the following:

1. **Information Object:** In AMDF, there are two kinds of information objects:
    a. **Lecture:** a lecture could have one or more of each of the following media elements but maximum of one per each. So for example a lecture in one node cannot have two videos but can have a video and an audio:
        i. Video
        ii. Slide
        iii. Audio

iv. Text

b. **Learning style:** learning style information objects have been designed as additional objects to the lecture to support all dimensions of FSLSM:
    i. Diagrams
    ii. Definitions
    iii. Facts
    iv. Concept hierarchy
    v. Course structure

2. **Question:** a node can contain maximum of one question. The question types are not limited to multiple-choice questions but could also be with checkbox or a text input.
3. Personalization Parameter Profile: contains a record of personalization parameters related to the learner.
4. Expiration Time: used if the tutor decides to define a deadline for a node.
5. **Hyperlinks:** any hyperlink that needs to be suggested to the learners.
6. **Attachments:** any attachment whether it is a pdf file or a binary file that has been provided for some exercise.
7. **Pointer:** for linking to other nodes in the lesson.

Figure 7 shows the above-mentioned concept in a visual format:

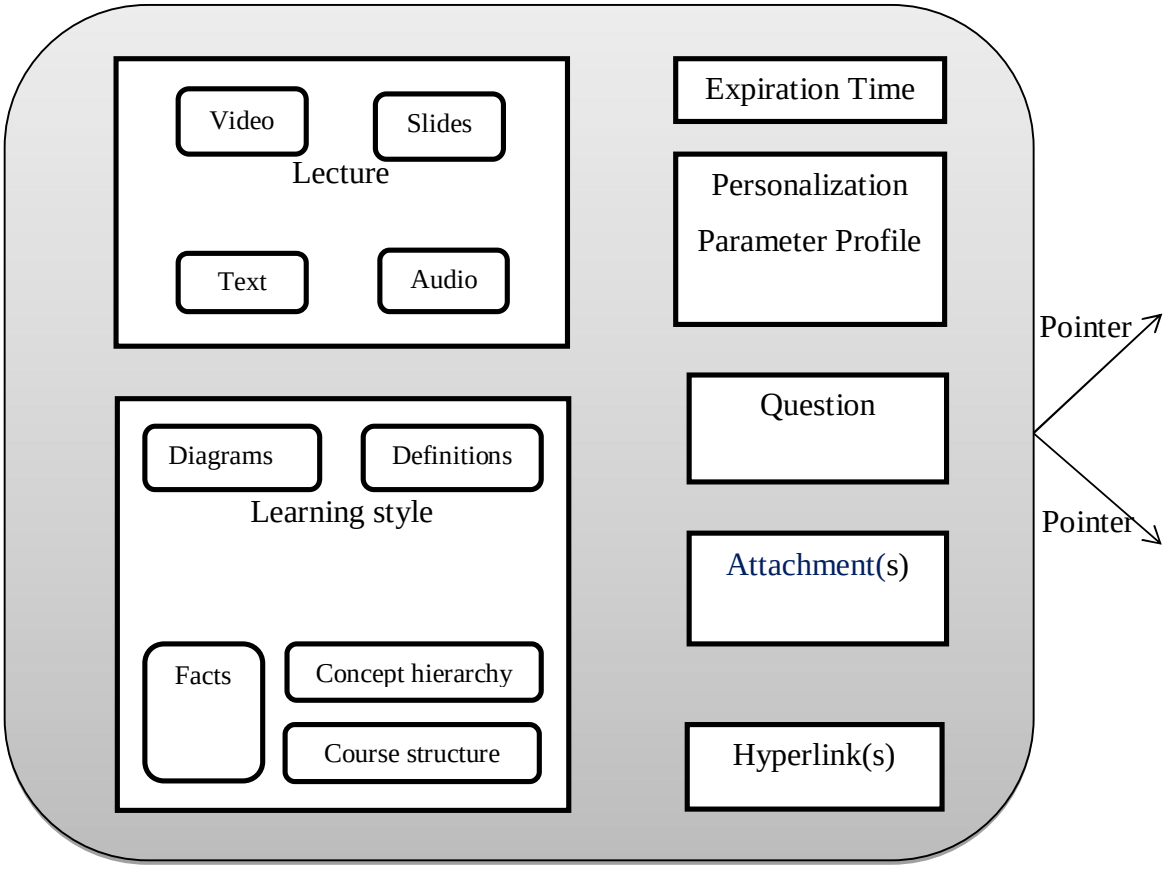

Figure 7: lesson node format in AMDF.

The golden rules

There are two general rules for designing a lesson in AMDF. First, for each node, there must be at least either one of the lecture media elements or else a question. Therefore, a node either does not have a question and is linked to a single node like Figure 8 (a) or it does have a question and is linked to two other nodes like Figure 8 (b).

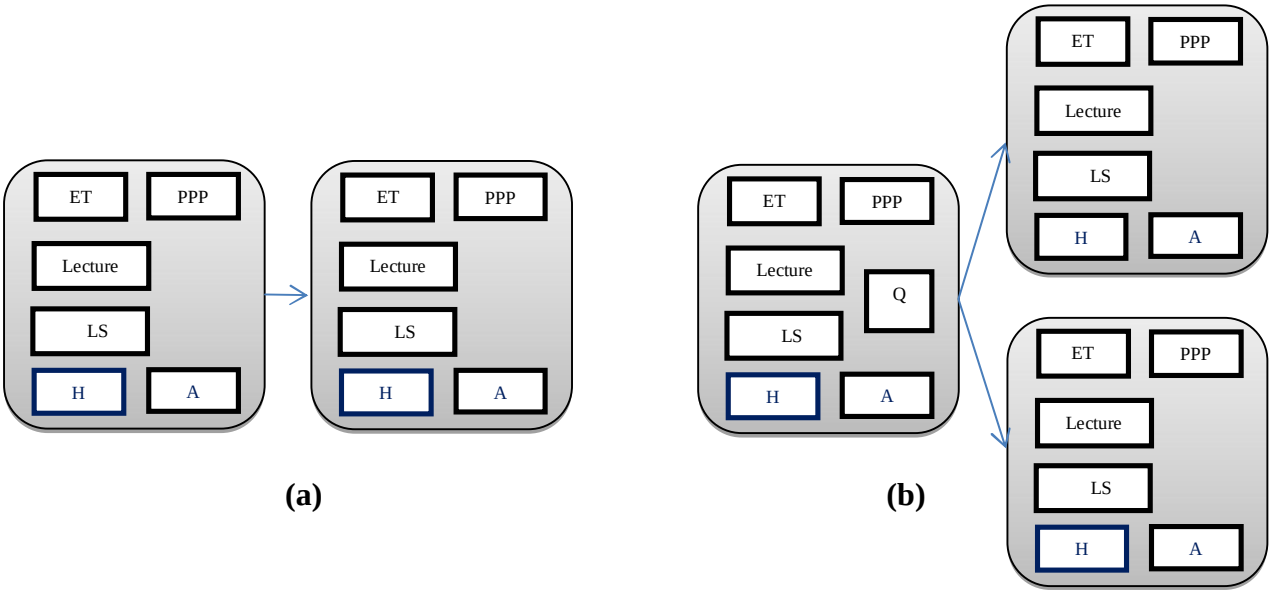

Figure 8: two types of node connections in AMDF one without a question and therefore, linked with only one node (a) and the other with a question and therefore, linked to two other nodes (b).

Second, in case the node contains a question, depending if the answer provided by the learner was right or wrong, the learner should be taken to two different nodes. In AMDF, the node that the learner is taken after giving a correct answer is called “correct node” and the node that the learner is taken after providing the wrong answer is called the “wrong node”. Similarly, the path that the learner is taken after going to the “correct node” is called the “correct path” and the “wrong path” otherwise. Moreover, if the node does not contain a question the learner is simply taken to the next “correct node”. Figure 9 shows the structure of a lesson in AMDF:

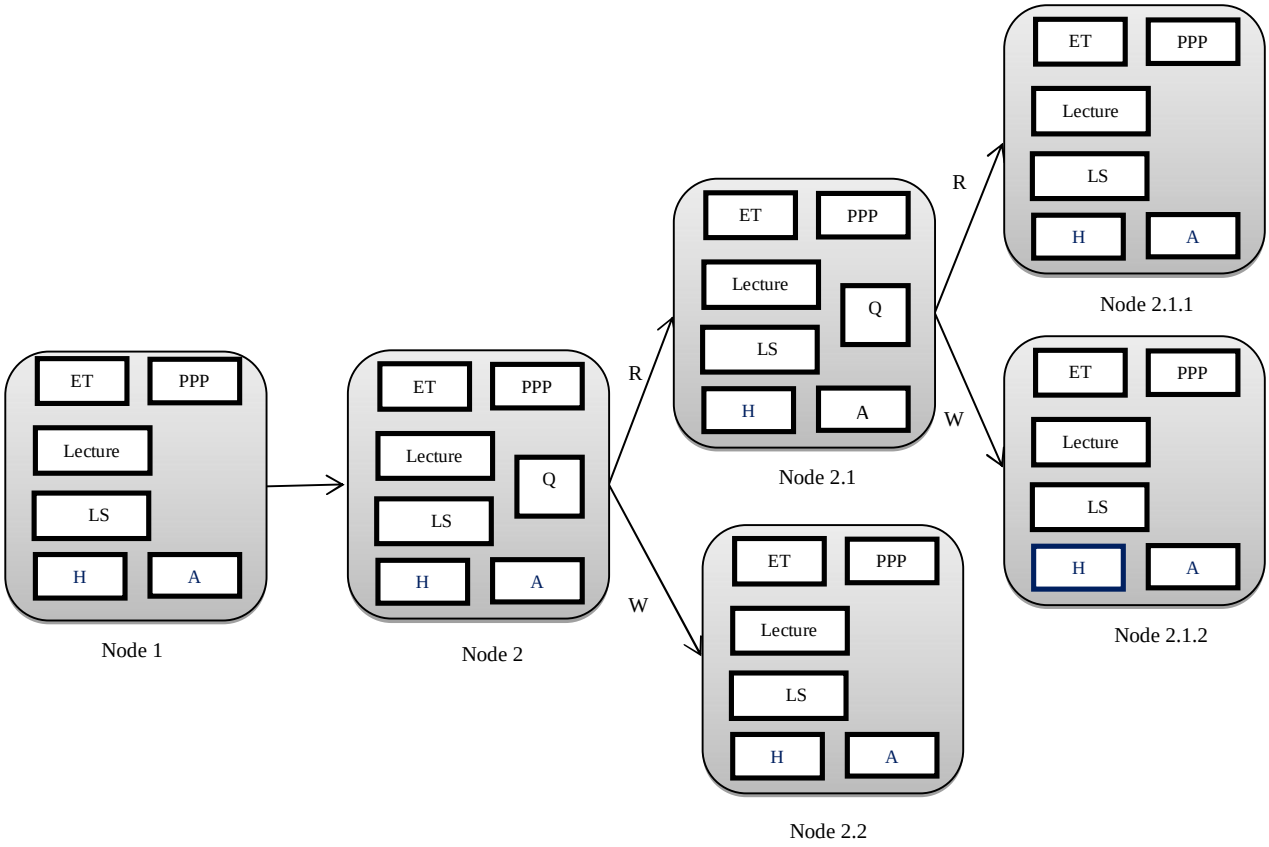

Figure 9: Fully Adaptive MOOC lesson structure. Each lesson consists lecture media elements, learning media elements, expiration time (ET), personalization parameter profile (PPP), question (Q), Hyperlinks (H) and attachments (A). One node could be linked to another node with a question and depending if the answer was right (R) or wrong (W), the learner is taken to different paths. Each node must have at least either a lecture media element or a question and a personalization parameter profile.

5.4 User-interface design

In this section, AMDF's design framework will be presented with a set of mockups. It should be stressed that the items used in this design framework are those items that are either considered necessary for fulfilling the personalization parameters and those for supporting the general MOOC design principals. For instance, the registration form has not been illustrated in these mockups as this view does not contain anything significant regarding adaptivity of MOOCs.

In addition, a scenario that a learner, Marko Rossi, registered for “Introduction of Python Programming” is taking a lecture on “Variables in Python” will be illustrated in Appendix 1 to further explain the design has been provided. The mockups will be separated for each of the stakeholders, learners, tutors, course designer and the MOOC platform manager.

5.4.1 Learners’ interfaces

The first interface is the course information template. In this temple, the learner can find information related to the course like the course title, the difficluty level of the course, the tutor’s information, course objectives, the course duration, course progress timeline, the rate of the course given by the learners as well as the language of the lectures and the subtitles. Figure 10 shows the template of the course information page:

Figure 10: Course information page in AMDF.

The main interface of AMDF looks like Figure 11. The learner will find either the lecture

information object, either video, slides, audio or the question in the middle of the page. Beneath this the lecture or question section, is the section related mainly to supporting the visual, verbal, sensory, intuitive, active and reflective learning styles according to Table 7. However, the attachments and the hyperlinks given by the tutor are also available. The media elements supporting the global and the sequential learners is on the right hand side of the lecture and question section. There is a chatbox in the bottom right hand side, and the links to other interfaces and the rating the course interface on the left. On the top the learners name, the awards achieved in the gamification feature, the searching the nodes tool, the course title and the nodes difficulty level are available. The learner can see his or her own profile and messages in the links provided on the top right hand side of the interface.

There is also a course material with several icons on top left hand side of the lecture and question section. These icons determine which media elements to be visible to the learner and which not to be visible.

Figure 11: the template of the main interface of AMDF.

If the learner clicks on the “User upload” link, the interface related to the user uploads will appear. In this interface, the learner can define his or her own questions as it can been seen in Figure 12:

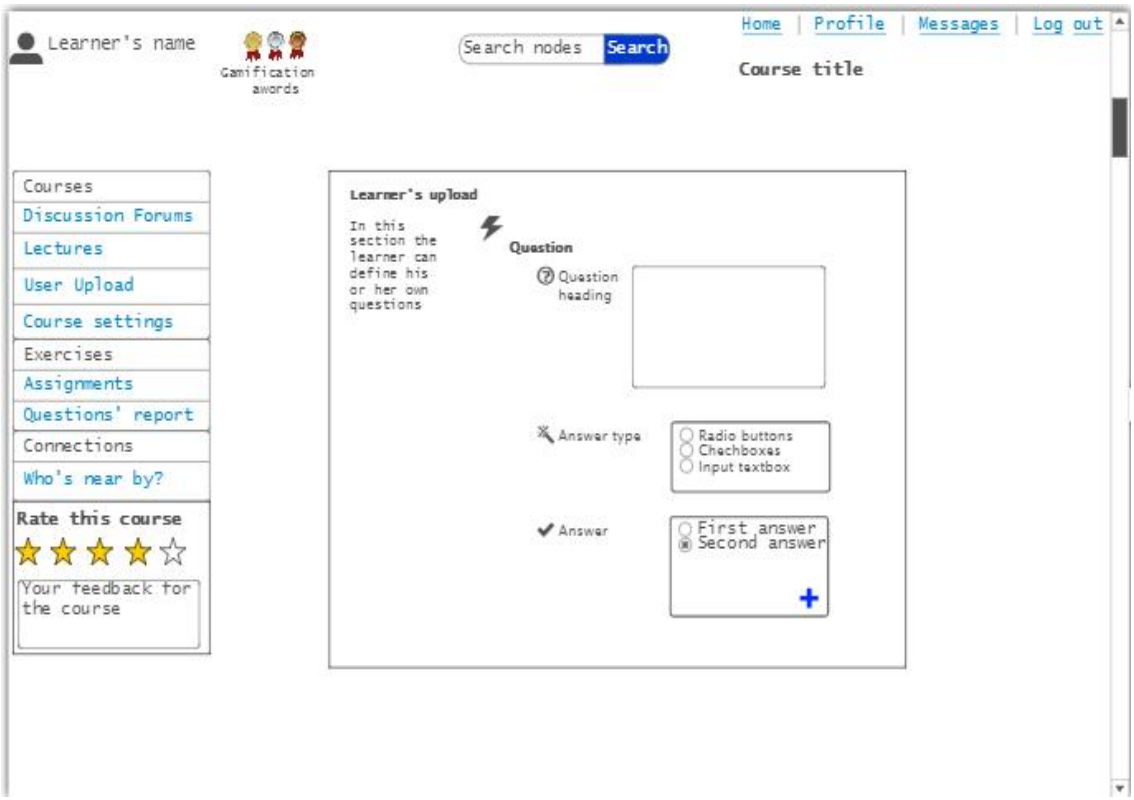

Figure 12: the template for the user to upload a question defined by herself.

Double clicking on the medals will take the user to the gamification interface. As Figure 13 shows, the learner can see his or her gamification awards in the middle of the page. In the “top universal ranks” section, top three ranked students in the world are named and in the “top ranks this week”, top three ranked students this week in the world are named. The “Overall rank”, “Overall rank this week” and the “Rank in your country” show the, rank in the world, rank in the world this week and rank in the learner’s country respectively.

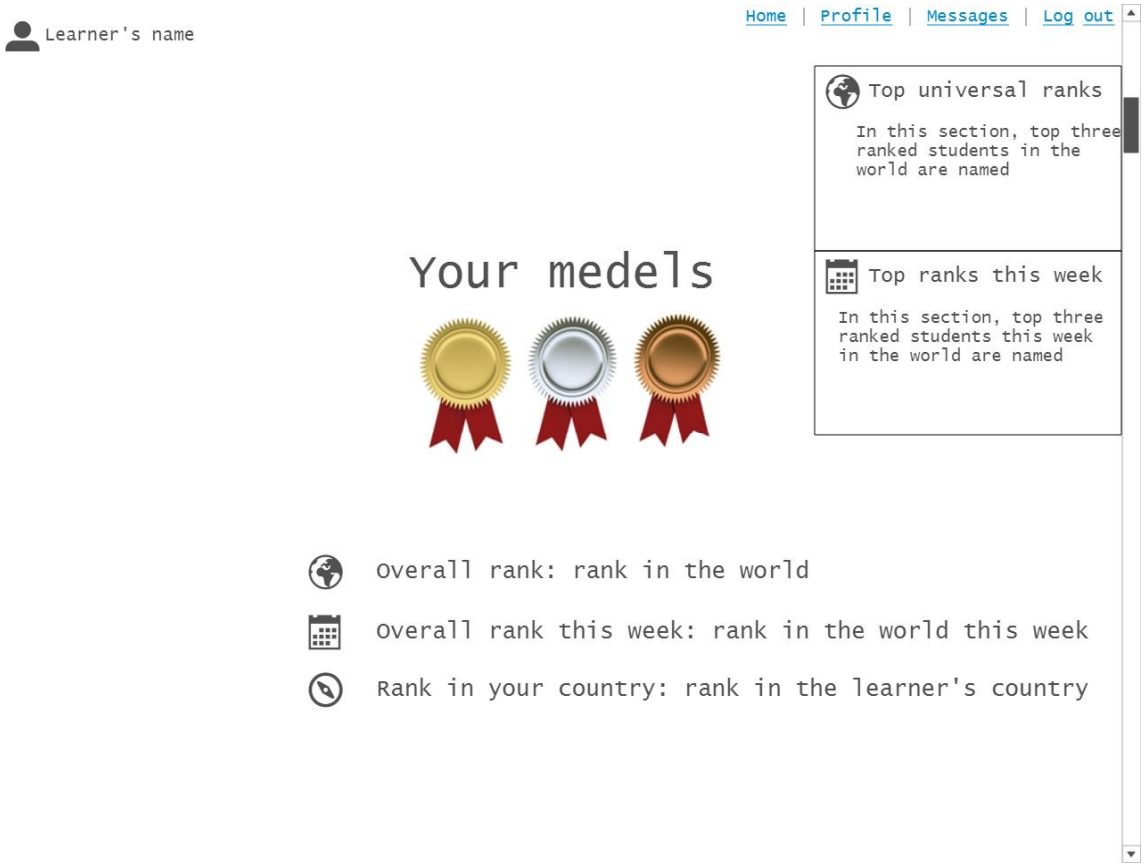

Figure 13: the template of the gamification interface.

Furthermore, the discussion forum will appear like Figure 14. The learners can post a question. Other learners' answers are available beneath this section. This green check-mark indicates that the answer was accepted by the original learner that had posted this question. Each of the question and the answers could be rated by the learners by clicking the up arrows and the down arrows.

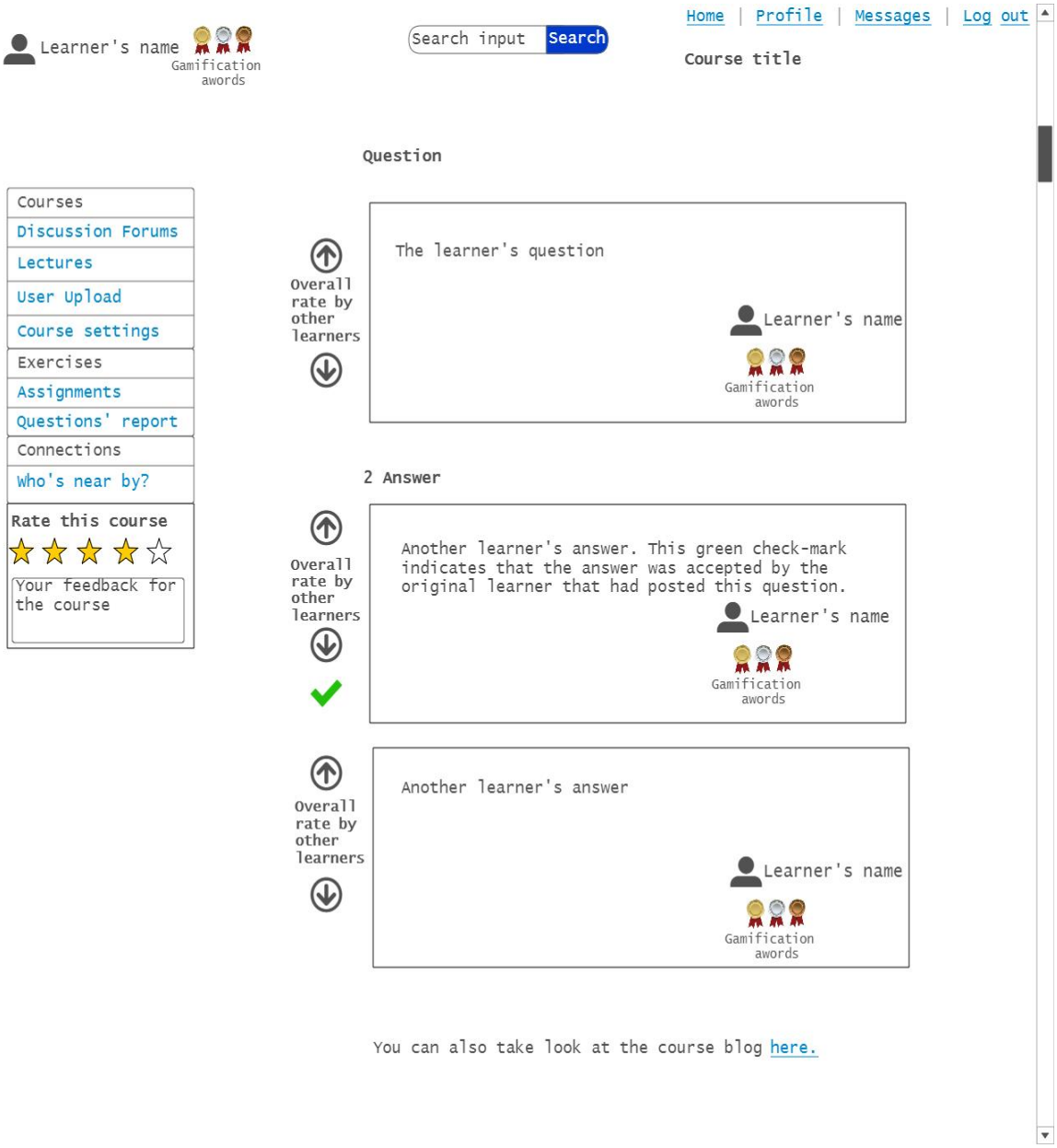

Figure 14: the template related to the discussion forum.

There could be some assignments defined by the tutors, which will be presented in an interface similar to Figure 15. The problem defined by the tutor will be shown in the top section. The tutor can also provide a hint when defining the problem. The learner can upload a single attachment if she wishers.

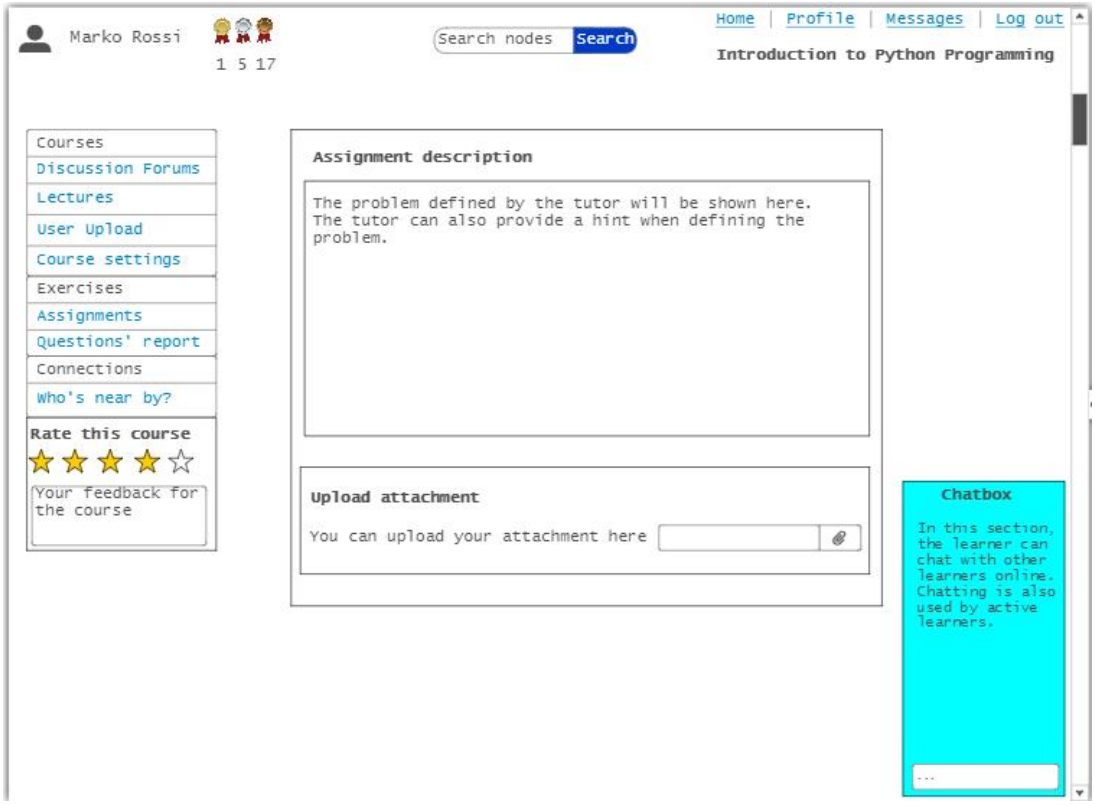

Figure 15: the template for the assignments.

5.4.2 Tutor's interfaces

In order to build a lesson, an exam or an assignment, the tutor has to create the nodes; if the node ends with a question, the tutor would have to create both "correct node" and "wrong node". The node creation has been divided into the following sections for understandability:

1. **Map:** this section is set by the tutor to show where in the course the learner currently is as shown in Figure 16. It is itself composed of the following items:
    a. **Lesson tree:** this section shows the lesson's tree. Each circle represents a node in the lesson. By clicking on the nodes, the tutor can jump to the corresponding node. By hovering the mouse over each node, information regarding which course structure items this node corresponds to pops out.
    b. **Course structure:** this section shows checkboxes of the course structure that was originally designed by the course designer. The tutor has to check

the boxes that were covered during this lesson node. These checkboxes were originally written by the course designer.

c. **Concept hierarchy:** this section shows checkboxes of the concept hierarchy that was originally designed by the course designer. The tutor has to check the boxes that were covered during this lesson node. These checkboxes were originally defined by the course designer.

2. **Node level:** this section is for the tutor to indicate the difficulty level of this lesson node. Node level can be seen on the bottom of Figure 16.

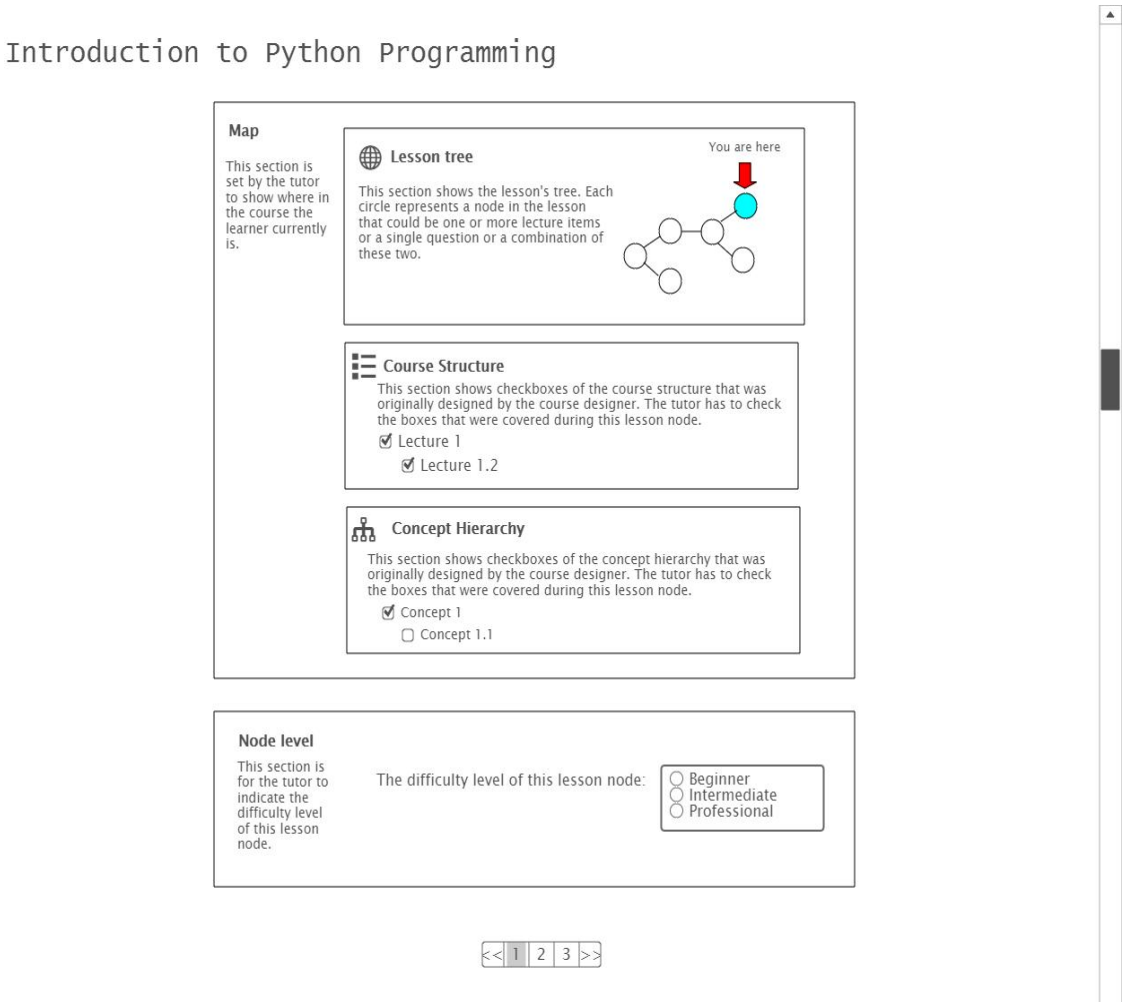

Figure 16: first page of the template of node creation by the tutor; contains the map for indicating the node and its content details in the course.

3. **Lecture:** As it can be seen in Figure 17 this section is for the tutor to upload the

lecture materials; video, slides, audio. The keywords could be given to enable easy searching for the learners.

4. **Learning style:** this section is for the tutor to enter items that are designed to support different learning styles but do not exist in the lecture section mentioned above. As depicted in Figure 17, the learning style section itself is composed of the following items:
    a. **Definitions and examples:** for verbal, reflective, sensor and intuitive learners and more textual information.
    b. **Facts:** this section contains some facts that were pointed out during this lesson for sensor learners.
    c. **Diagram upload:** pictures, figures, diagrams, mind-maps and charts mainly for visual learners.
5. **Other items:** this section is for the tutor to enter hyperlinks and upload attachments to this node as it is shown in Figure 17.

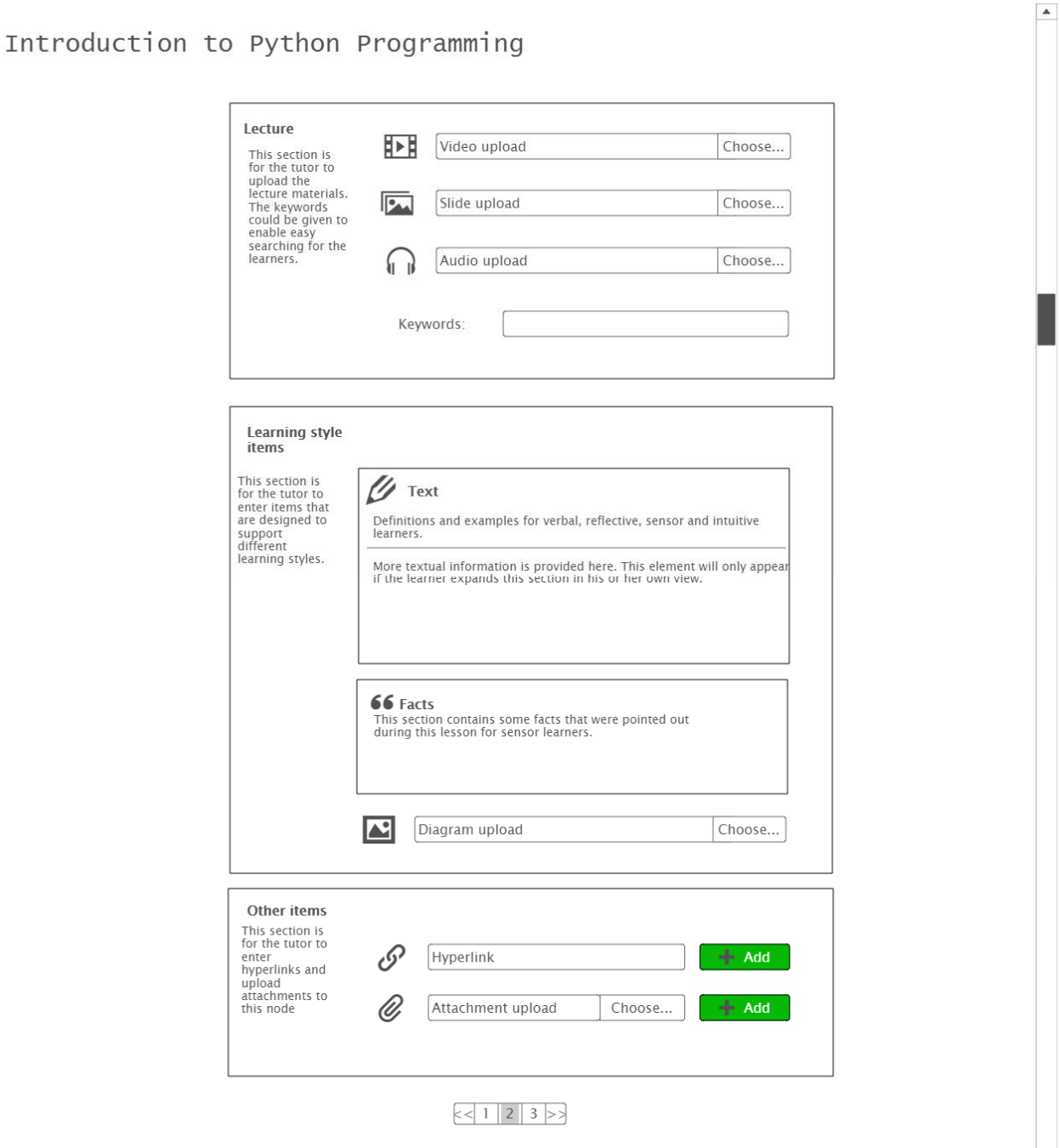

Figure 17: second page of the template of node creation by the tutor; contains the lecture information objects, learning styles' items and other items.

6. **Assessment:** this section is for defining a question as it can be seen in Figure 18. If the answer to the question was correctly given by the learner, she is taken to the next "correct node"; otherwise, to the next "wrong node". If checked as an

assignment, the tutor can set to extend the deadline for every day with a particular weather. It can also be set to count the number of business day of the location of the tutor and set the deadline for different learners based on the number of business day.

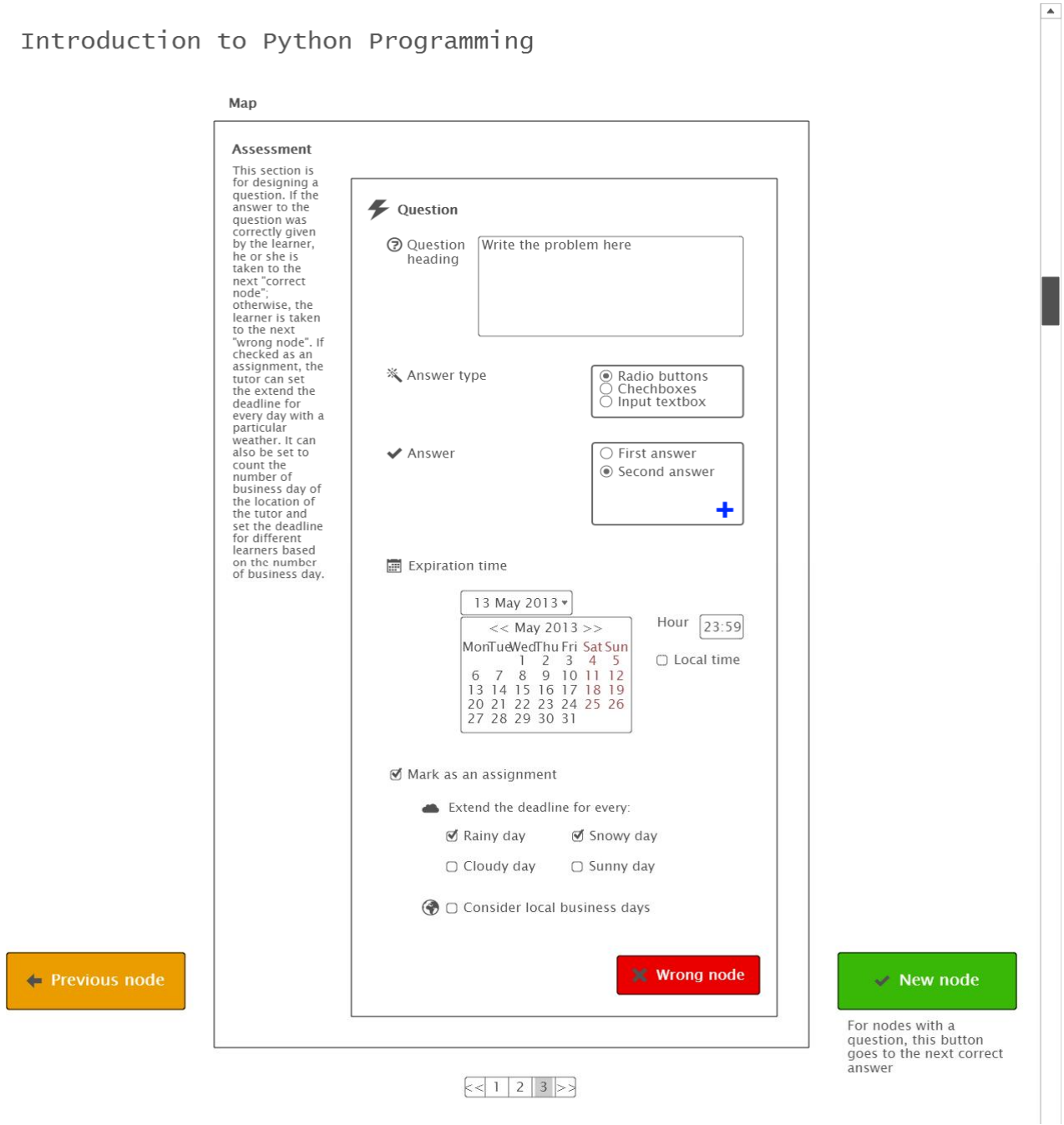

Figure 18: page three of the template of node creation by the tutor; contains the assessments section of the node.

5.4.3 Course designer's interface

The course designer can design the overall information about the course from an interface like Figure 19. There are different sections for the course level, course objectives, course duration, course structure, concept hierarchy, course hashtag and course blog address:

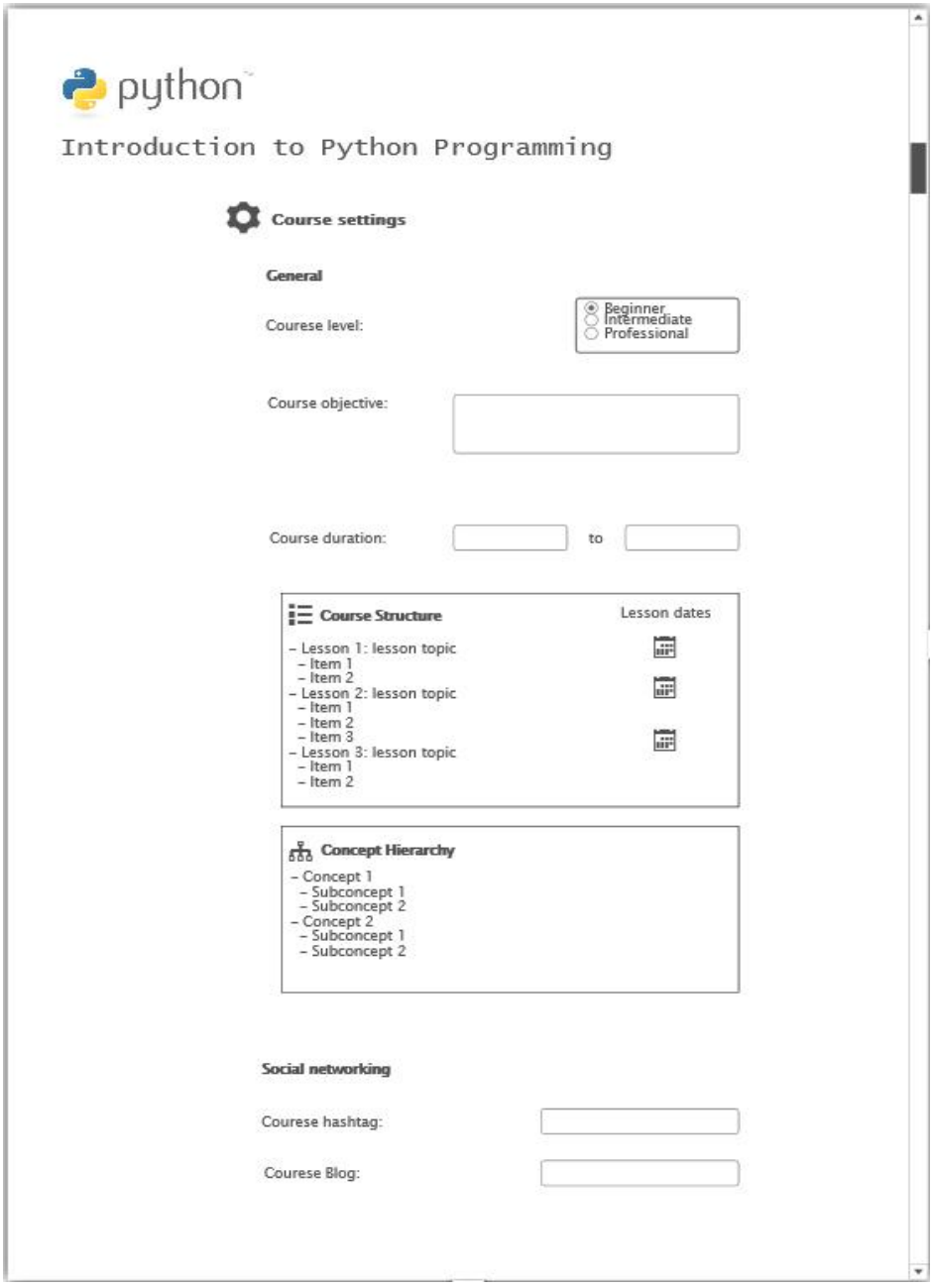

Figure 19: the template for the course designer.

5.4.4 MOOC platform manager's interface

The MOOC platform manager can set how many points the learners get for the points

given for the correct answers to the questions embedded in the lessons and the discussion forum. MOOC platform manager's interface can be seen in Figure 20. The MOOC platform manager can also add more weather types that could be considered to extend the deadlines of the assignments.

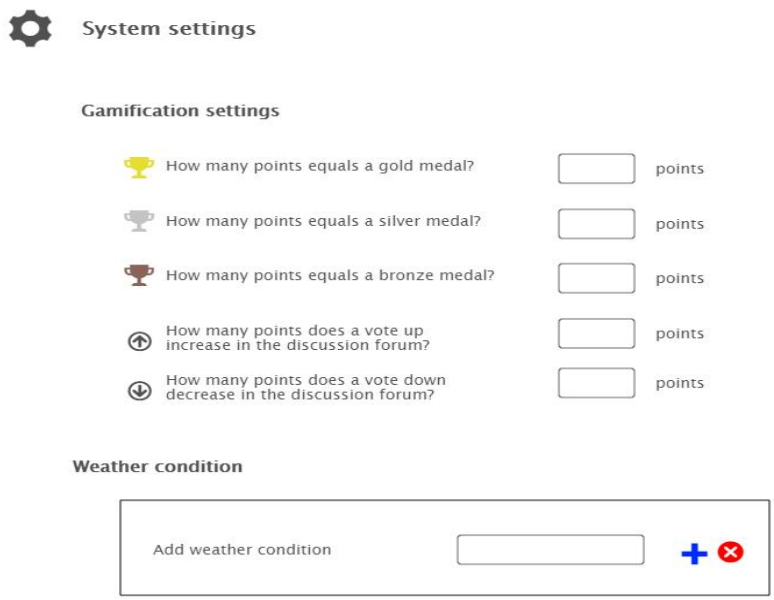

Figure 20: the template for the MOOC platform manager.

5.5 Personalization parameters in AMDF

Information seeking task

This parameter is supported by means of searching in the nodes. Since the nature of AMDF structure is on its tree of lesson nodes, when it is evaluated by the system that the learner is searching for a keyword, all the items in the course structure that do not correspond to the nodes that have that keywords become hidden and therefore, it fulfills the information seeking task parameter.

Level of knowledge

Since the structure of each course in AMDF has been designed to be a tree of lesson nodes, and the path that the learner goes depends whether that individual answers the embedded questions correctly, the system is constantly adapting to the learner's level of knowledge; if the learner answers the questions correctly, they are taken to the "correct path" and finish the lesson fast, otherwise the learner is taken to the "wrong path" to learn more preliminary contents before advancing to the "correct path".

Motivation level

The reason given for AMOL in section 4.1.5 for passing the motivation level parameter also applies in AMDF. However, in addition, the gamification used in the system will raise the learners' motivation level [75].

Media preferences

In AMDF, the main lecture could be given via videos, slides, audio and text. The video should be in the center of the screen with the following capabilities:

- **Video speed:** the user should have the option to play the video in different speeds like 0.5x, 1x, 1.25x, 1.5x, 2x; where 1.5x means it should be played one and a half times faster than the original pace of the video.
- Subtitles: the videos should be provided with subtitles in different languages.

In addition, the audios should have the feature to be played in different speeds.

Language preferences

Language preference should be accomplished in two different ways:

1. The MOOC platform should be able to provide the subtitles in different languages
2. All the menus should be customizable to different languages
3. The platform should give the users the opportunity to search the courses that are lectured in a specific language

Learning style

After evaluating some of well-known learning style models, FSLSM was chosen because of the following reasons:

1. It has been successfully implemented in previous studies [88-90]
2. It has been approved by its author and other researchers [43, 91]
3. It is user-friendly and the results are easy to understand [92]
4. It has been recognized as the most suitable learning style for eLearning or web based learning platforms [28]

So, the following set of elements is designed to support the FSLSM.

Course material: different elements have been used to fulfill the dimensions of FSLSM. There should be a 'course material' section in the main view that contains the icons of all media elements. By logging which elements the learner clicks more from this 'course material', the learning style of the learner can be analyzed and therefore, provide an automatic student modeling.

Diagrams: contains pictures, diagrams, mind-maps, figures and charts used for the visual learners.

Text: contains definitions and examples. By clicking to this element it will be enlarged and more explanation will be available. This element is useful for verbal, reflective and intuitive learners.

Course structure: contains the course structure divided into different lectures. It is somewhat similar to the course's "Table of content". This element is used for sequential learners.

Facts: contains the facts that were mentioned in the course. Facts are useful elements for sensor learners.

Concept hierarchy: contains the hierarchy of the concepts that were taught in the course.

Unlike the course structure element, the course hierarchy is not divided into course lectures. This element is used for the global learners.

Hands-on laboratory: contains the online laboratory tool that is useful in the course. Examples of these laboratories are Programming environments, Networking tools, and etcetera. This element is useful for active learners.

The use of these elements to fulfill different dimensions of Felder and Silverman's learning style could be summarized in the table below:

Table 7: proposed design framework evaluation based on FSLSM.

Style	Media elements	Opposite style	Media elements
Active	Hands-on laboratory, chatbox	Reflective	Definition, quizzes
Sensor	Definition, example, facts	Intuitive	Definition, concept-maps, examples and explanations
Visual	Picture, diagram, mind-maps, figures, charts	Verbal	Definition, examples, explanations
Sequential	Course structure	Sequential	Concept hierarchy

As the table shows, unlike some of the platforms developed based on the Felder and Silverman's learning style, this framework supports all dimensions of this learning style model.

Navigation preference

This parameter is fulfilled by having each of the items in the course structure and the concept hierarchy to be linked to its corresponding node. So, when the learner clicks on them, he or she will be taken to the first node related to them.

Patience

The feature that enables lecture videos and lecture audios to be played in different paces will fulfill this personalization parameter.

Location

The platform should be able to give learners that are in the same location for example the same town to know one another and form face-to-face group discussions if they want.

Weather

Take the weather in consideration if the MOOC requires the students to perform some outdoor. In AMDF, the tutor can set to extend the deadline for the assignment for everyday that was for example raining or snowing. More weather types can be added by the manager.

Date and time

Set the deadline for the assignment according to the number of business days of the learner's location. For example, if it was Monday and the deadline for the assignment was on Friday in the same week in USA, the deadline will be extended one day in Middle East because Friday is weekend.

Goals and plans, participation balance, progress on task, waiting for feedback, cognitive traits and pedagogical approach parameters have not supported in AMDF.

Summary personalization parameters of AMDF

To conclude, Table 8 the summery of the methods that were designed to implement each of the personalization parameters:

Table 8: summery of the methods designed to implement the personalization parameters.

Personalization parameters	Designed method
Information seeking task	Searching for keywords and getting the related nodes
Level of knowledge & skills	Questions
Goals & plans	
Media preference or presentation styles	Video, subtitles, diagrams, charts, pictures, mind-maps, course
Language preference	Subtitles and searching the courses that were given in one specific language
Learning styles	Diagrams, text, course structure, facts, content hierarchy and hands-on laboratory
Participation balance	
Progress on task	
Waiting for feedback	
Motivation level	Questions, different levels of engagement and certificates, user ratings
Navigation preference	When the learner clicks on the items of the course structure and the concept hierarchy items they will be taken to the corresponding nodes
Cognitive traits	
Pedagogical approach	
Patience	Configurable video speed
Location	Local group discussions
Weather	Postponing deadlines
Date and time	Extending the deadline of assignments based on the local calendar

Summary personalization features of AMDF

Furthermore, Table 9 shows the summary of the use of personalization features in AMDF that were described in section 3.3:

Table 9: Summary of the personalization features used in AMDF

Features	**AMDF**
Automatic student modelling	
Quiz	The optional embedded questions in each node
Adaptive feedback	
Graded assessment	The points given for correct answers to the questions
Hands-on simulation experience	Hands-on laboratory media elements provided for the active learners
Adaptive link hiding	
Content navigation tree	Course structure and the concept hierarchy media element provided for the global and sequential learners which the learner can click on each of the items to navigate in the course.
Note-taking	
Hypermedia system	Designing lessons with the lesson nodes and supporting the learners' level of knowledge personalization parameter
Social learning	Discussion threads in the discussion forum where the learner can ask her question from other learners
Collaborative grouping	
Real-time course adaptation	Designing lessons with the lesson nodes and supporting the learners' level of knowledge personalization parameter
Mind-maps	The diagrams and maps media element
Gamification	Provided as gold, silver and bronze medals that is achieved by answering to the questions and up-votes in the discussion forum.

5.6 Advantages of AMDF

The advantages of this designed could be classified as follows:

1. **Multiple learning paths:** the main idea behind this design was to have different learning paths for learners depending on their level of knowledge in the field. Hence, like the approach proposed in [24], a learner with good background knowledge in the field can advance to the end of the lesson faster while the learner with less knowledge. For example, if the course is regarding Python programming, a student with prior knowledge about other programming languages does not have to go to the sections where the tutor is explaining a basic concept like what a variable is. Furthermore, this design provides full flexibility. For example, a course can even start with a single question like “Who has prior experience in programming?”
2. **Mastery learning:** AMDF has been designed to thoroughly support mastery learning as it is one of the pedagogical benefits of MOOCs [103]. In Mastery Learning, "the students are helped to master each learning unit before proceeding to a more advanced learning task" (Bloom 1985) in contrast to "conventional instruction" [104]. In general, mastery learning programs have been shown to lead to higher achievement in all students as compared to more traditional forms of teaching [105].
3. **Self-assessment:** as one of the critical design principals of MOOCs is to have a self-assessment system because of its large number of participants [103] and AMDF has been designed to support this feature with its quizzes and automated marking.
4. **Retrieval learning:** in general, the quizzes provide students with an opportunity for retrieval learning [106]. “Retrieval practice is the act of enhancing long–term memory of facts through recalling information from short–term memory”. Some believe that retrieval learning will also enhance learning [107].
5. **Short videos:** having the lesson in a tree of nodes will encourage having short videos. Based on an empirical study done in MIT on 6.9 million learners on edX, it has been found that shorter videos are much more engaging by the learners and

have been recommended to divide videos into less than 6 minutes chunks [108]. Short videos give the chance to the learner to control the pace, pause, rewind, explore and return to the content [103].

6. **Examinations:** an exam could be designed with the same structure. To do this, the tutor should only choose a single question for all learning objects of the lesson with no lecture or learning style information objects.
7. **Assignments:** an assignment can be designed with the same structure. Here, an assignment has been defined to be a single node with only one question that enables users to upload an attachment. If the tutor, creates a lesson with a single node that meets this criterion, it can been seen by the learner in the assignments' view.

Furthermore, AMDF supports six out of eight types of interface-adaptation introduced in chapter 2. Table 10 shows how AMDF supports these types of interface-adaptation:

Table 10: summary of the methods used in AMDF to support the interface-adaptation types that were introduced in [71].

Types of interface-adaptation	**Supporting method in AMDF**
Interface-based	Hands-on laboratory, Mind-maps,
Flow-based learning	Support of "level of knowledge" personalization parameter
Content based	
Interactive problem solving support	
Adaptive grouping	The discussion forum
Adaptive information filtering	Support of "information seeking task" personalization parameter
Adaptive evaluation	The optional questions at end of the nodes
Changes on-the-fly	Support of "level of knowledge" personalization parameter

5.7 MOOC design criteria evaluation

As an adaptive MOOCs are a subset of MOOCs, this design should obey other MOOC design frameworks presented in the literature. Therefore, in this part of the research, we evaluate the design criteria used for AMDF based on the design principals introduced in general for MOOCs in the literature. For instance, [87] has suggested ten design principles for MOOCs. The items below show what are each of the principals, how it was suggested by [87] to be achieved and how AMDF supports that:

1. **Competence-based design approach:** focuses on outcomes of learning and addresses what the learners are expected to do rather than on what they are expected to learn about. This principal could be achieved by including contextual variation with simulations, problem-based, case-based and project-based learning [109]. In AMDF, the hands-on laboratory provide the opportunity for the tutor to achieve this principal.
2. **Learner Empowerment:** MOOC design should take advantage of learner-centered approach which could be obtained by self-regulation, self-paced, self-assessment, peer support and interest group formation [87]. In AMDF, the lesson node structure that enables learners with better knowledge to go through the course faster than the less informed learners, knowing the level of difficulty for each video chunks, multiple pace option for videos, quizzes, the chatting system are designed to fulfill this principal.
3. **Learning plan and clear orientations:** as planning is crucial in MOOC, the learners plan should be taken into account [87]. Indicating difficulty level of each lesson node by the tutor will to some degree support this principal.
4. **Collaborative learning:** allows the addition of exchange spaces for and by learners. It could be obtained by adding teamwork activities and discussion forums [87]. In AMDF, discussion forums will add an exchange space for and by learners.
5. **Social networking:** focuses on setting up a space to foster social interaction and frequent contact between the learners. This principal could be fulfilled by creating a course hashtag for social media applications [87] like Twitter. The course hashtag set by the course designer will help the learners to have more social interaction and

contact with other learners.

6. **Peer assistance:** MOOC design should include co-creation of ad-hoc spaces for dialogs and support which is achieved by adding peer assistance through commenting and social appraisal [87]. In AMDF, the chatting system, discussion forums and social media hashtag were designed to achieve peer assistance.
7. **Quality criteria for knowledge creation and generation:** emphasizes on Learner Generated Content [110] which promotes critical thinking that gives value to make good questions rather than only good answers [87]. As discussion forums have known to be mean to promote critical thinking [111], In order to fulfill this principal, questions in the discussion forum should be rated by the learners, and these rates should be counted in the gamification points. In addition, the learners can suggest their own questions for the node.
8. **Interest groups:** provides opportunity for small group discussion and exchange [87]. Having the feature to group learners in the same town or region to have face to face meetings will achieve this principal.
9. **Assessment and peer feedback:** this principal could be achieved by suggesting the use of blogs for collecting, reflecting, annotating and sharing learning outcomes and reflections [87]. In AMDF, the course designer has the option to set up and suggest a blog for the course which will meet this principal.
10. **Media-technology-enhanced learning:** stresses on providing a variety of rich-media for capturing the learner's attention [87]. In AMDF, variety of media elements like diagrams uploaded both by the tutor and the learners, definitions, facts, course structure and concept hierarchy will help to have rich-media for capturing the learner's attention.

Another set of design criteria suggested in the literature were the lecture organization criteria and E-Assessment Criteria [20].

Lecture Organization Criteria

1. **Objectives should be clearly defined at the beginning of each lecture:** the course designer has the option to write about the objectives of the course, which

will fulfill this criterion.

2. **Supporting the collaborative learning among learners:** discussion forum, group assignment, blogs and course hashtag have been designed to pass this criterion.
3. **MOOCs system should provide coaching and scaffolding at critical times:** this criterion is not supported in AMDF.
4. **Offer course outline that contains objective, subject list and time schedule:** providing course objective, course structure and time schedule for both the whole course and for each node will fulfill this item.
5. **Providing opportunities for learners to become more self-organized:** this criterion is very close to "Learner Empowerment" of [87] and the fulfillment method has already been explained.
6. **Write down the video keywords to help learners search for related videos:** the tutor can enter the keywords used in the lecture material in each lesson nodes, which will fulfill this criterion.
7. **Offer the course progress time line in visualization graphs:** when the course designer is entering the course structure, he or she is able to set the date for each lesson. Therefore, out of these dates, the platform will generate the progress time line and present it to the learner when he or she wants to register for the course.
8. **Each short video lecture should cover at most three objectives:** the way the lessons are divided into nodes, and each node covering one objective will achieve this criterion.
9. **Let the learners be responsible for obtaining the objectives, have a voice in setting them:** this criterion has is not supported.

E-Assessment Criteria

1. **Each quiz should give feedback and or show the correct answers:** the system is designed so that when the learner gives wrong answers he or she is taken to a different path and after finishing that path, the learner is taken back to the original node where he or she made a mistake and is given the chance to answer the question again. Therefore, the learner has to learn the correct answer by herself so the framework has not been designed to give feedback or show the correct answer.

2. **Providing quiz – test report for learners to know their performance:** the system only takes the learner forward if she has answered the questions so by knowing how far she has proceeded in the course, she should know her own performance so the system has not been designed to fulfill this criterion.
3. **Using different types of questions:** when the tutor is defining each question, he or she is asked to specify the type of the question which will achieve this item.
4. **Using of electronic assessment such as E-test, short quizzes and surveys:** the tutor can choose which type of electronic question he or she wishes to be taken which will pass this criterion.
5. **Define deadlines for each quiz-test:** the questions have the option to have a deadline.
6. **Provide integrated assessment within each task:** the questions embedded into nodes fill support this criterion.
7. **Identify the maximum number of marks for a question:** the questions have points that is set by the tutor.
8. **Allow learners to suggest new questions:** the learners have the option to suggest their own questions.
9. **Create the question database:** this criterion is implicitly obtained. Furthermore, the tutor can design an exam with nodes that only have questions.
10. **Each assignment should have hints:** the tutor can always provide a hint alongside defining the question.

5.8 Assessment

The assessment regarding AMDF was conducted first, with three unstructured interviews with two MOOC designers and a professor of educational software where the interviewees were asked to give feedback about the design framework that was proposed in this research. Each of these interviews was done in one to one and face-to-face sessions and after each interview, the design framework was refined according to the feedbacks that were given. Then structured interviews were conducted where three groups of eight students were gathered together, the design framework and the personalization parameters were explained to them and then, they filled-in an online anonymous survey regarding:

1. Their passed experience using MOOCs, teaching in university level courses, designing MOOCs or other online courses with a “yes” and “no” answer options.
2. How well each of the personalization parameters was used in the design framework with a zero to a hundred percent answer options.

All these students were from the computer science department ranging from a bachelor degree students to doctoral students from different countries. Table 12 shows their past experience in MOOCs and also teaching educational level courses. The numbers in the table indicates the number of interviewees who voted for that answer. The result of this table shows that most of the interviewees had prior experience using other MOOC platforms. In addition, it also indicates that half of these students had experience teaching in university level courses. Therefore, they had a good ground of knowledge in the field of teaching and MOOCs.

Table 12: the general questions regarding the interviewees past experience in using MOOCs and teaching

Questions	**Yes**	**No**
Have you ever used a MOOC for your own learning?	5	3
Have had experience teaching in a university level course?	4	4
Have you had experience designing an online course?	0	8
Have you had experience designing a MOOC?	0	8

Table 13 shows the interviewees answers regarding how well they thought the personalization parameters were used in AMDF. The numbers in the table shows the number of interviewees who voted for that percentage of quality of use of personalization parameters in AMDF as well as their average rating. Table 13 indicates that all of the personalization parameters used in AMDF had an average rating above 60%. In addition, the best supported parameter according to this survey was the media preference. The overall results show that AMDF supports the personalization parameters well.

Table 13: the interviewees' rates regarding how well the personalization parameters were applied in AMDF and the percentage or their rates. The numbers in the table shows the number of interviewees who voted for that percentage

Personalization parameters	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	Average
Information seeking task	0	0	0	0	0	3	3	0	2	0	0	61.30%
Level of knowledge	0	0	0	0	0	2	1	0	2	2	1	75,00 %
Media preference	0	0	0	0	0	0	1	1	0	2	4	88.80%
Language preference	0	0	0	0	0	0	1	1	2	2	2	83.80%
Learning styles	0	0	0	0	0	1	0	0	3	3	1	82.50%
Motivation level	0	1	0	0	0	1	1	2	1	1	1	67.50%
Navigation preference	0	1	0	0	0	0	1	1	1	1	3	77.50%
Patience	0	0	1	0	0	0	2	0	1	2	2	75.00%
Location	0	0	0	0	0	3	0	2	0	2	1	71.30%
Weather	0	0	0	0	1	3	1	0	0	2	1	66.30%
Date and time	0	0	0	0	0	1	1	0	1	2	3	83.80%

6 CONCLUSION AND FUTURE WORKS

To summarize, currently MOOCs are in the center of attention in the eLearning world. However, the main problem of MOOC platform is their lack of support for personalization. Personalization gives the possibility for learners to learn according to their own level of knowledge, learning style and other learning preferences. These parameters are called personalization parameters in the literature. Therefore, in this research the list of 17 personalization parameters in the literature were identified and some of the popular MOOC platforms as well as adaptive MOOC platforms were evaluated to see how many of the personalization parameters they are supporting. In addition, the features used for personalization in the literature regarding eLearning were identified and the same set of MOOC platforms were evaluated to see how close they are to supporting the personalization parameters.

The results show that the popular MOOCs are at most supporting 6 of the personalization parameters but do have some of the features needed to meet these parameters. The adaptive MOOCs on the other hand are mostly fulfilling some of the personalization parameters like level of knowledge and only one is supporting the learning styles. Therefore, an Adaptive MOOC Design Framework called AMDF was proposed in this research that fulfills 11 out of 17 personalization parameters including learning styles based on Felder and Silverman's learning style model. It also passes most of the design principals introduced in the literature for MOOC platforms. It uses a novel course design that takes the learners different learning paths depending on their level of knowledge in the course. The result of an assessment with university level students shows that AMDF supports the personalization parameters.

For further research on this topic, one can extend this design framework so that it would:

1. support more than two paths for every question. For example, when there are 4 multiple choice answers for a question there would be four different paths for the learner to go to.
2. support the personalization parameters that has still not been supported.

3. use student modeling in the platform so that the learner's learning preferences is taken into account for showing the media elements. For example, if a learner is detected to be a highly visual learner and the other learning style dimensions are moderate, the interface with a large diagrams will be shown to the learner by default.

Another future work should also be to develop a platform from this design and evaluate the results to see how much it helps learners in their education in practice.

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APPENDIX 1. Description of AMDF in a scenario

In this appendix, the scenario where Marko Rossi, is taking a course on “Introduction to Python Programming” will be presented.

Learners’ interface

The course information template has been presented in Figure 21

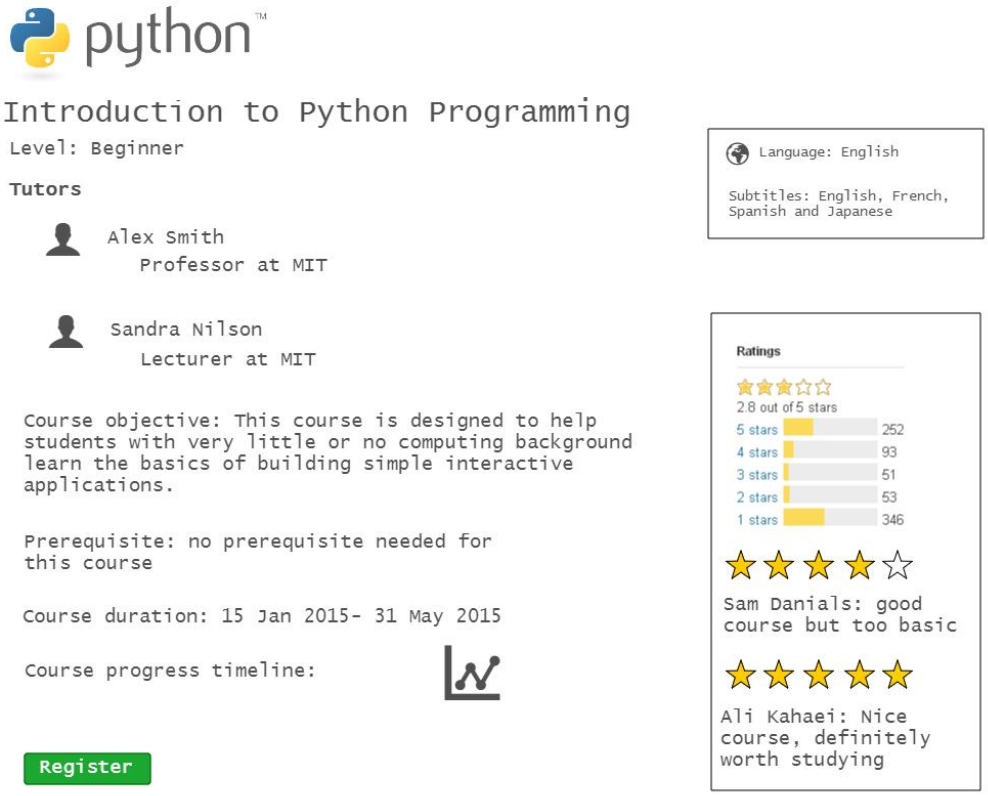

Figure 21: course information in a sample scenario.

The main interface that Marko sees is going to be like Figure 22:

(continues)

APPENDIX 1. (continues)

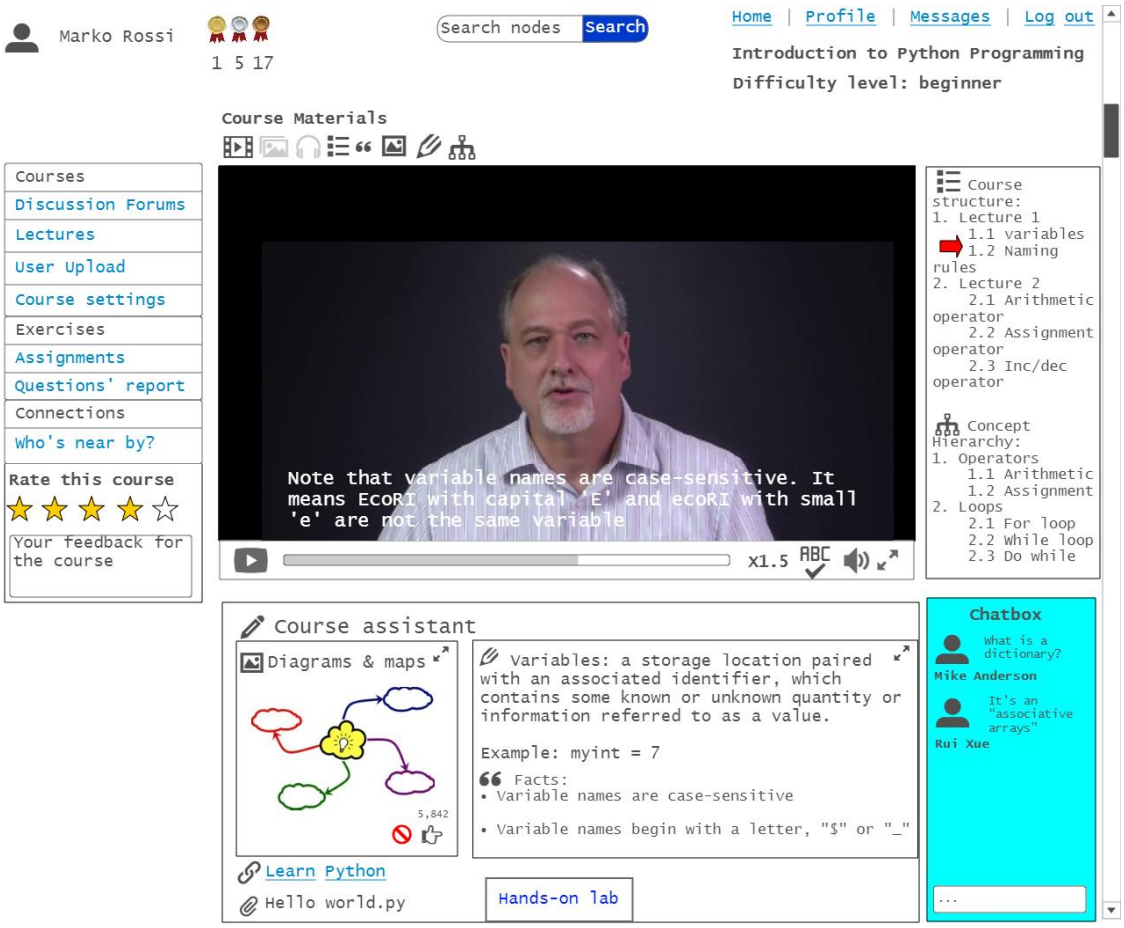

Figure 23: a sample for the main interface of AMDF.

Figure 24 shows an alternative version of the main interface where instead of a video, the slides are available and only the concept hierarchy has been shown because the learner has been evaluated to be a sequential learner.

(continues)

APPENDIX 1. (continues)

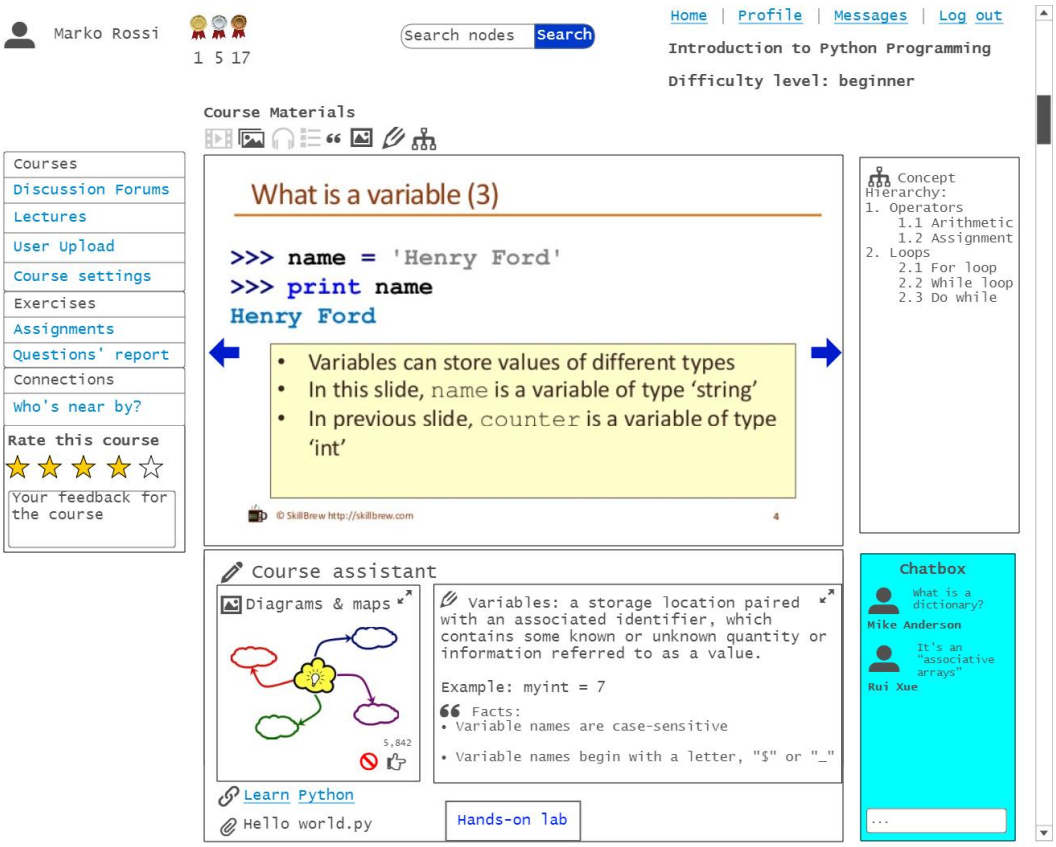

Figure 24: an alternative sample to the main interface of AMDF.

At the end of each node there might be a question similar to the figure below:

(continues)

APPENDIX 1. (continues)

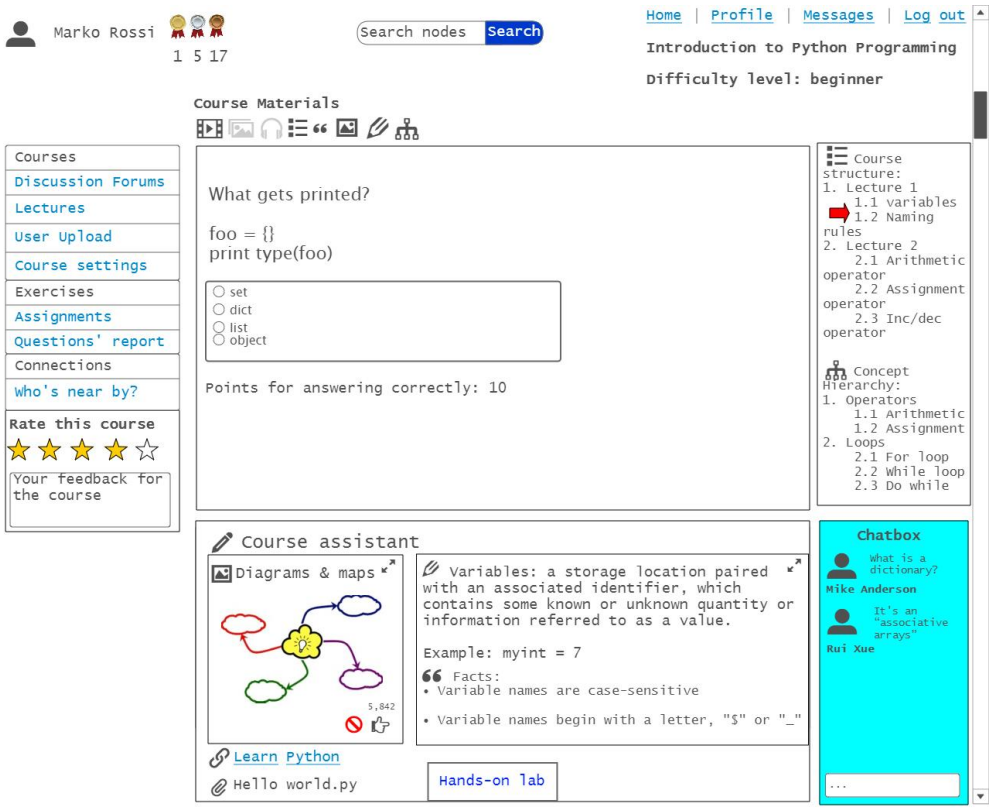

Figure 25: a sample interface for the question that might be provided at the end of the node.

The diagram and maps section and the textual media elements can expand if needed.

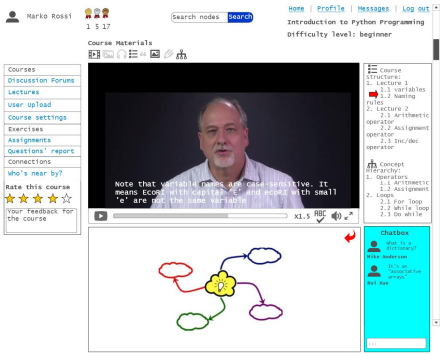

Figure 26: a sample of the main interface for the visual learners.

(continues)

APPENDIX 1. (continues)

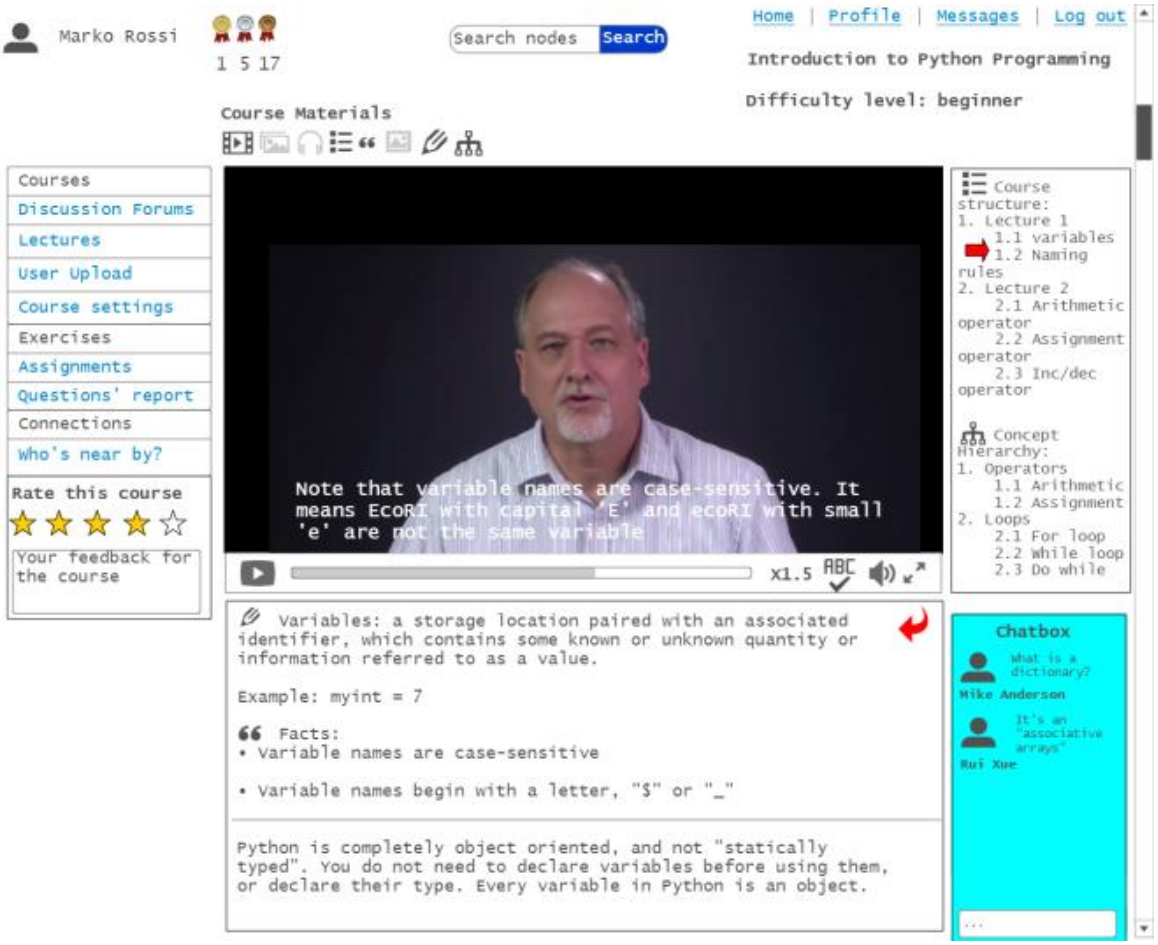

Figure 27: a sample of the main interface for the verbal learners.

Also, for active learners, the hands-on lab can expand and look something like this:

(continues)

APPENDIX 1. (continues)

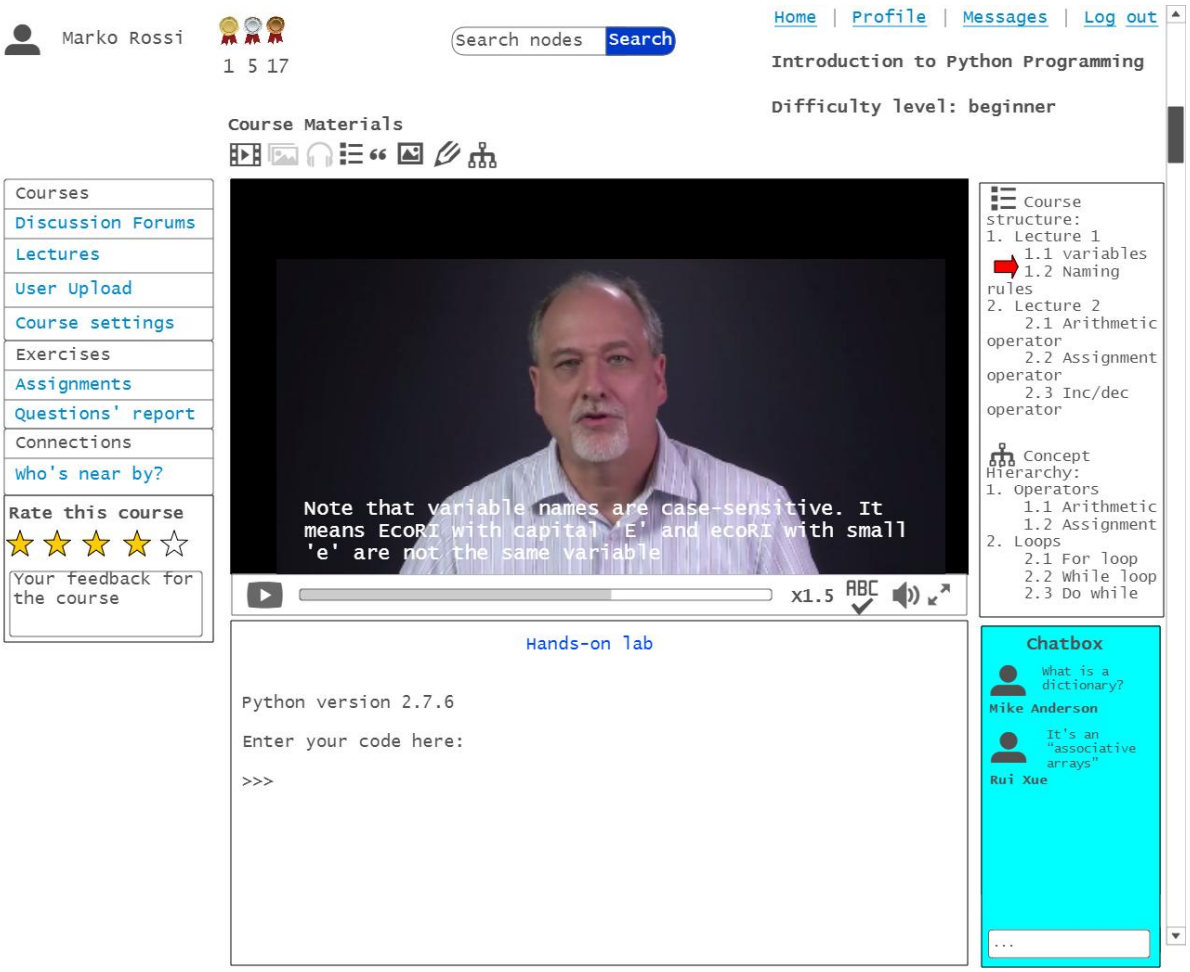

Figure 28: a sample of the main interface for active learners.

The discussion forum looks similar to Figure 29:

(continues)

APPENDIX 1. (continues)

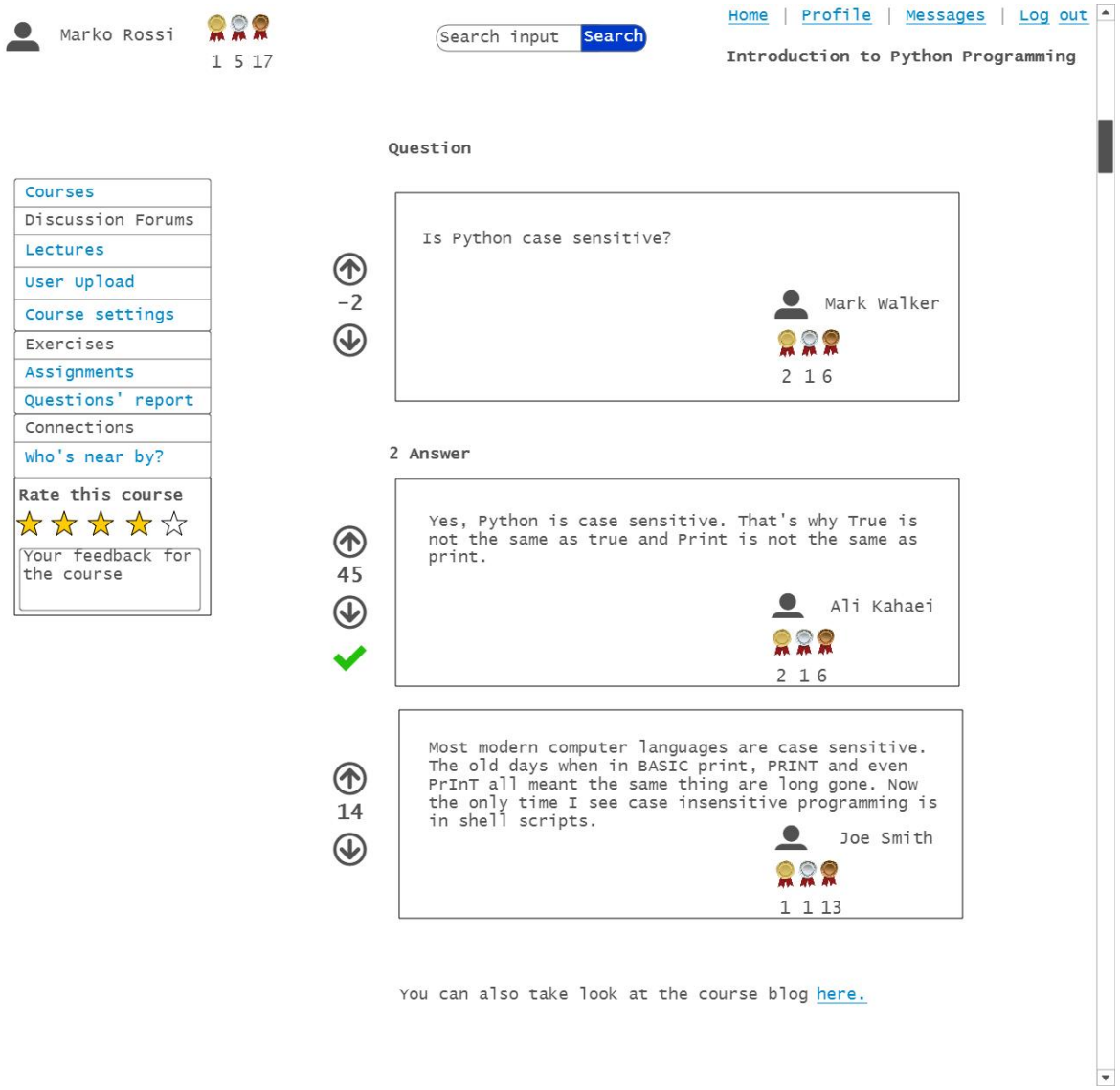

Figure 30: a sample interface for the discussion forum.

There could be exams in the course where Marko can upload a single attachment.

(continues)

APPENDIX 1. (continues)

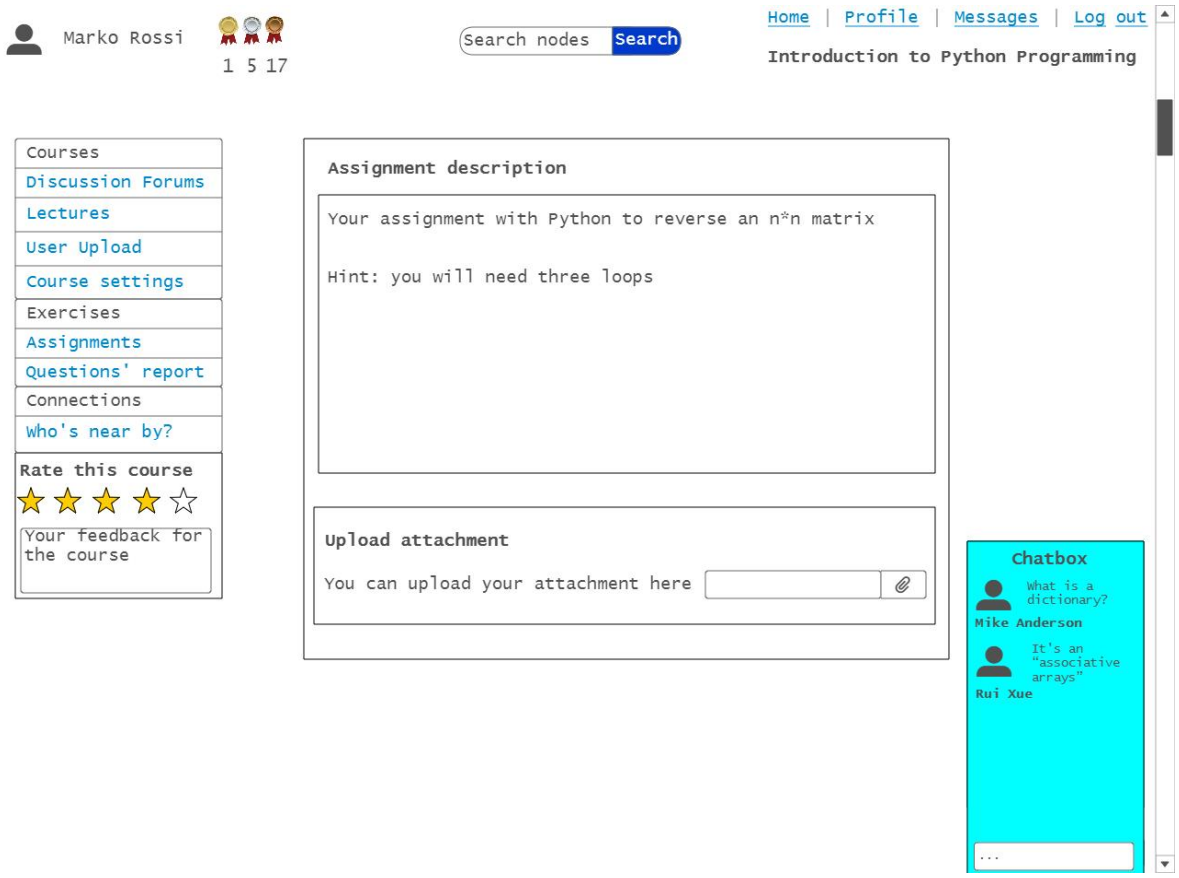

Figure 31: a sample interface for the assignments.

(continues)

APPENDIX 1. (continues)

Tutor's interface

This is what the tutor has to fill out for building the lesson related to what Marko is taking:

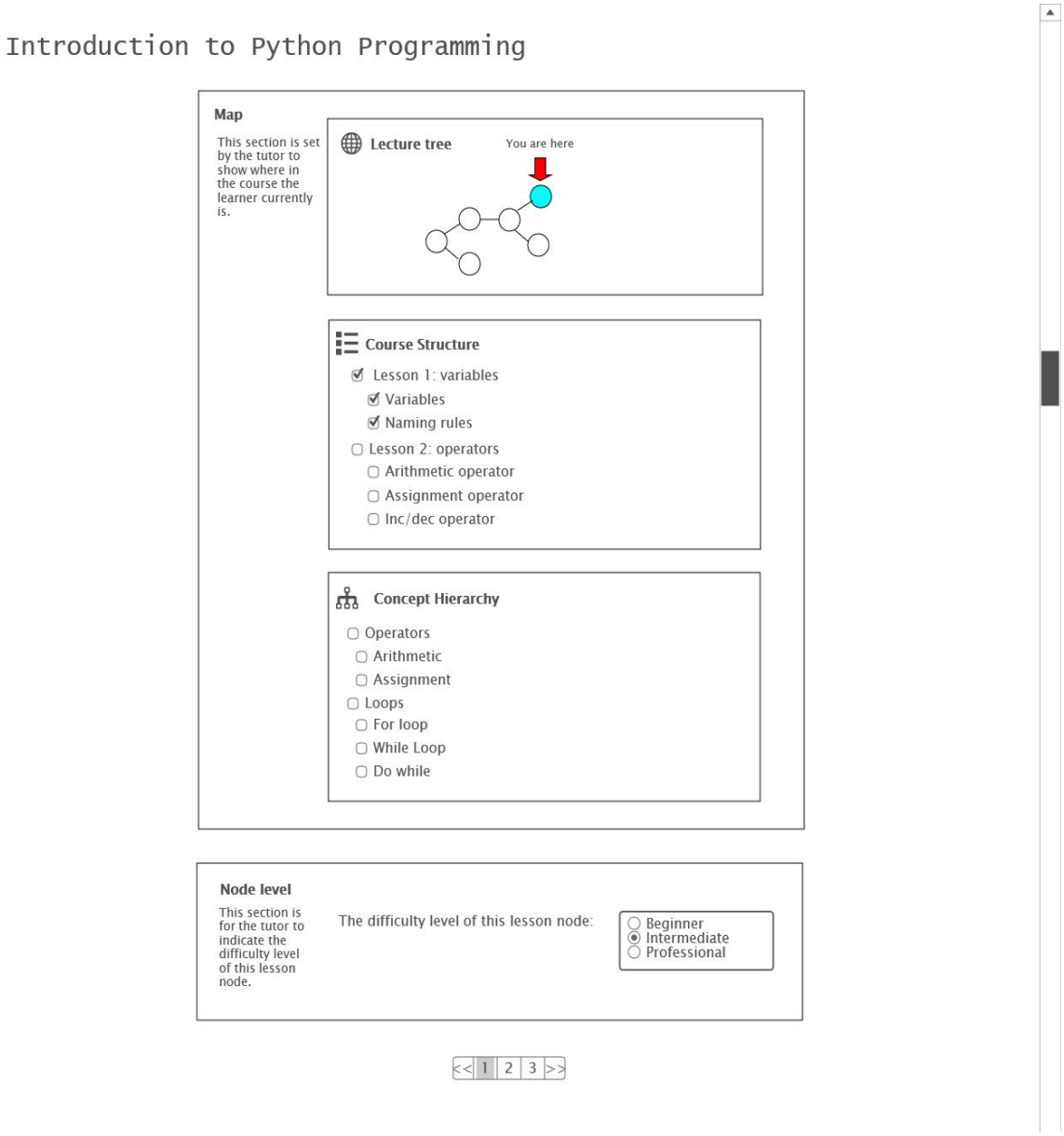

Figure 32: first page of a sample of node creation by the tutor; contains the map for indicating the node and its content details in the course.

(continues)

APPENDIX 1. (continues)

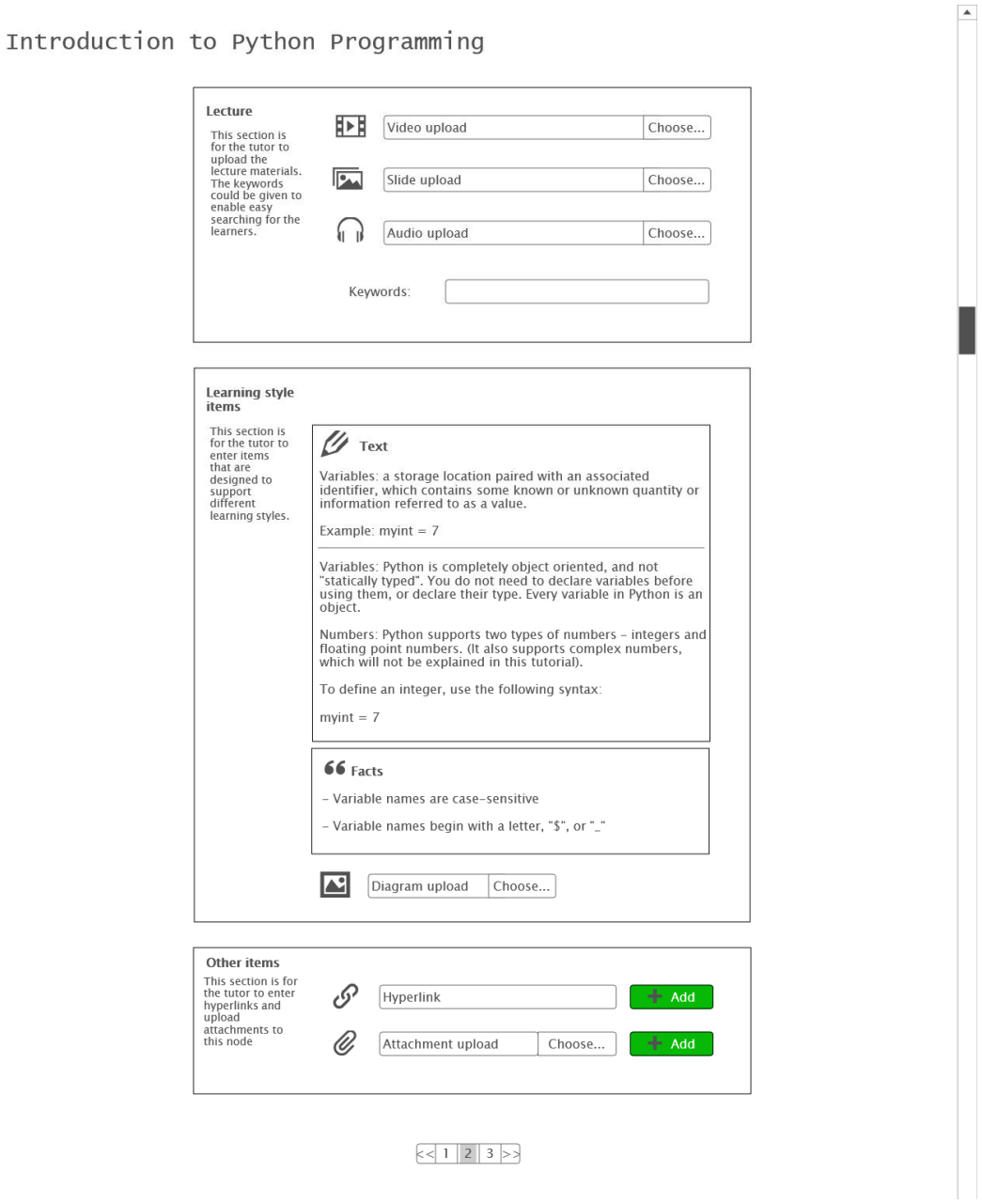

Figure 33: second page of a sample of node creation by the tutor; contains the lecture information objects, learning styles' items and other items.

(continues)

APPENDIX 1. (continues)

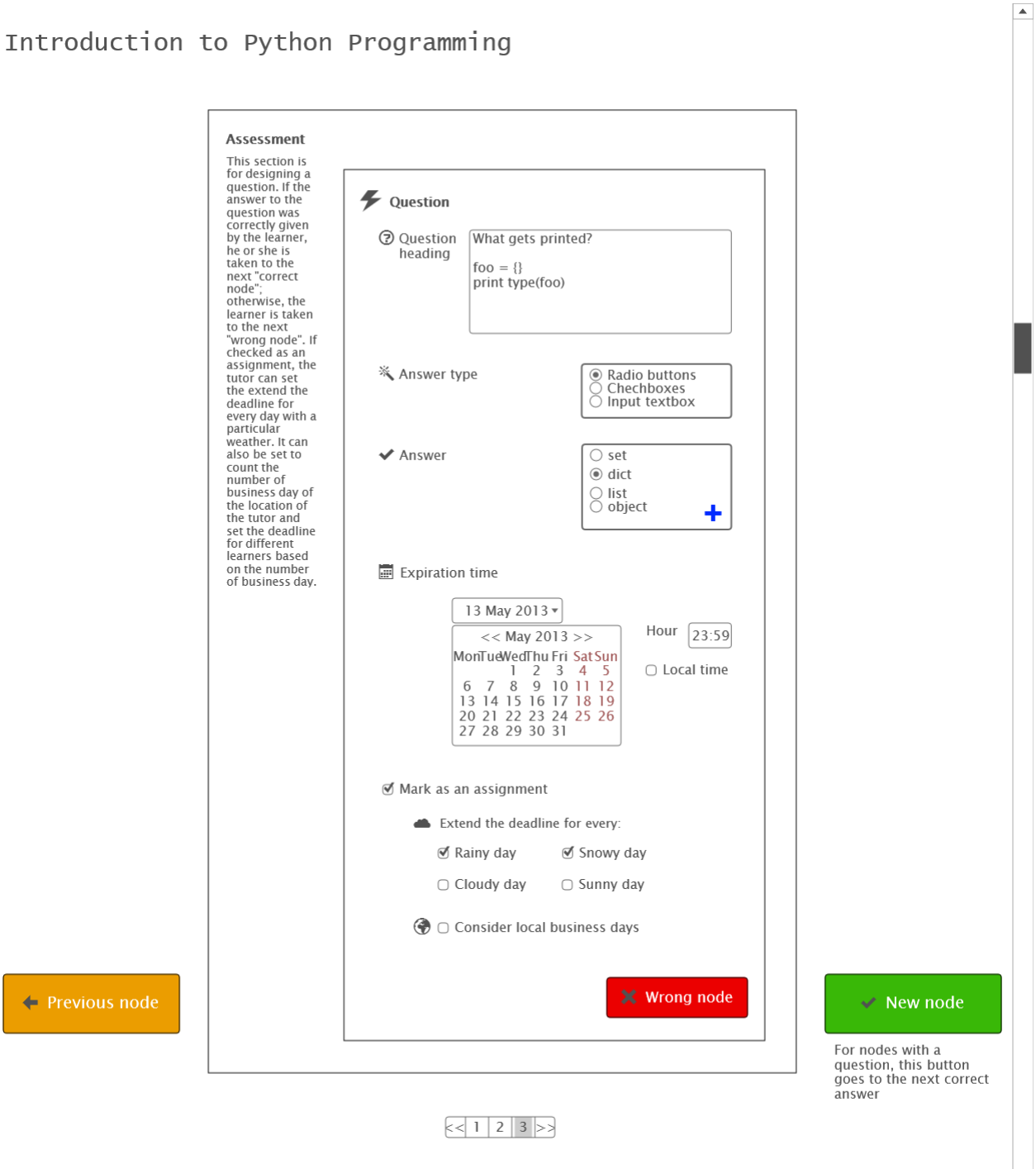

Figure 34: page three of a sample of node creation by the tutor; contains the assessments section of the node.

(continues)

APPENDIX 1. (continues)

Course designer's interface

This is what the tutor has to fill out for building the lesson related to what Marko is taking:

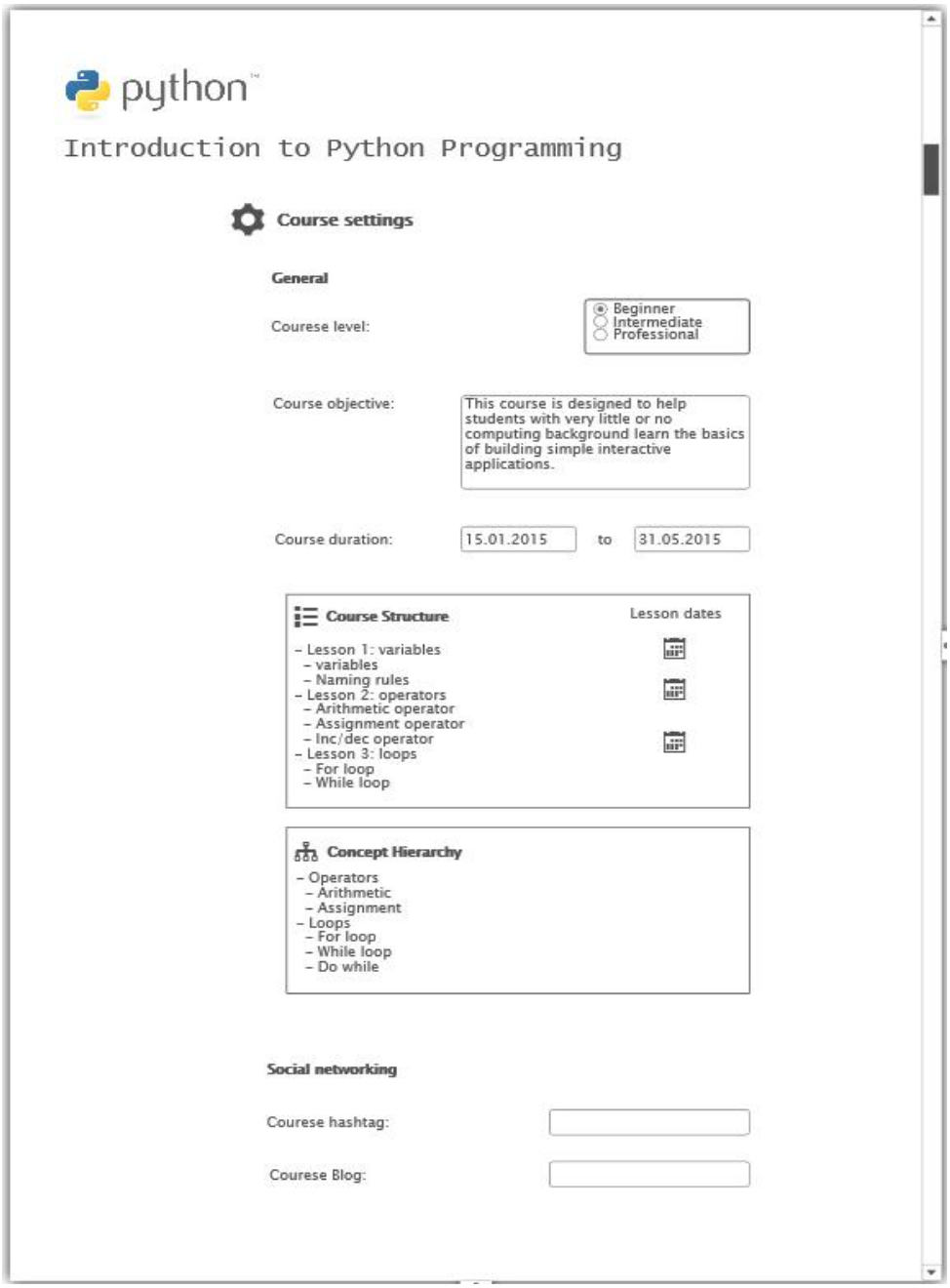

Figure 35: a sample interface for the course designer.

(continues)

APPENDIX 1. (continues)

MOOC platform manager's interface

This is what the MOOC platform manager will see in his or her interface:

Figure 36: a sample interface for the MOOC platform manager.