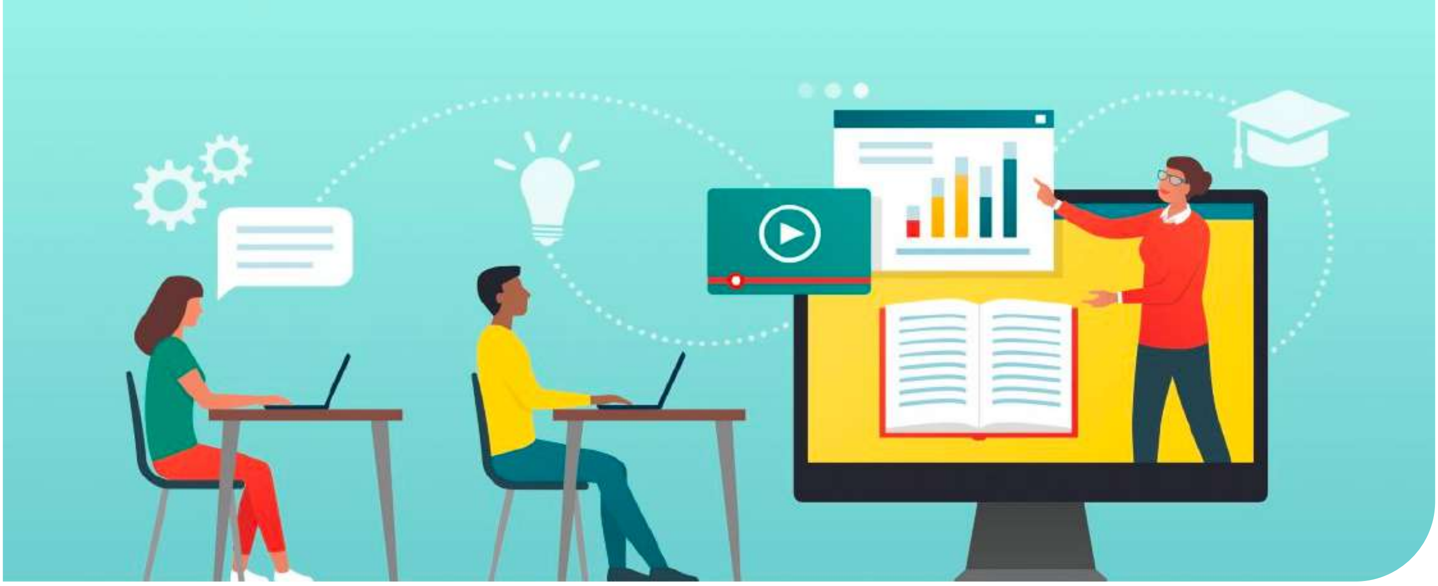
A guide to teaching Alloy 6 with Module



WHAT IS A DIDACTIC MODULE

A teaching module is a significant, highly homogeneous and unified part of a planned disciplinary program, having well-defined verifiable objectives based on building up skills and knowledge in discrete units. Distinctive hallmarks of a module are: clarity in the definition of learning goals, active participation by learners, utilization of a variety of media and systematic organization of learning opportunities.

WHY MODULE ON ALLOY 6?

In the last decades, efforts have been made to overcome the limitations of a traditional teaching method which has been found to be uninspiring and uninvolving by students and likely to result in their passive participation in lectures. In this regard, teaching modules can be an effective teaching alternative since their goal is to transform classrooms into active, student-centered learning environments. Especially, disciplines like software engineering that are deeply linked to practical aspects lend themselves well to the use of teaching modules. In these cases, an engaging method that holds students more accountable, and calls them in for self-assessment on their understanding of new concepts and for solving exercises and real problems is necessary. In particular, for what concerns software engineering, the main goal is to develop good software that can be delivered within specific requirements and for this purpose a formal specification language like Alloy can be useful, especially with the new temporal logic introduced in the sixth version. For this reason, we propose here an exhaustive teaching module for understanding and learning Alloy 6.

THE PROBLEM

The purpose of this guide is to find the most effective way of presenting the new concepts in Alloy 6 to students already familiar with Alloy 5, trying to make teaching as engaging and exciting as possible and ensuring that the students will be able to transform theoretical knowledge into practice.

The fundamental aspect in the definition of a teaching module is the identification of learning objectives so that students understand what is required to them.

In order to get students more deeply involved in the learning process, it is necessary to adopt a strategy that allows a "balance of power" between students and teachers, making lessons interactive and dynamic.

A successful lesson requires the introduction of alternative teaching strategies that allow students to test themselves and assess their own level of understanding during the lesson.

SOLUTION

Different didactic forms were used to define an effective Alloy 6 teaching module, all are listed and will be detailed throughout this work.

1 LESSONS

2 EXERCISE

3 CHALLENGE

1. LESSONS

Two lessons of 45 minutes each are designed to give a full explanation of the features introduced by Alloy 6. A flipped-classroom is provided between the two classroom lessons, described in detail in the following sections.

1.1 PREREQUISITES

In order to be able to deliver these lectures, students are required to be familiar with first order logic and notation and specification methods of Alloy5 in particular.

1.2 LEARNING STRATEGIES

The main strategy to follow in the theoretical part of the module is structuring lessons with the aid of succinct slides to call attention especially to the main concepts. At the beginning of the theoretical part, setting goals strategy is chosen to explain exactly what students are supposed to understand and what they must be able to do. The first part of the two lessons must link to the previous students' learning, while the end of the second reviews the main ideas of the theoretical part of the module. The second lesson also furnishes opportunities for self-assessment, peer feedback and teacher feedback through quizzes that also signal transitions between lesson parts. In order to indicate the students’ level of content understanding, traffic light questioning[1] and feedback from students must be present during both lessons.

[1] traffic light questioning: red (stop),yellow (caution), and green (continue)

1.3 LESSON MATERIALS

Both the first and second lessons are to be explained with the support of a set of slides created with Microsoft Power Point and attached to this guide. In addition, quizzes to test comprehension of the topics and the effectiveness of self-study are to be given at the beginning of the second lesson in class, as will be detailed later in the guide.

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1.4 FIRST LESSON

The aim of the first lesson is to make a comparison of how variant time systems are represented in Alloy 5 and Alloy 6, showing how the latest version of the language is more effective for this purpose due to the introduction of a new logic and new keywords.
After this, some of the innovations introduced by Alloy 6 will be presented in detail. A detailed list of the topics covered in the first lesson is given below along with the time required to fully explain each one.

1.4.1 PRE-REQUISITES see section 1.1

1.4.2 LEARNING STRATEGIES see section 1.2

1.4.3 TOPICS

Overview of learning objectives (5 min.)

Static vs. Dynamic World (5 min.)
- What is the meaning of "static" in Alloy
- What is the meaning of "dynamic" in Alloy

How to represent dynamic models in Alloy 5 (20 min.)
- Overview of the ordering method and limitations
- Overview of the use of the time signature and limitations

Alloy 6 (10 min.)
- Introduction to the use of Linear Temporal Logic
- Use of the "var" keyword.

1.4.2 LESSON MATERIALS see section 1.3

1.4.5 LEARNING OUTCOMES

At the end of this first lesson, students should be able to understand:
- How Alloy 5 deals with dynamic modeling
- The limitations of dynamic modeling in Alloy 5 and the need for the new version of Alloy.

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1.5 FLIPPED LECTURE

The flipped classroom method is used to help students to learn the part of the topics related to temporal connectors introduced in Alloy version 6. Since the pattern used for their explanation is fairly repetitive, students are ready to understand all the connectives, with the possibility to dwell on the more complex ones as they see fit.

1.5.1 PRE-REQUISITES

Students should have attended the first lecture where the LTL and the “var” mutable keyworkd were presented.

1.5.2 LEARNING STRATEGIES

The strategy used by the teacher is that of explicit-teaching. The teacher, in the recorded video, unidirectionally explains the concepts leaving the opportunity to raise doubts and gather opinions in the next lesson, using feedback and questioning later.

1.5.3 TOPICS

The focus of the flipped-classroom is on temporal connectives, both present and future, which the user can use after having understood the concept of LTL to define assertions, facts and predicates. All connectives are presented in the same way, always following the same pattern: syntactic definition, semantics and application example.

1.5.4 LESSON MATERIALS

The teacher provides the video and the slide set containing the whole content of the video.

1.5.5 LEARNING OUTCOMES

At the end of the flipped-classroom, students are ready to use with awareness all temporal connectives provided by Alloy 6 and they are able to face the following arguments such as time horizon, new visualizer and concurrency. With this method, students develop the ability to study independently with a video, without a guide.

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1.6 SECOND LESSON

The second lesson has two main objectives: the first is to check, as mentioned above, the student's understanding relative to the first lesson and the flipped classroom; the second is to carry on the explanation of the new features introduced by Alloy 6.

1.6.1 PRE-REQUISITES see section 1.1

1.6.2 LEARNING STRATEGIES see section 1.2

1.6.3 TOPICS

Quizzes about the previous lecture and the flipped one (20 min.)

Alloy 6 (25 min.)
- Time horizon
- New visualizer
- Concurrency

1.6.4 LESSON MATERIALS see section 1.3

1.6.5 LEARNING OUTCOMES

At the end of the class, students will be able to evaluate themselves and comprehend whether their study method for Alloy 6 was effective or not, based on the results of quizzes taken during class time. Finally, they will have a comprehensive overview of the innovations and expressive power of Alloy 6 .

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2. EXERCISE

The exercise lecture is an optimal time to fix the concepts seen in class. Two paradigmatic exercises allow the lecturer to exhaustively review what was explained during the theoretical lecture and to show some of their possible application through the Alloy Analyzer. The total duration of the exercise is 90 minutes.

2.1 PRE-REQUISITES

To tackle the in-class exercise and solve the home exercise, students must:

- have attended the lectures in which the features of Alloy 6 were presented
- have watched the video related to connectives, which will be extensively used when defining predicates, facts and assertions.
- have successfully installed the latest version of the Alloy tool that can be downloaded from http://alloytools.org/download.html

2.2 LEARNING STRATEGIES

The strategy to be adopted by the teacher in the exercise is the worked-example, along with questioning and feedback. In detail, the lecturer starts the exercise by writing the code together with the students using the exercise prompts as an opportunity to review and demonstrate how to get to the definition of facts, predicates, and assertions with a practical and easy-to-understand example. In order to have a learner-centered lecture, the lecturer leaves space and time to students by interacting with them and having them come up with possible solutions for the exercises and ask when in doubt.

2.3 TOPICS

Exercise 1 (15 min.):
Concurrent Communications in Distributed Systems.
After reviewing the property of a system to perform operations in parallel over time, we go further to model the exercise with respect to signatures that are mutable over time, facts that must always be guaranteed, and facts that can change over time (see the location of a message, sent by one node and received by another).

Exercise 2 (30 min.):
Travel (Interrail)
As in the previous exercise, the first thing to do is to define signatures, then static modeling and eventually dynamic modeling. A person can travel from one city to another following an itinerary and consider the journey completed if he returns to the same city he started from.

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Exercise 3 (20 min.): Mailbox

A message can be deleted and later restored from the recycle bin (its location changes over time).
This exercise can be assigned as homework as it is simpler and easier to do independently.

2.4 EXERCISE MATERIALS

The teacher can use the set of slides created with the texts and codes from the exercises. The slides also contain animations that graphically render what the code means all the way through. In addition to the slides, there are .als source codes of all the exercises, already tested, which can be run in the classroom and left to the students.

2.5 LEARNING OUTCOMES

At the end of the exercise, students will be more aware of the potential of Alloy and some of its applications. They will be able to model realistic scenarios thanks to the examples seen and the strategy adopted by the teacher, and thus ready for the extra activity (challenge) explored in depth in the following sections.

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3. CHALLENGE

The extra activity offered by the module is a challenge in which students can apply what they have learned in solving a particular specification within a two-week time frame. The challenge aims to model a particularly complex scenario using the approach seen in the tutorial and all the background provided by the lectures.

3.1 PRE-REQUISITES

To tackle the challenge exercise and solve the exercise, students must:

- have attended the lectures in which the features of Alloy 6 were presented
- have watched the video related to connectives, which will be extensively used when defining predicates, facts and assertions
- have attended to the exercises
- have installed the latest version of the Alloy tool that can be downloaded from http://alloytools.org/download.html
- have understood the delivery methods

3.2 LEARNING STRATEGIES

The teacher uses the strategy of collaborative-learning, having students work together in small groups (2 or 3 students) and allowing them to develop skills related to teamworking and problem-solving. Since the effectiveness of the teaching module is to be observed all the way through, the lecturer should give directions only when strictly necessary.

3.3 TOPICS

The proposed theme for the challenge is Software-Defined Network: a very current approach in cloud computing and network architectures that facilitates their administration and configuration in order to improve performance and facilitate their monitoring. It is required to model signatures, then static behaviour and finally dynamic behaviour.

3.4 MATERIAL

The teacher provides the slide set containing the outline of the challenge and how to deliver it.

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3.5 LEARNING OUTCOMES

At the end of the challenge and thus at the end of the module, students will be able to face situations in which they are required to model something very complex by working in a group in a very current, practical and professional setting. What students are going to model is a real and current problem that does not necessarily have only one solution. Problem solving, which is the skill that the challenge greatly develops, wants each person to propose a personal solution based on what they have seen in class. Students need to put their own spin on what they have seen in class.

MATERIALS

You can find all the materials by scanning the QRcode below: