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Additional Information

EXPERIENCES ON USING INTELLIGENT PLANNING FOR CURRICULUM PERSONALIZATION IN MOODLE

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Abstract

In this paper we discuss our experiences on using artificial intelligence to plan customized learning paths in the Moodle platform. In particular, we found some limitations in defining students' profiles, complex relationships between activities and personalized views of the learning contents. We show how we solved this kind of problems in order to create an integrated system for the application of our planning approach in Moodle.

Keywords: E-learning, curriculum personalization, LMS, Moodle, planning.

1 INTRODUCTION

Enhancement of technology in education has increased the adoption of e-learning. An on-line connection makes it possible to access thousands of contents in e-learning platforms based on Learning Management Systems (LMSs), which eliminate the barriers of time and space that usually limit traditional teaching. LMSs facilitate the administration, delivery, visualization and monitoring of e-learning contents in a simple and functional way.

There are many LMSs (Moodle, Ilias, Atutor, Docebo, .LRN, etc.) widely used to support learning/teaching activities. In particular, in our work we focus on Moodle (Module Object-Oriented Dynamic Learning Environment, www.moodle.org) that is a free, open-source web application for modular internet-based courses. Teachers and students interact in Moodle by means of activities and resources, which optionally provide additional information to the activities. Hence, courses can be created by appropriately combining activities and resources. Considering how the Moodle platform (as well as all other LMS) was initially conceived, the courses do not allow personalized learning paths according to the specific needs of each student but they can be built to be executed in the same manner by all the participants. On the contrary, the maximum benefit in e-learning is achieved when each student can execute a fully personalized learning path.

Curriculum personalization can be faced in several ways with the objective to offer the best contents to the adequate person. We focus on intelligent planning as a valuable formalism to describe actions (course's activities) in terms of preconditions and causal effects to find plans (learning paths) that entirely fit the students' profiles.

The integration of planning into LMSs is not straightforward. We have embedded a planning approach in Moodle to support this personalization by facing all the limitations that we found in the platform. Here, we discuss about these limitations and how to solve them. First, complex relationships between activities that usually appear when planning elaborate courses cannot be easily defined in Moodle. Second, the information that students input into Moodle are not always sufficient to exhaustively define their background and learning goals, essential to customize each learning path. Third, a challenge arises to personalize the visualization and navigation of each individual learning path.

1.1 Related Work

The use of LMSs makes the learning process friendly to students, who interact with teachers in a better way than in traditional classroom teaching [1]. It is important to consider the differences between students' characteristics (profile, learning style, prior background and learning objectives). In fact, these characteristics are very useful to provide each student the most adequate learning path to attain his/her learning outcomes ([2], [3]). According to previous considerations, it is reasonable to consider that it is not enough to plan a general learning path for all the students enrolled in a course but it is fundamental to customize as much as possible each learning path. The recent literature shows

that there is a great need for systems that can provide customized educational content automatically built by combining appropriate learning elements ([2], [3], [4], [5], [6]).

There are a number of studies that, not focusing on a specific LMS, approach the problem of personalization in different ways. For example, a study based on the students' results of pre-tests, has led to a genetic-based customized e-learning system [5] or even by using the Item Response Theory (PEL-IRT) it is possible to find personalized learning paths by considering the difficulty of the learning material to be provided and the ability of the students [7]. It is also possible to achieve tailored learning content by combining a personalized multi-agent e-learning system based on item response theory with an artificial neural network [4]. There are also a variety of studies that approach the customization problem from the point of view of artificial intelligence. For example it is possible to use Bayesian networks [8] to achieve the general prediction of the students' behavior towards distance education as a guide to help in decision-making teaching's procedures. Studies on intelligent planning similar to our idea have been used for personalization of learning paths ([2], [6]) and involve the idea to create a planning ontology from the e-learning information and use standard planners to solve the problem.

Our work involves intelligent planning specifically geared to Moodle. There are studies that consider Moodle as valid LMS to learning/teaching activities but just focus on its characteristics and explain how it works ([1], [9], [10]). By focusing on improving a non-real time course management (i.e. statistics, clustering, classification, visualization, etc.) it is possible to work in Moodle by using data mining techniques [11]. On the contrary, our work applies the artificial intelligence to Moodle in order to create a real time learning paths' customization based on the specific learning characteristics of each student.

2 PLANNING VS. E-LEARNING

In this section we will show at first what a planning activity is in general and then how we can integrate planning with e-learning.

2.1 The Planning Activity

In general terms, doing a planning activity implies taking the right decision about the most appropriate action to be done at a given time, by considering a certain lapse of time. Technically speaking, a planning activity selects a subset of actions in a certain domain in which these actions are related by links of cause and effect, so that after their execution it is possible to achieve a certain goal state, by starting from an initial state [12]. The standard language used in planning is PDDL (Planning Domain Definition Language) [12] that divides the domain data (which describes a family of similar problems) from the problem data. In particular, the domain contains a set of actions (each one with its preconditions and effects) while the problem contains an initial state of the world, the goals that need to be achieved by using the appropriate subset of actions of the domain and a metric that needs to be optimized (number of actions, makespan, etc.). By considering the problem and the domain file, a planner returns a plan that is a sequence of actions that allows us to achieve the objectives starting from the initial state.

2.2 Planning in E-learning

Customize a learning path means, in essence, to design a sequence of learning activities that allows the student to achieve a set of learning goals, starting from his/her initial learning state. So, through an e-learning to PDDL mapping, we can compare the initial learning state and the learning goals of each student as the initial state and the goals of a PDDL problem and all the learning activities (related by causal links) as actions of a PDDL domain. The specific learning path for each student will be represented by a plan containing the adequate set of actions that permit him/her to achieve his/her learning objectives by starting from his/her initial state.

2.2.1 A Simple Example

Let us imagine that two students, Mark and Diana, want to take a Physic course. The course is composed by three sequential modules: Mechanics, Thermodynamics and Electromagnetism (M, T and E for short). M has duration of 35 hours, while T and E have duration of 30 hours. The last year Mark took the M module and for this year he is interested in taking the modules T and E. On the contrary, Diana does not have any previous Physics knowledge and for this year she wants to complete only the M module. We can represent the information about the course (preconditions and

effects of each module) in a PDDL domain while we can translate the information about the students (initial states and learning goals) in a PDDL problem. In Fig. 1 we show the action of the PDDL domain for the T module, while Fig 2. shows the PDDL problem.

```
(:durative action T
:parameters (?s - student)
:duration (= ?duration 30)
:condition (at start (and
        (not (T_done ?s))
        (M_done ?s)))
:effect (
        (at end (T_done ?s))))
```

Fig. 1. The representation of the T module in a PDDL domain.

```
(:init
        (M_done Student_Mark))
(:goal (and
        (T_done Student_Mark)
        (E_done Student_Mark)
        (M_done Student_Diana))
```

Fig. 2. The PDDL problem for Mark and Diana.

3 PLANNING INTEGRATION IN MOODLE

We chose Moodle as LMS to be integrated with a planning activity. Moodle is a platform used all over the world not only by schools and universities, but also by companies. There are several reasons which make Moodle so interesting: it is simply to use and to eventually modify and there is a forum (https://moodle.org/forums/) that connects users and developers all around the world to exchange ideas and resources. Moodle works on Windows, Linux and, in general, on all the systems that support PHP. Furthermore, the platform can use databases as Oracle, MySql and PostgreSQL.

Once shown a general overview of the tasks to be performed to implement the planning process in a LMS, in this section we will discuss about the limitations to be faced in the platform in order to implement the automatic generation of learning paths, according to the specific learning needs of each student.

3.1 General Overview of Planning Implementation

Once chosen the appropriate LMS, i.e. Moodle in our case, our work of personalized learning paths generation involves the following steps:

1. Carry out a mapping of the different elements (and any relationships) present in Moodle and study the way in which a student can enter the platform information about his/her background and his/her learning objectives.

2. Build a course with all its elements and relationships.

3. Students who take the course have to fit into the platform information about their own initial states and learning goals.

4. Create the PDDL documents: the relationships between the course's activities are translated into actions of a PDDL domain, while the information about students' initial states and learning goals are translated into a PDDL problem.

5. Use a planner that, considering the PDDL documents can generate a plan, or a set of learning paths (one for each student enrolled in the course);

6. Create a personalized course's view for each student. In particular, it is necessary that each student visualizes only the tasks that belong to his/her learning path;

7. Develop an appropriate monitoring activity which takes into account the possible variations of students' learning objectives, in order to eventually re plan the paths;

We found some difficulties in the steps 2, 3 and 6. In particular, in the step 2 we found a limitation in establishing complex relationships between the course's activities while in the step 3 we had to face the problem of the lack of sufficient information insertable by the students in the platform. Finally, in the step 6, we found a limitation in creating personalized views for the students.Thus, in the following paragraphs, we will discuss more deeply about these limitations and how we solved them.

3.2 Building a Course: Limitations in Defining Complex Relationships

In Moodle we define a course by using the activities such as lessons, chat, wiki, forums, etc. In addition, we can use the resources (web page, link to a web page, page text, label etc.) which are used to transmit additional information to activities.

We chose to design a course by only using the lesson module. We selected this kind of activity because it is very simply to use for both students and teachers and, above all, it is the only activity that allows us the definition of relationships with other activities. A lesson is composed of a sequential series of pages. The teacher can add or remove pages, depending on the specific educational requirements. The total number of pages depends on the total content which is necessary to provide. Each page ends with a question which contains a number of possible kinds of answers (true/false, multiple-answer, numeric answer, etc.). Only if the student answers correctly, s/he will be able to continue with the next page in the lesson, or otherwise s/he will have to repeat the entire lesson or the single page. It is not mandatory that the student completes the lesson at one time but s/he can access it several times. The teacher can optionally associate a percentage grade of completion, by taking into account the contribution of resolution of the individual pages.

In general, when defining a lesson the teacher can set two kinds of links related to other activities: "dependency" and "activity link". The first is a binding link while the second is considerable as a simple suggestion. Let us clarify these concepts with an example. Let us imagine that the teacher is structuring a certain lesson L2, as shown in Fig. 3. We suppose that L2 cannot be executed before the completion of the lesson L1. Like shown in Fig. 3, the teacher can set the dependence of L2 from L1. Let us imagine also that it is necessary to suggest a lesson L3 to take after the completion of L2. This should be achieved by setting L3 in the field "activity link" in the configuration page of L2 (see Fig. 3).

As well as the "activity link" helps us connect a lesson just to a single activity, we cannot have a dependency on more lessons but, at most, only on one other lesson. From the perspective of planning this is very limiting because it requires the student to perform a single possible path within the course.

To ensure that a lesson can be constrained by multiple dependencies and that once concluded it can lead to more than one activity, we insert the concept of fictitious lesson. Unlike a real lesson, it is an activity that represents the achievement of a certain learning level (or learning state) on which depends the performance of others (real) lessons and that can be reached by completing one or more alternative lessons.

Let us elucidate the concept of fictitious lesson by making an example. Let us consider the fictitious lesson Lc of the Fig. 4. Lc can be reached by alternatively completing the lessons La or Lb (we have to set Lc in the field "activity link" of the two real lessons' configuration pages). Only after Lc is completed, it is possible to start the lessons Ld and Le (in particular, we can translate this constraint by setting Lc in the field "dependency" of Ld and Le's configuration pages). On the contrary, in this case it is not necessary to change anything regarding to the field "dependency" and "activity link" of the fictitious lesson (in the following paragraph we will explain that all the fictitious lessons within a course have to depend on a particular fictitious lesson).

Fig. 3: Definition of relationships for Lesson L2 in its configuration page in Moodle.

Thus, we can establish complex relationships within a course by using fictitious lessons to ensure that students can take more alternative learning paths. All the relationships between lessons will be translated into preconditions and effect of actions in a PDDL domain.
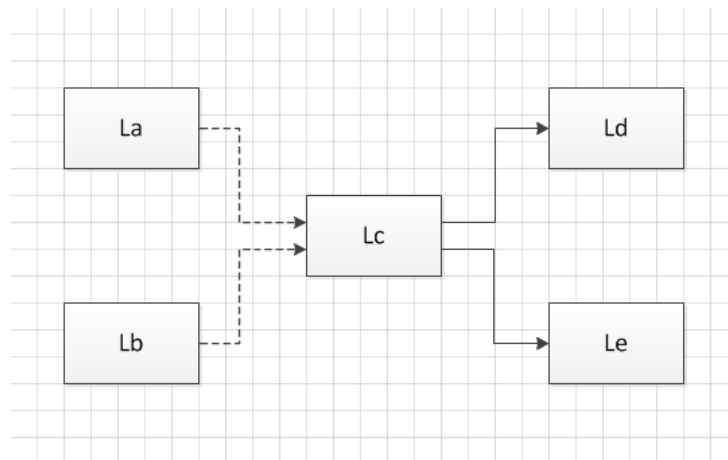

Fig 4. "Activity links" (as broken lines) and "dependencies" (as continuous lines) as relationships for the real lessons and the fictitious lesson Lc.

3.3 Students' Enrolling in the Course. Limitations in Defining Initial States and Learning Goals

Once built the course, it is the moment that the students have to input their initial states and learning goals in the platform. This step is fundamental because only knowing the specific learning characteristic of each student, it is possible to plan (before the effective start of the course) the learning path most appropriate to his/her needs. Similarly to LMSs, Moodle is not initially designed to provide customized contents to the different students enrolled in a course. In fact, as shown in Fig 5., the information insertable by a student in the platform refers just to his/her general characteristics (name, e-mail, city, etc.) but there is not a field in which s/he can express his/her own previous knowledge and what are his/her learning goals with respect to a certain topic.
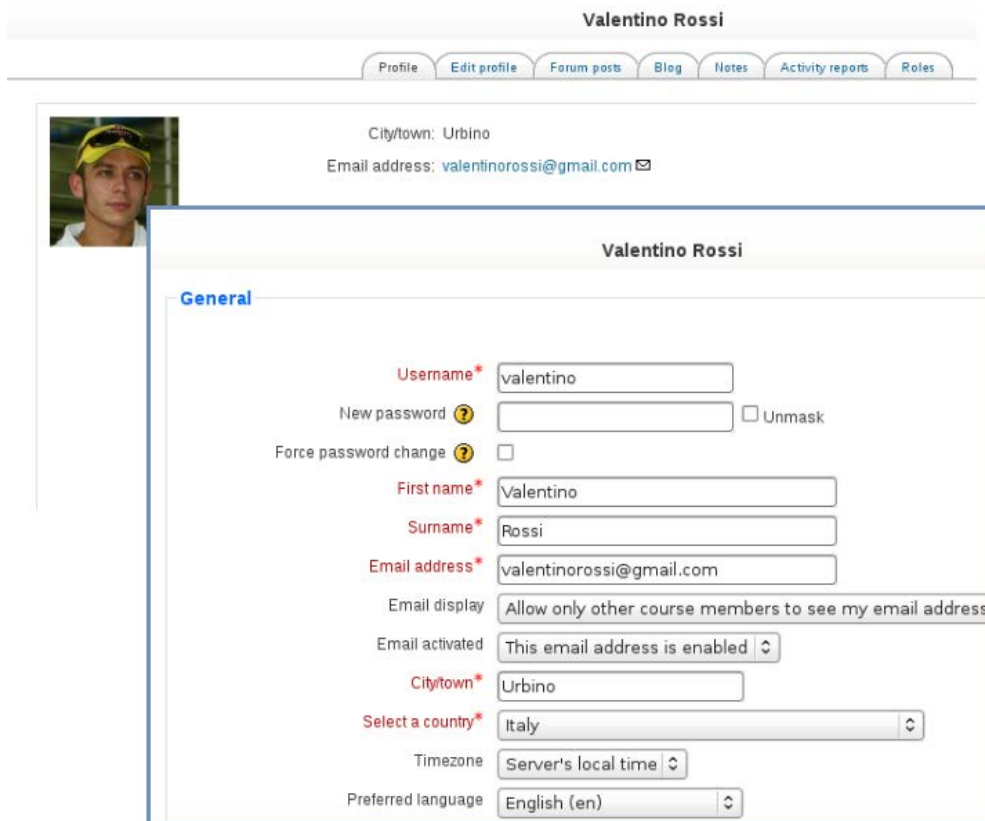
Fig. 5. A student's profile in Moodle

By using the concept of fictitious lesson, we found a way to define the initial state and goals of each student. In particular, we solved Moodle's limitation by creating an initial questionnaire L0, which is a particular lesson to be executed before the effective start of the course. L0 consists of two question pages, concerning respectively the initial state and the learning goals of the student. Let us revisit the example of the Physics course in section 2.2.1. We can create a L0 as shown in Fig. 6. In particular, we can observe that in the two question pages students can define their initial states (in terms of modules already performed) and their learning goals (in terms of modules to take). All the fictitious lessons will depend from the initial questionnaire (by setting L0 in the field "dependency" of their configuration pages). The execution of L0 makes it possible to know the necessary information which has to be appropriately translated into initial states and goals of a PDDL problem. This document, along with the PDDL domain, will be used by a standard planner to generate a plan that includes a learning path for each student.
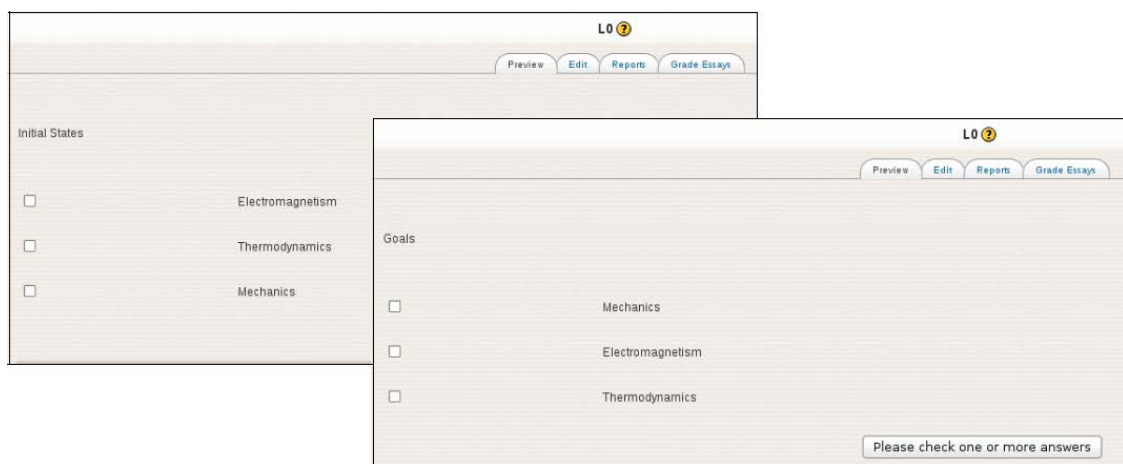

Fig. 6 Initial states' and Learning goals' question pages in L0 for the Physics course

3.4   Course Navigation. Limitations in Defining Personalized Views

Once generated a plan (which involves a learning path for each student enrolled in a course) it is necessary to create personalized views for the different students by considering the specific lessons that belong to each learning path. But this process is not so simple. In fact, as explained above, Moodle platform was initially designed to provide the same material (activities and resources) to all the students enrolled in a course. Thus, we found some limitations concerning the ability to create groups of students for membership in the various lessons of a course.

In general, if we want to assign one particular activity (and thus make it visible), which can be a lesson or any other activity, only to a selected cluster of students, it is necessary first of all to create a "group" containing the selected students and then a "grouping" associated to the particular activity. Thus, we have to make the association between the "group" and the "grouping". In particular, a "grouping" can contain one or more "groups".

Let us consider the example in Fig. 7. Let us imagine to have a course consists of three activities: A1, A2 and A3. Students enrolled in the course are Paul and Kate. Considering the specific learning paths of a supposed plan, it is necessary that Paul takes the activities A1 and A2 while Kate has to take the activities A1 and A3. Thus, it is necessary that the two students visualize both the activity A1 and in addition, A2 must be just visible for Paul and A3 must be only visible for Kate. These constraints in Moodle should be achieved by creating two "groups" g1 and g2, each one associated to a student. Then, it is necessary to create three "groupings" to be associated to the three activities and to set for each activity the "separate group" mode. In fact, without setting this parameter, activities will be visible for each student enrolled in the course. Finally, we have to make the associations between "groups" and "groupings". Unfortunately, for all we know about the structure of the platform, the desired results (prior to any modification) were not achieved. In fact, Paul visualized only A2 while Kate visualized only A3. We had to write some modifications in the code and we got the correct visibility of activities for groups of students. Consequently, once a plan is generated every student can now visualize only the lessons which s/he has to perform, that is, him/her own learning path.

4   DISCUSSION AND CONCLUSIONS

Learning paths' personalization in Moodle, faced from the point of view of artificial intelligence involves a number of steps to execute. Once built a course and enrolled a number of students, by using the PDDL language it is possible to convert the information about the course in a PDDL domain and the information about the students enrolled in the course (in terms of initial background and learning goals) in a PDDL problem. Then, it is necessary to give these documents to a standard planner to generate a plan, i.e. a learning path for each student. It is essential that each student only visualizes the activities that are included in his/her own path. The last step to perform consists in developing a way to monitor the execution of each learning path to eventually re plan the routes.

The aim of this paper was to discuss about all the difficulties that we had to face in performing these steps. These difficulties arise mainly from the fact that Moodle (as well as other LMSs) is not originally designed to provide personalized contents. In fact, prior to any modification, it is not possible to create customized learning paths by considering initial state and learning goals of each student. In particular, it is not possible to create complex relationships between the activities within a course and the information about initial state and goals insertable by students in the platform is very limited. By supposing to generate a plan (which includes a learning path for each student enrolled in a course), it is not possible to create personalized views of the course's activities and so it is not possible to associate (and thus make visible) to a student only the activities included in his/her own path.

Thus, we had to do a number of modifications in the platform, in order to achieve our objective of customized contents. In particular, we decided to create courses by only using the lesson module because it is the only activity that allows us to create relationships between activities. Then, we solved the problem of the lack of complex relationships by creating fictitious lessons that allow us to establish more than one link between two lessons. We used this kind of lessons also to model students' profiles (background and learning goals). In particular, we created a specific fictitious lesson, called L0 or initial questionnaire, that is composed by two question page where students can express their initial states and goals before a course starts. Only with these modifications it is possible to create the PDDL documents to be passed to a standard planner in order to generate a plan. By modifying the code we obtained that, assuming to have a plan, i.e. a number of learning paths (one for each student enrolled in a course), each student can have a personalized view of the course.
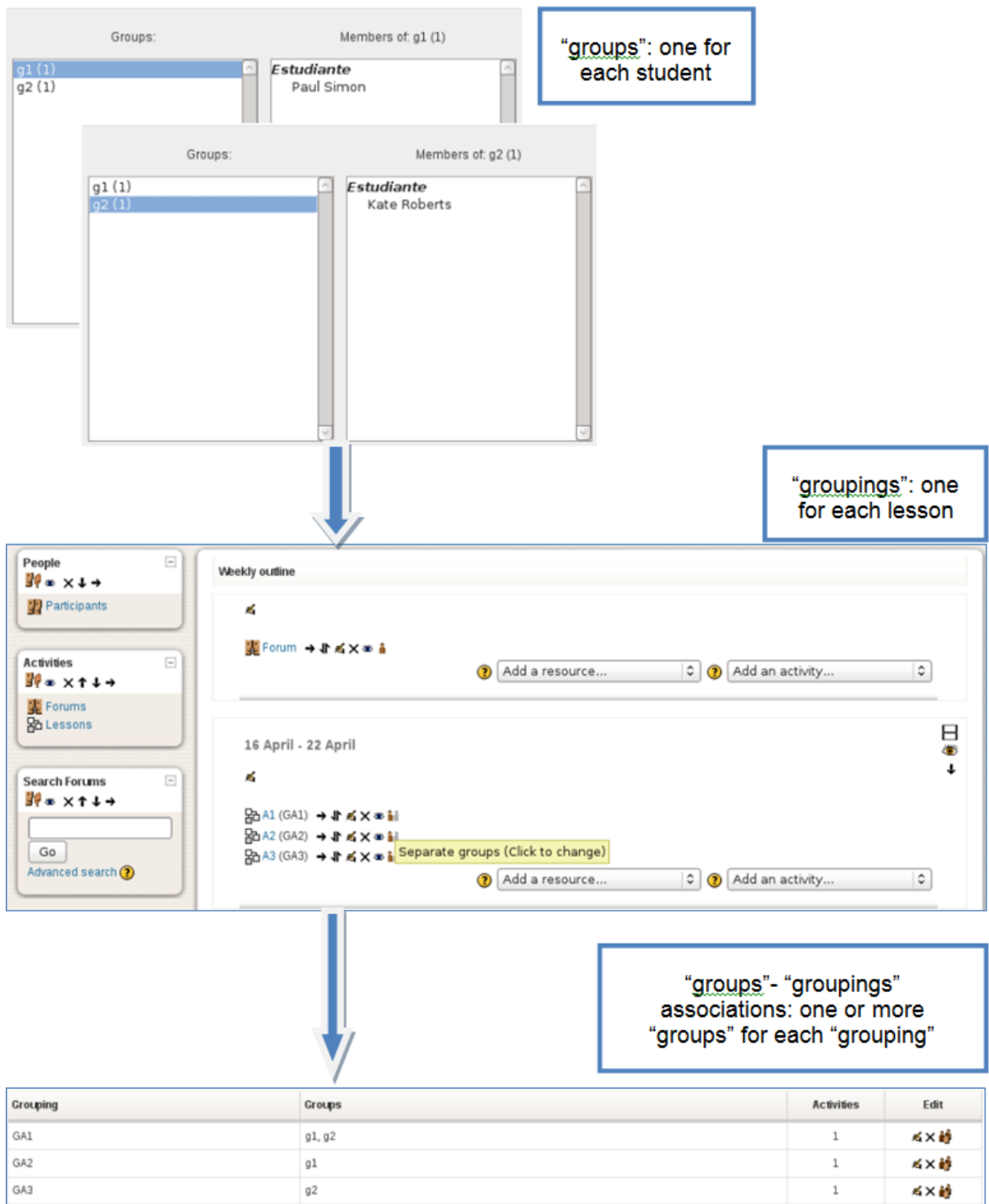
Figure 7: How to associate activities to students in Moodle.

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