



**Embed4Auto
Upskilling to Model-Based Software Development
in the Automotive and Embedded Software Sector**

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Methodology handbook

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This document describes how the developed toolkit (PENCIL/StudentUML) can be used to support model-based development training. It also gives a brief introduction to possible extensions and the integration of further tools.

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Change Log

Vers.	Date	Author	Description
0.1	19.07.2010	Jürgen Böstler (JB)	Initial draft.
0.2	05.09.2010	JB	Draft text to sections 1 and 2 added. "To do notes" added to remaining sections (in red).
0.3	07.09.2010	JB & Ervin Ramollari (ER)	Added subsections, more draft text and comments.
0.4	08.09.2010	Sonja Trapp (ST)	added text to Sections 1, 4 and 6
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0.6	03.10.2010	Matthias Heintz (MH)	Subsections 3.4.2, 4.1.1 and 4.2
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1.0	08.10.2010	ST	Review, Formatting & Finalising

List of Applicable embed4Auto Documents

Ref.	Title, author, source, date, status	Deliv. id.
D2.2	Educational Scenarios, Jürgen Böstler	D 2.2
D2.4	Design of Learning Objects, Jürgen Böstler	D 2.4
D2.6	Exercises for PENCIL/StudentUML, Jürgen Böstler	D 2.6
D3.2	Technical conception of PENCIL, Sebastian Weber & Matthias Heintz	D 3.2
D4.4	System Description and PENCIL Usage Guide, Ervin Ramollari, Sebastian Weber, and Matthias Heintz	D 4.4
D5.3	Evaluation results, phase 1, Ömer Bay & Meltem Baturay	D 5.3

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1. Introduction

This document describes how the developed toolkit can be used to support model-based development training. It also gives a brief introduction to possible extensions of the existing tools and the integration of further tools.

The method and tools developed in this project aim at providing the European embedded/automotive industry with training for model-based development technologies and to promote their usage. Training needs are addressed by means of an Integrated Learning Environment (ILE) that incorporates Web 2.0 technology to improve social interaction in a community of learners and tutors.

The ILE incorporates (1) a set of learning resources on the Unified Modeling Language (UML2) and the Systems Modeling Language (SysML) (Moodle), (2) a UML modelling tool with educational capabilities (StudentUML) and (3) a Web 2.0 collaboration tool for sharing and discussing solutions to modelling exercises (PENCIL client for discussing solutions collaboratively by learners and tutors, PINBOARD). Tool integration is achieved by means of a Platform for Exercise sharing and Collaborative and Interactive Learning support (PENCIL), see D3.2 for more detailed information. Figure 1 shows a high-level overview of the ILE. Please note the open "stubs" indicate the possibility to integrate further tools by means of the application programming interface (API) provided by PENCIL.

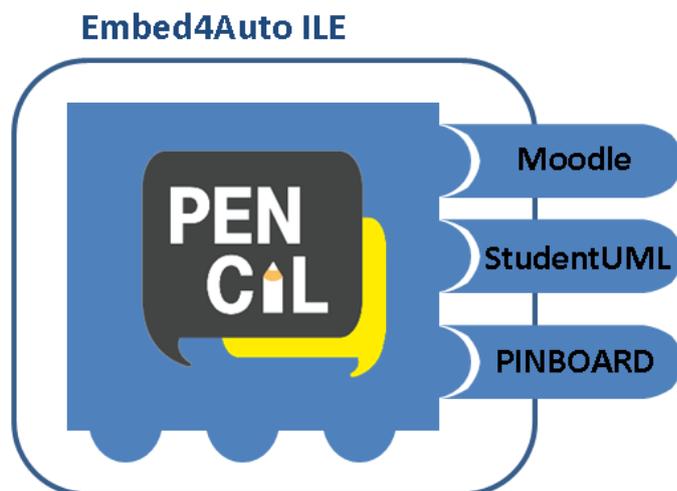


Figure 1 - High-level architecture of the Embed4Auto ILE

The main components of the learning resources are:

- Traditional text-based material (theory, introductions and definitions)
- Examples and case studies
- Multiple-choice exercises.

2. Usage scenarios

In Deliverable D2.2, we identified several educational scenarios based on the results from a survey on the training needs of the European embedded/automotive industry (see Deliverable D2.1 for details on the results of this survey).

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The learning content is organized in lessons. Each lesson focuses on a particular training need and can be easily interrupted and resumed. That makes it possible to run training sessions of varying lengths. It also makes it easier to build various kinds of activities on top of the lessons, like connecting to forums or accessing exercises, since these activities are basically independent of the actual content. The learning activities in the lessons are customizable. Quizzes or (interactive) exercises can be added, modified, or replaced by others.

The lessons are organized into the following groups or tracks (see D2.4 for details):

- Introduction to UML and SysML (3 lessons),
- Requirements Engineering (7 lessons),
- (Software) Architectural Modelling (8 lessons) and a
- Case Study (1 lesson).

The lessons are quite independent of each other. That means that lessons can be combined to suit a particular organization's training needs. The following table gives an overview of the lessons and their recommended prerequisites.

Lesson	UML2	SysML	Recommended prerequisite
<i>Introduction</i>			
Introduction to UML2	X		
Introduction to SysML		X	Introduction to UML
Extending UML and SysML	X	X	Introduction to UML or Introduction to SysML
<i>Requirements Engineering</i>			
Introduction to Requirements Engineering	X	X	
Use Case Modelling	X	X	
Activity Diagrams	X	X	
Sequence Diagrams	X	X	
State Machine Diagrams	X	X	
Requirement Diagrams		X	
Communication Diagrams	X		
<i>(Software) Architecture</i>			
Introduction to Architectural Modelling	X	X	
Package Diagrams	X		
Class Diagrams	X		
Object Diagrams	X		Class Diagrams
Block Definition Diagrams		X	
Internal Block Diagrams		X	Block Definition Diagrams
Parametric Diagrams		X	Parametric Diagrams
Allocation Tables		X	Requirement Diagrams and Block Definition Diagrams
Case Study	X		Introduction to UML and one or more of: Use Case Modelling, Package Diagrams, Class Diagrams, Sequence Diagrams, and State Machine Diagrams

For all lesson configurations, we recommend to start with an introduction lesson on UML, SysML, or both. However, except the lessons Extending UML/SysML and UML Case Study, all lessons require only minimal prerequisite knowledge on UML or SysML.

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For a thorough coverage of UML2 or SysML, we recommend a lesson sequence that follows the entries in columns UML or SysML, respectively, in the table above in a top-down manner. If a course should specifically focus on a particular development phase, as pointed out in the needs analysis, and time does not permit thorough coverage, we recommend to focus on the lessons in one of the groups Requirements Engineering or (Software) Architecture, respectively.

3. Usage guide

3.1 Installation and configuration

Installing the Embed4Auto ILE consists of a number of steps and depends on the fulfilment of several system prerequisites. From a high-level point of view ILE installation consists of: installation of the PENCIL database; installation of the PENCIL back-end; installation of the client tools; and installation and configuration of the Moodle CMS. A technically comprehensive installation guide is out of scope of this deliverable and is provided in deliverable D4.4.

Once the learning environment has been successfully installed, it requires administration of several components. This includes user management, course and learning content management, and exercise management.

3.2 User management

Both PENCIL and Moodle users are stored in a single repository in the PENCIL database, provided that Moodle has been properly configured to access user information in the PENCIL database (see D4.4). As a result once a user is registered or manually added in the PENCIL database, he or she is also automatically registered in Moodle to access the learning content and exercises. Nevertheless, if a user logs in the PENCIL platform, he/she is not automatically logged in the Moodle CMS. That is, the user has to log in twice to access the whole ILE: once in the PENCIL platform through PINBOARD/StudentUML, and once through Moodle.

The Embed4Auto ILE supports three types of users, with distinctive roles: *administrators*, *tutors*, and *learners*. All three types of users can be self-registered in the system portal by providing the necessary information. These include nickname, email, first and last names, and optionally a profile picture. The password is provided by the system through an e-mail shortly after the registration procedure, which can be changed anytime.

By default, users registered in the system through open registration have a *learner* role. For obvious reasons, they are not allowed to choose their role upon registration, or change it later after registration. For the moment this task has to be performed manually by the system /database administrator using a MySQL front-end tool to edit the respective row in the "User" table. That is, an administrator or tutor registers first as a learner, after which the database administrator promotes their user roles to admin and tutor, respectively, upon request. Notably, an administration back-end for PENCIL has been outside the scope of Embed4Auto, and has not been developed.

3.2.1 User groups

Managing user groups is not yet supported by the PENCIL platform. Technically there is one user group per installation. As a result, all registered users (learners and tutors) are one community that can see and interact with each other, access the same set of learning resources, and work on the same set of modelling exercises. Also, it is expected that all users use the same language in PINBOARD discussions, even though it might not be their first

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language. In cases when this is impossible, or when the user group is too large, it is suggested to set up separate installations of the system, one for each target group.

3.3 Course management

Learning content may be organised differently in different Course Management Systems (CMS's). In Moodle learning content is organised into courses, which in turn are split into lessons (activities). Depending on the style of each course, it may be split into weeks, or other ways. If a course is organised into weeks, there will be one lesson for each week. For more guidance on how to organise learning content in Moodle, please refer to the Moodle documentation¹.

The learning material on UML2 and SysML, created as part of Embed4Auto, is intended to fit into one course. This course consists of 19 lessons, each of which is provided in compressed SCORM packages (See Section 3.4), including examples, case-studies, and multiple-choice exercises.

3.4 Adding and creating learning content

3.4.1 Adding provided learning content

The learning material created in the Embed4Auto project is provided in compressed SCORM (Sharable Content Object Reference Model) packages. Each SCORM package represents one lesson and can be imported in a Moodle course.

For example, adding zipped SCORM packages in a weekly-structured Moodle course is performed as follows. The Moodle user must have administrator, course creator, or teacher role to be able to add course content. Thus he/she will be able to enable course editing by pressing the "Turn editing on" as in Figure 2.

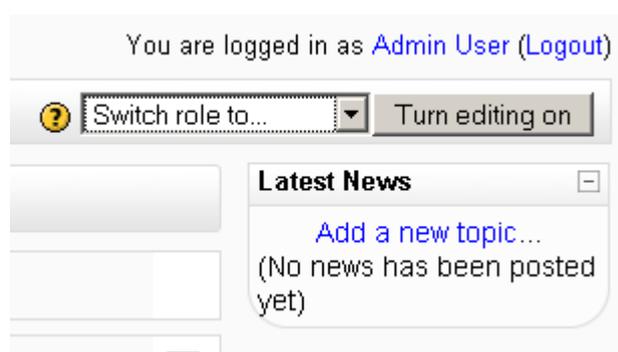


Figure 2 - Enabling course editing

With editing enabled, the weekly-outline view changes as in Figure 3.

¹ http://docs.moodle.org/en/Main_Page

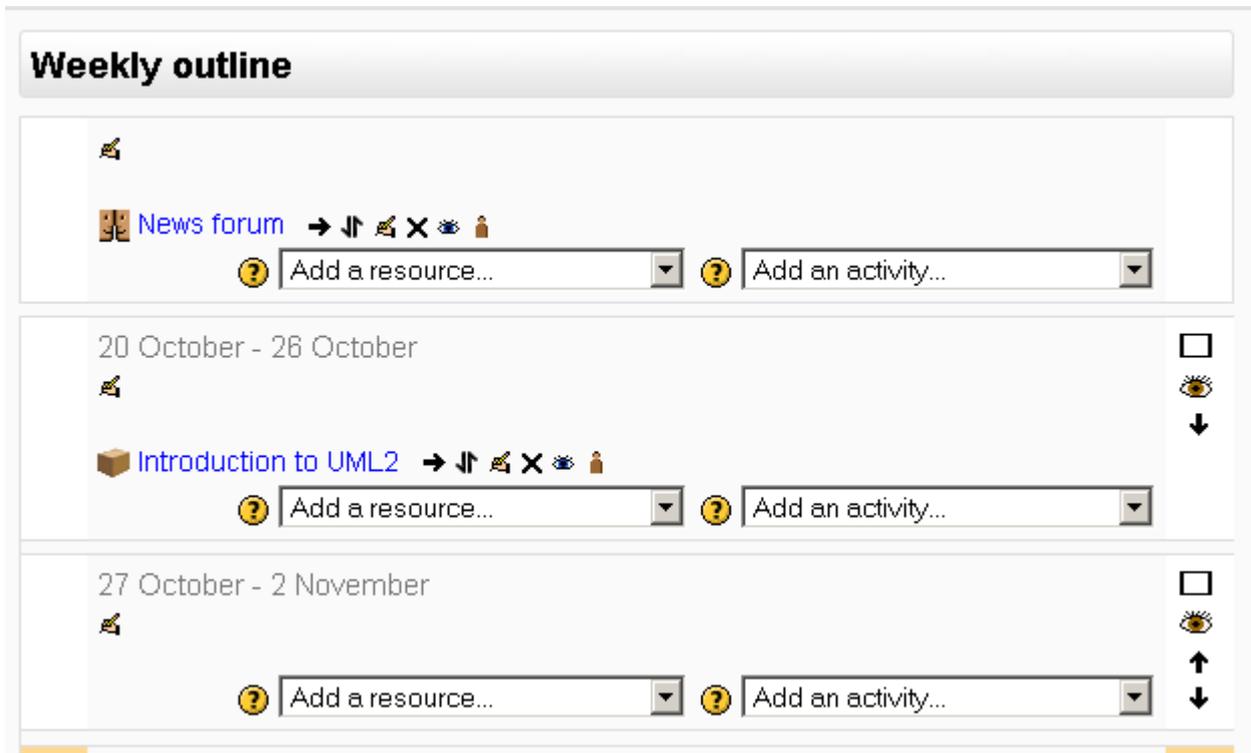


Figure 3 - Course view in editing mode

In the "Add an activity..." drop-down box for the corresponding week, select the option "SCORM/AICC". This opens a new form as in Figure 4.

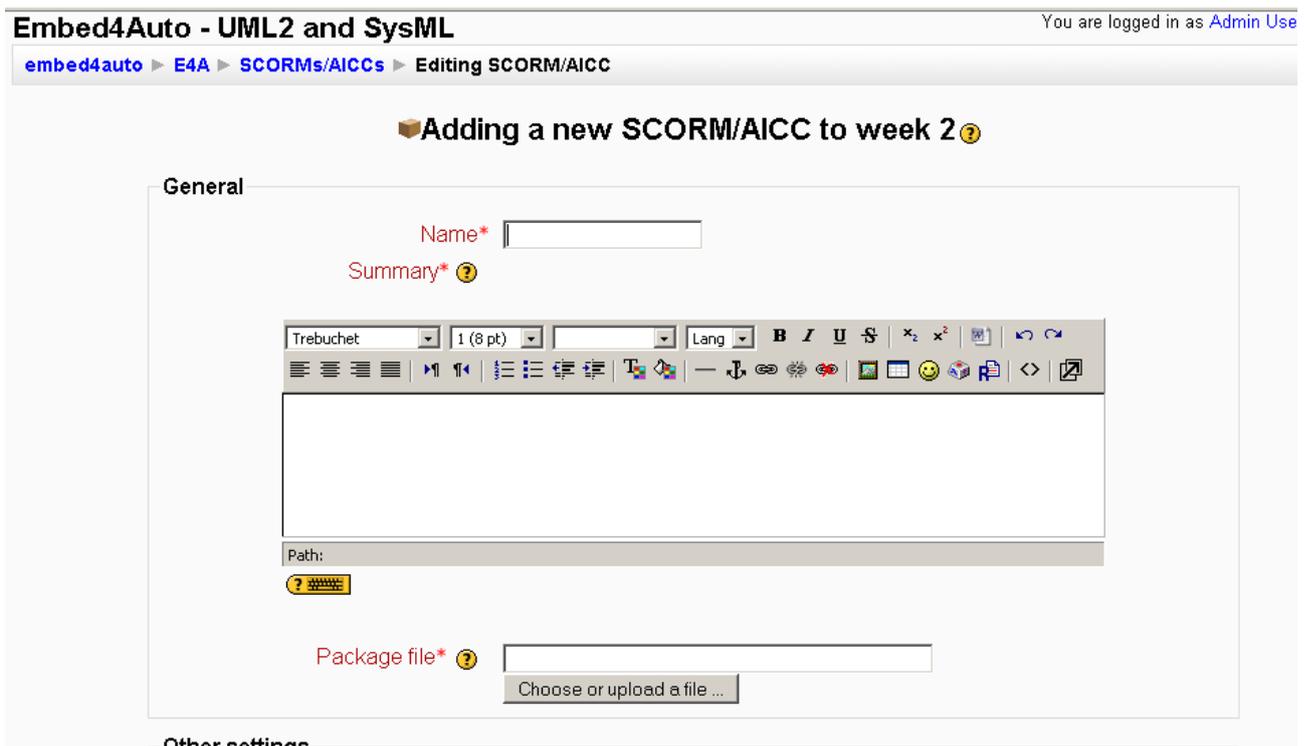


Figure 4 - Adding a SCORM package to a course

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The data to be provided includes the lesson name, a summary, and the location of the zipped SCORM package file. In the end, pressing the button "Save and return to course", adds the learning material in Moodle for the specific lesson and week.

3.4.2 Creating new learning content

Learning content can be created in any way you like, as long as the result is accessible through a link it can be used by the PENCIL system. Our process of creating new learning content as SCORM packages from Microsoft PowerPoint files through the plug-in iSpring is described in detail in deliverable D3.5.

4. Handling exercises

An essential aspect of learning with the PENCIL ILE is the exercises. There are three types of exercises:

- Integrated multiple-choice exercises (quizzes). These exercises are built into the lessons and are solved directly within a particular lesson on an individual basis.
- Modelling exercises that are solved with the integrated modelling tool StudentUML. These exercises contain a link that transfers control to an integrated modelling tool.
- Modelling exercises that are solved with external tools. These exercises must be solved with an external modelling tool.

Proper exercise management in terms of type, content, number and publication time is a considerable as well as important task involving lecturers and tutors. This section describes how multiple-choice and interactive modelling exercises are created, published, and handled before and during learning sessions.

4.1 Integrated multiple-choice exercises

Multiple-choice exercises (or quizzes) are provided with the learning resources at the end of each lesson. Their goal is to check the understanding of key concepts covered in the lesson, by the individual learner. There are at least two multiple-choice exercises for each lesson.

The key feature of multiple-choice exercises is that they provide just-in-time feedback based on *predefined* model answers. This feedback informs the learner on correctness of the answer, as well as the attained score, depending on the number of correct selections.

Three attempts are allowed before submitting the final solution so as to give students the chance to revise their choice and retry new answers. Questions are presented in random order if the learner returns to a quiz. After the student finishes the quiz or after three attempts, the final results are displayed. They consist of the final score, the passing score, and whether the quiz has been passed (Figure 5). The quiz can be reviewed for further feedback listing the correct and incorrect selections.

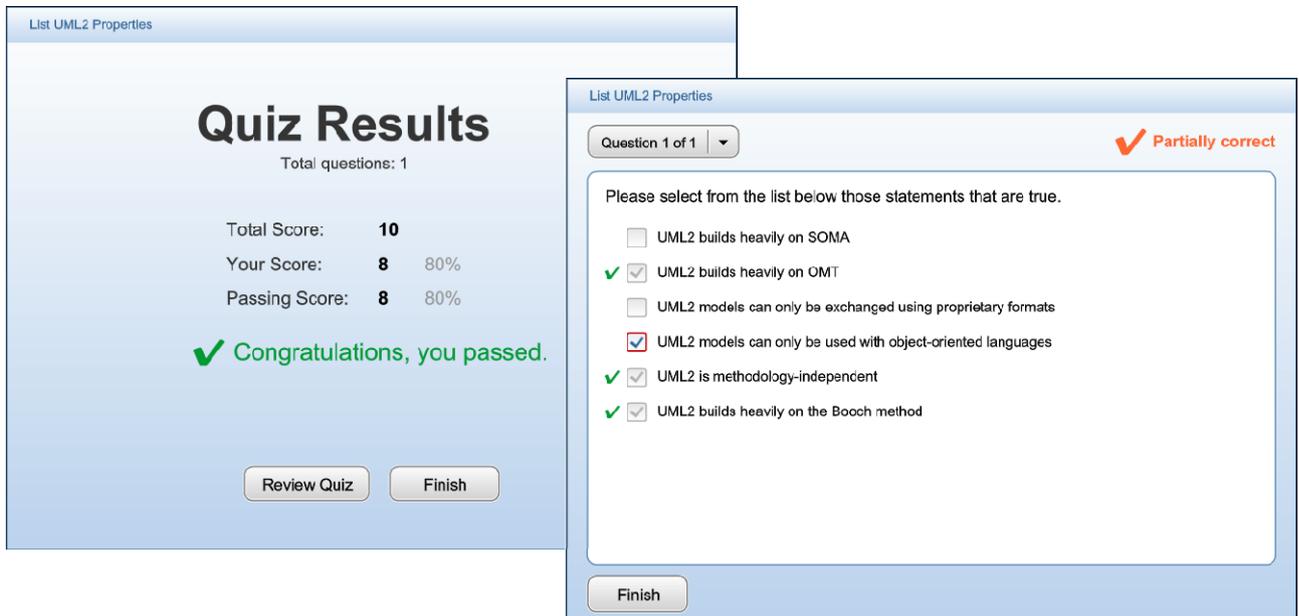


Figure 5 – Example of quiz results

4.1.1 Adding new multiple-choice exercises

Multiple choice exercises are created with the same tool as the learning content, which is described in deliverable D3.5.

4.2 Managing modelling exercises in Moodle and PENCIL

Modelling exercises in PINBOARD can be created by tutors and administrators. They have an entry in the settings dropdown (see figure).

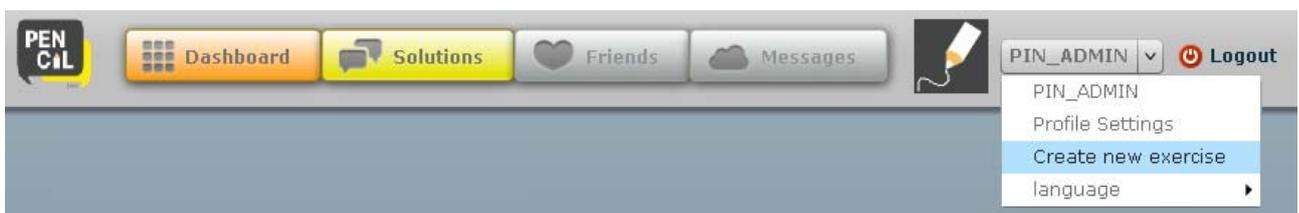


Figure 6

Each exercise in PINBOARD consists of a title, a short description and a link to a long description. These data are specified in the "Create new exercise" popup, as shown in the next figure. Notably, this popup also asks for the solution-creation tool to be used to solve this (type of) exercise, which by default is StudentUML.

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Create new exercise

You can create a new exercise with this dialog. Therefore, please specify a title and a short description of the exercise. The actual exercise description / explanation has to be referenced with the URL field. Please choose the appropriate tool that has to be used for solving this exercise.

Titel of the exercise *

Short description of the exercise *

URL of the detailed exercise description *

What tool is supposed to use for that exercise? ▼

Figure 7

The URL of the detailed exercise description can point any Web page (accessible by a link). On the other hand, if you would like to have a direct link to the exercise in PINBOARD you need to get the id of the exercise from the database. This id has to be added at the end of the following link (adapted to your server/URL): http://embed4auto.iese.de/pencil/pencil_client/pencil.php?exerciseid=. Opening this link will display the exercise and an overview of all solutions created for it.

The process of adding an exercise in PINBOARD triggers automatic e-mail notification of the users, except those who have disabled these kinds of notifications. The e-mail notifications serve to prompt learners to go and read the exercise description in PINBOARD and Moodle and start posting StudentUML solutions to the exercise.

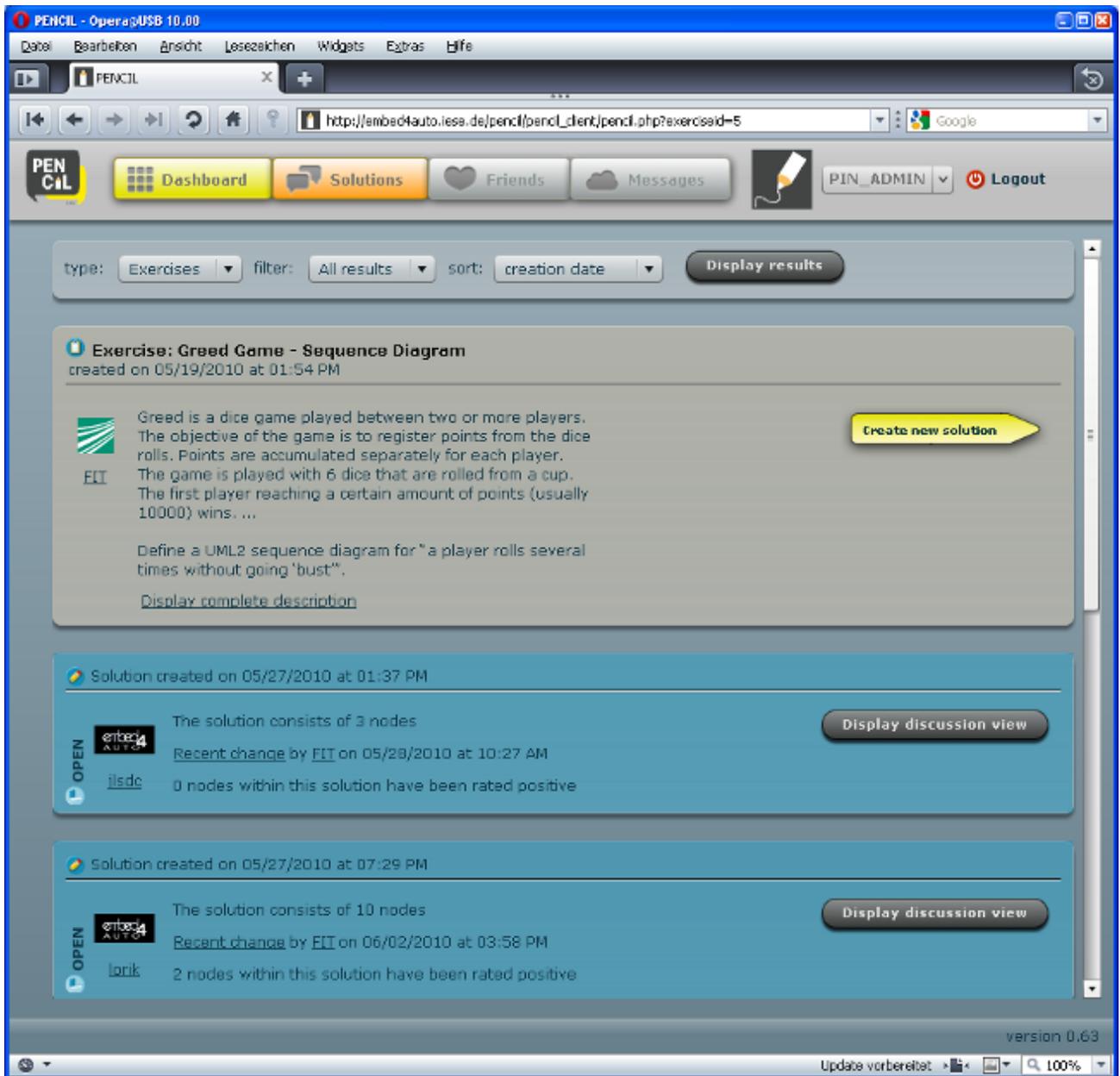


Figure 8

4.3 Solving modelling exercises with StudentUML

The PINBOARD Web 2.0 social collaboration platform and the StudentUML modelling tool are used together to enable collaborative solving and discussing of modelling exercises in the UML 2.0 notation. The problem definitions are such that the solutions consist of UML diagrams, which are created or edited using the integrated StudentUML tool.

In contrast to multiple-choice quizzes, modelling exercises are solved collaboratively by learner groups rather than by individual learners that read through the lessons. There are no predefined model solutions, no instant automated feedback, and no numeric grades. While those features are especially valuable for certain types of exercises, they are not effective for

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other more challenging problems. Modelling exercises typically address problems that introduce the need for collaboration in a community consisting of learners and tutors as well. Such problems usually have no obvious or perfect solutions, but instead, may have several alternative ones. As a result, they foster user collaboration through the PENCIL forum, through posting alternative StudentUML solutions or continuing/improving existing ones, and through annotations of StudentUML diagrams with UML notes.

An indicative set of such exercises has been provided in this project with deliverable *D 2.6 – Exercises*. Each section consists of a problem statement that describes the context, and based on that context a number of exercises follow. This set of exercises has been successfully used during two pilot sessions with groups of students (see D5.5).

Creating new modelling exercises in the ILE involves adding their descriptions in PINBOARD and in the Moodle CMS (as described in Section 4.2) and subsequently notifying the users. What follows is a period of discussions and StudentUML solutions in PINBOARD about that exercise. The length of time dedicated to collaborative solving of an exercise till an acceptable solution is reached or discussions have been exhausted, is indefinite. However, as experience from the two evaluation sessions showed, this period of time is usually a few days and rarely more than one week.

Collaborative solving of an exercise is a rich interaction between learners and tutors, and involves a number of use cases for both PINBOARD and StudentUML. PINBOARD enables discussion of exercises and solutions in a forum, sharing of attempted solutions, and continuation/improvement of attempted solutions. The learners are also able to use the modelling tool in sandbox mode without sharing solutions to exercises, so that they can get used to the features of the tool. Also, independently of collaboration, learners may benefit from any educational or intelligent tutoring features.

Therefore, as regards the StudentUML tool, the three key usage scenarios are:

- (1) StudentUML trial in sandbox mode,
- (2) sharing solution to exercise, and
- (3) continuing existing solution.

The following subsections describe the proper fulfilment of the above scenarios.

4.3.1 StudentUML trial in sandbox mode

Before learners can start posting solutions in PINBOARD, created with StudentUML, they can learn using the tool using the sandbox mode. The purpose is to allow users to freely draw UML diagrams without necessarily referring to an exercise. This is particularly useful for independent learning, when users want to experiment with the tool features, draw different types of UML diagrams, learn the UML notation, and take advantage of intelligent tutoring capabilities, such as diagram consistency checking.

StudentUML is started in sandbox mode either from the main portal (Figure 9) or by directing the Web browser to the address of the `student_uml.php` page without passing any URL parameters.

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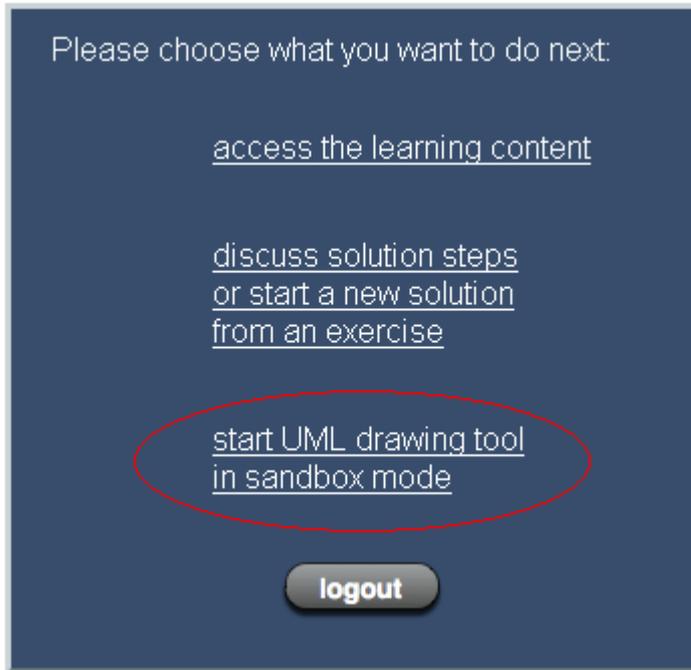


Figure 9 - Main ILE portal

In sandbox mode StudentUML starts with an empty project where diagrams can be created, edited, or removed. Projects created in sandbox mode cannot be shared in PENCIL, although they can be saved in the private space in the server for later retrieval.

4.3.2 New solution to exercise

In this scenario a user creates and shares a new solution to a modelling exercise. Navigation starts from PINBOARD exercise view (Figure 10), which provides links for each exercise to open StudentUML in a browser popup (iFrame).

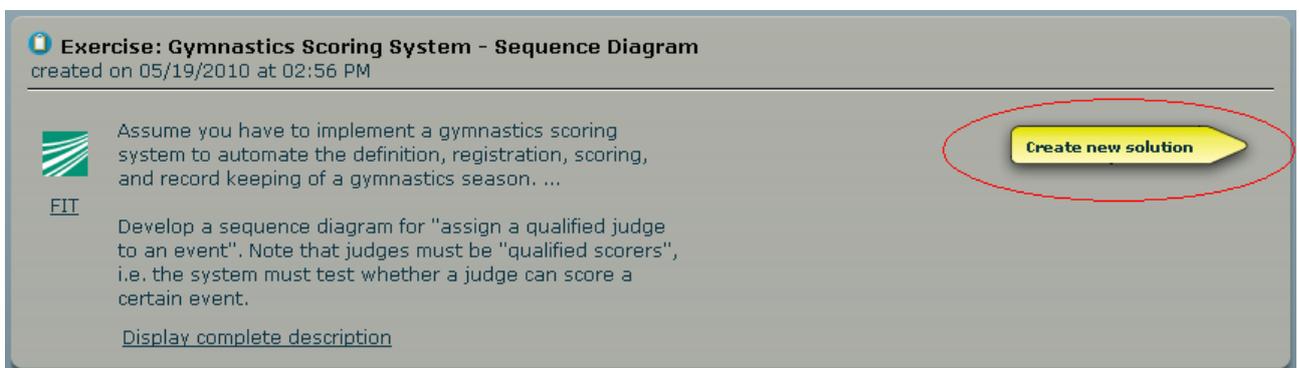


Figure 10 - Exercise description in PINBOARD

StudentUML is initialized with an empty project as a solution to the exercise. Diagrams of any type can be created, added, and/or removed.

When ready to share the solution, the user can press the "Share/Save" button in the application toolbar. This event opens the "Your solution info" dialog box, which asks for further

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metadata about the solution, comprising of a solution title, comment, node type (i.e. solution type/status), and whether the solution is public or private (Figure 11). Of these metadata the Title, identifying the solution, is mandatory. The comment serves to clarify further details about the solutions, or to ask questions about it. The Node type drop-down combo box serves to specify the initial status of the solution. The "Save as private" checkbox allows the user to share the solution either in PENCIL or save the solution in the private space in the server. As the "OK" button is pressed, the solution is shared or saved and, in case of success, a confirmation message is displayed. At this point the user can decide whether they want to continue their solution.

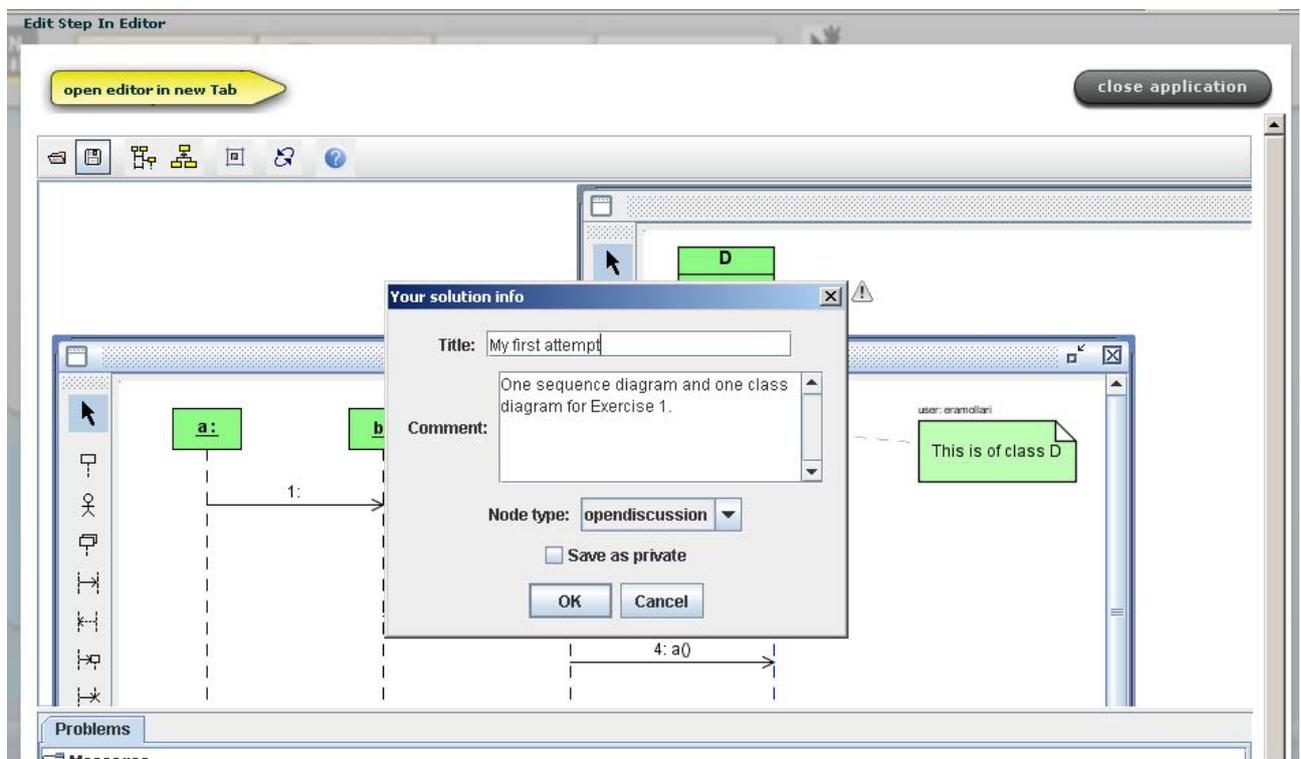


Figure 11 - Sharing new solution in StudentUML

The event of sharing a solution from StudentUML adds the solution in the PENCIL platform, which in turn appears in PINBOARD. Moreover, subscribed users are notified via e-mail. Therefore, other learners and tutors are prompted to go to PINBOARD to discuss the new solution or to continue/review it, hence resulting in a PINBOARD thread for that solution.

4.3.3 Continuing existing solution

In this usage scenario, a user creates and shares a new step to an existing solution, started either from the same user or from a different one. This is beneficial when other learners or tutors want to improve or to correct an existing solution, or to provide a slightly different version. Moreover, users may decide to post a solution with subsequent steps illustrating the different steps taken to arrive to the final diagrams.

Navigation starts from the PINBOARD view for the given solution, which provides links to open StudentUML in a new browser tab/window. StudentUML is initialized with the solution at the chosen step, meaning that the diagrams are opened in the workspace. After that new diagrams can be created, edited, or removed, as necessary.

When ready to share the updated solution (or step, or node), the user can press the "Share/Save" button in the application toolbar. This event opens the "Your solution info" dialog box, which asks for further metadata about the step, which comprise of a title, comment, node type, and whether the step is public or private (Figure 12).

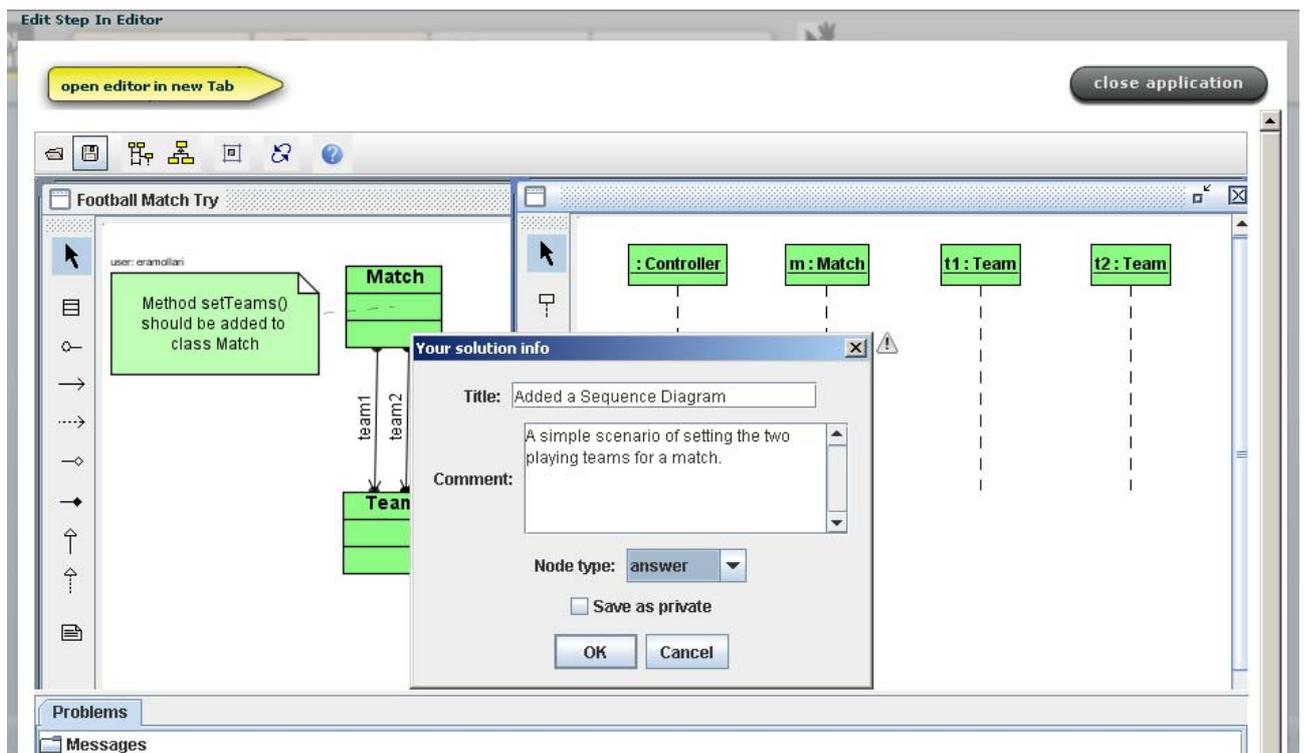


Figure 12 - Sharing new solution step in StudentUML

Of these metadata the title, identifying the solution step, is mandatory. The comment serves to clarify further details about the step, or to ask questions about it. The Node type drop-down combo box serves to specify the type of step added to the solution. The types of steps are one of the following:

- Question
- Hint
- Alternative
- Answer
- Continued,

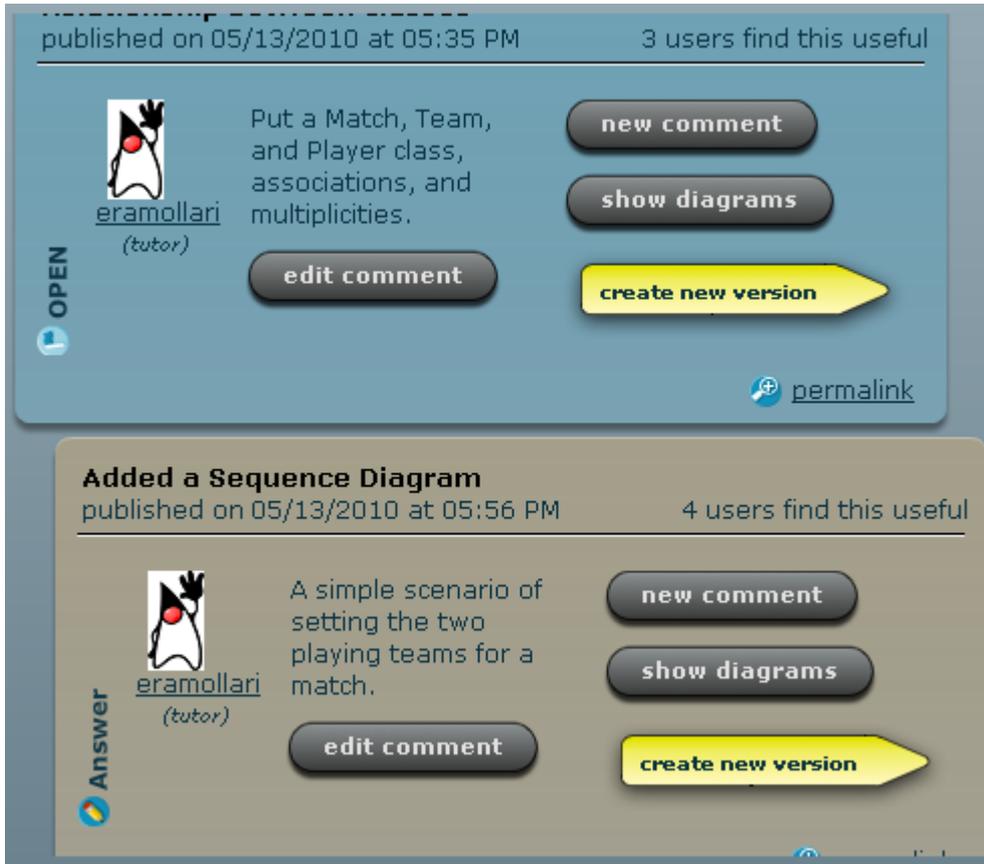
from which the closest alternative is chosen.

The "Save as private" checkbox allows the user to choose to share the step in PENCIL or save the step in the private space in the server. As the "OK" button is pressed, the step is shared or saved and, in case of success, a confirmation message is displayed.

At this point the user can decide whether they want to continue the solution from the previous step. Pressing the "share/save" button again will save a new step as the next one to the most recently saved/shared step by them.

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The new step to a solution notifies subscribed users via e-mail and prompts them to discuss, continue, or review it. It appears in PINBOARD as a node next to the node for the continued step as in Figure 13.



The screenshot displays two comment nodes in a discussion view. The top node, published at 05:35 PM, is titled "Put a Match, Team, and Player class, associations, and multiplicities." and is marked as useful by 3 users. It features a user profile for "eramollari (tutor)" and buttons for "new comment", "show diagrams", "edit comment", and "create new version". A "permalink" button is also present. The bottom node, published at 05:56 PM, is titled "Added a Sequence Diagram" and is marked as useful by 4 users. It also features the same user profile and buttons. The interface includes a vertical "OPEN" indicator on the left side of the top node and an "Answer" indicator on the left side of the bottom node.

Figure 13 - PINBOARD discussion view after a next step has been posted

4.4 Solving modelling exercises with other tools

The Integrated Learning Environment (ILE) has been designed to be extensible with other modelling tools, so that further kinds of diagrams, or even notations other than UML or SysML are supported. StudentUML is just one of the possible solution authoring tools and is used as a proof-of-concept in this project. Other modelling tools can be developed or modified to be used with PINBOARD and the PENCIL platform, provided that they fulfil a well-defined set of requirements (See Deliverable D4.4). For example, a solution authoring tool that supports Entity-Relationship Diagrams (ERD) could be integrated into the ILE to support database design courses.

A generic image editing tool would be another option. This would allow for maximum generality and could be used together with any graphical modelling language. However, this would make it impossible to apply any (semi-) automatic consistency checking and therefore be of limited educational value.

The key learning scenarios of using any other modelling tool are similar to the ones described in subsection 4.3. The significant difference is in the modelling notation and in the educational features of the tool. StudentUML does have additional learning value to collaboration, through

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educational features such as minimalism, consistency validation, and help material. However, other tools do not have to offer such benefits.

Instructions on developing/modifying and installing new solution authoring tools in the PLE are provided in Deliverable D4.4.

Currently there is no possibility of adding to a PINBOARD comment. This would be an elegant solution for all types of diagrams not supported by diagram authoring tools in the ILE. However, since we cannot check actual contents of image files, we cannot guarantee that users only add diagrams. To avoid all kinds of problems with copyrighted or offending material, the current version of our ILE does not support adding image files.

5. Managing participant collaboration

A key aspect of the ILE is learner-learner collaboration. Collaboration is achieved by means of posting notes to a common forum accessible by all learners and tutors. The notes can contain links to models developed using the integrated modelling tool StudentUML. The unique feature of the ILE is that other learners or tutors can manipulate the submitted StudentUML models. That makes it easier to comment on models and/or propose changes to the solutions submitted.

A problem with this model of collaboration is to separate different communities or groups of learners. On one hand, one wants to have as large and diverse groups as possible to increase the positive effects of collaborative learning. On the other hand, one wants also be able to have full control over a course and particular groups of learners (e.g., when custom-designed exercises have been added).

Proper management of participant collaboration is essential toward effective learning outcomes. The goal is to encourage collaboration as much as possible, where learners as well as tutors play a role. Collaboration is considered successful when a high number of users are involved, many solutions are shared, many relevant questions, comments, and suggestions are made, etc. The importance of social collaboration is also supported by the results of the questionnaire filled in by students after the two evaluation sessions (see Deliverable D5.3). The following propositions received Likert scales (range 1-5) that were among the highest:

- Feedback I wrote was helpful to my comprehension (4.0)
- Feedback from the tutor was helpful to my comprehension (4.0)
- Discussing the exercises & solutions contributed to my learning (4.2)
- I enjoyed interacting with the community of learners (4.2)

Additionally, a number of 'best practices' toward successful collaboration have emerged from the two pilot evaluation sessions with multi-national user groups. In a nutshell, these practices are about preparing learners before system usage, learners' best practices during usage, and tutors' best practices. These are described in the following subsections.

5.1 Preparing learners

Given that the learning environment is up and running, the learners should be introduced to the features of the PENCIL ILE before they start using it. Moreover they need to know what is expected from them during the learning sessions (see 5.2). This introduction is to be provided by tutors or course instructors either face to face or in distance. Although a face to face kick-off introduction for the student group is preferable, this might not always be possible, as learners might be participants in distance-learning courses.

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The respective tutors are expected to provide the link(s) to the ILE as well as links to help material and guidelines. The help material is expected to cover key scenarios with the main components of the ILE: Moodle, PINBOARD, and StudentUML.

In the case of the demo installation used in the pilot evaluations², navigation starts from a central portal page that leads to the other ILE components. The portal also contains help material in the form of screencasts, covering usage scenarios such as:

- how to register and change password
- how to access the learning content
- how to start a new solution
- how to help a fellow student.

Comprehensive online help on using the integrated StudentUML modelling tool in combination with PINBOARD is included with the tool and accessed from the application's main toolbar.

In addition to reading the help material and guidelines, learners are also expected to familiarise themselves with the tools before they start creating and posting solutions. StudentUML offers a *sandbox mode* where users can try drawing any diagrams and experiment with its features without referring to any exercise. Nevertheless, StudentUML has been designed as a minimalist tool (in terms of supported UML 2.0 notation and graphical user interface) in order not to confuse beginners, thus it is expected to have a shallow learning curve. This claim is also supported by the evaluation results in D5.3, where students put a high Likert scale of 4.2 to the item reading "The modeling tool is easy to learn and use".

Finally, students should have a clear view of what is expected from them during the time they use the ILE and what is their role towards effective learning outcomes. The information in Section 5.2 should be handed out to students or linked from the ILE or Moodle portal. This information should also consist of other course-specific information, such as learning phases, expected minimum time per day spent on the tools, number of exercises, and so forth.

5.2 Role of learners

The handouts given to students during the two pilot evaluation sessions consisted of the following:

- Participate regularly for the minimum agreed time (e.g. 1 hour) during the whole validation period
- Read / work through learning material
- Work on exercises by using StudentUML and PENCIL intensively -> try to work on the solutions in a Web 2.0 way that means give feedback as often as possible and ask questions whenever you have a problem
- Check back from time to time on a day for a few minutes in order to see feedback provided by tutors or other learners
- Look at solutions of other students and provide feedback (alternatives, hints, etc.) whenever possible
- Comment on solutions of other students
- Create new solutions based on other people solutions (branches), i.e. provide alternative steps (do not create whole solutions for others)
- Ask questions in English in PENCIL, otherwise, no communication or collaboration will take place.

² <http://embed4auto.iese.de/pencil/html/>

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- Fill in the checklist on the Lime-Survey after education is over. (Wait for your tutor's instructions)
- Reflect and state whatever you think about the educational material during the think-aloud protocol.

5.3 Role of tutors

Tutors or course instructors are also users of the learning environment and are expected to provide a supportive role in collaboration. As they assist learners with the exercises, tutors are not expected to provide final answers or solutions, but instead they should give hints and stimulate discussion whenever it vanishes.

The handouts given to tutors during the pilot evaluation sessions consisted of the following:

- Conduct introductory meeting with all participants.
- Inform the students about the hours you are available for tutoring.
- Follow the time-table and implement the prototype.
 - Avoid chat capabilities in case the users would not need to use PENCIL collaboration features.
 - Help users with the system problems, bugs and difficulties.
 - Encourage users to ask questions in English in PENCIL, otherwise, no communication or collaboration will take place.
 - Participate daily for the minimum agreed time (eg 1 hour) during the whole validation period.
 - Make sure that all students are participating (spot cases of non-participation and contact them).
 - Visit & review (do not provide solutions but hints, e.g., if something wrong was identified) students solutions.
 - Read students comments and reply if necessary.
 - In case of a conflict between students and their solution, provide resolving feedback.
 - Towards the end of a period examine students solutions and provide concrete solutions in case one has not yet been found.
 - Act as e.g. a wiki gardener or forum moderator -> take care of the activities and try to foster communication if the discussions drop off.
- Direct users to the online checklist and surveys after the implementation of the prototype. Give the necessary instructions.
 - Announce to the users that they should fill in the checklist and surveys only once and carefully.

6. Online- versus offline usage

The learning materials on UML2 and SysML including multiple-choice exercises can also be worked through in offline mode. Print versions of the lessons can be provided which contain the same contents, graphics and diagrams as the online version. This is done to facilitate more intensive and more flexible knowledge acquisition. Actually, most students prefer to study theoretical content using textbook-like learning resources. However, only by working with the ILE, a more enriching learning experience can be guaranteed. Only within the online lessons, direct links are provided which lead to more complex tasks and exercises that can best be solved by collaborating with other students and / or tutors. Research has shown that collaboration is a key element for successful and deep learning. The PENCIL platform offers an easy way for solitary learners to interact with fellow students and to form a learning group for

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a special learning purpose. The benefits of collaboration lie mostly on a social and emotional level, and thus contribute to enhanced learner motivation:

- Online collaboration allow for democratic participation (which is not guaranteed in (large) face-to-face courses).
- Asynchronous tools admit increased reflection time which might lead to better learning results (or more considered answers to questions or solutions to exercises).
- Individual learning potential is maximized because of an increased amount of information and experience reports from peer learners.
- Moving in a community of people with similar goals increases self-confidence. The risk that weaker students are left behind becomes much lower.

7. Integration of further tools

The architecture of the PENCIL platform allows integration of client tools other than PINBOARD and StudentUML. There are two types of such third-party tools: social collaboration tools for sharing and discussing solutions (similar to PINBOARD), and modelling tools (similar to StudentUML).

Such third-party tools can be either developed from scratch, or existing tools can be modified to be integrated in the PENCIL ILE. As a result, new social collaboration tools that depict modelling exercises, solutions, discussion threads, etc, in a way different from PINBOARD, are possible. Similarly, modelling tools that support further diagram types and graphical notations, and offer educational capabilities additional to StudentUML, can be developed and integrated into the PENCIL ILE as solution authoring tools.

Having multiple solution creation tools integrated into the ILE will allow support for different types of exercises, e.g. UML modelling, SysML modelling, ERD modelling, even textual exercises such as maths or physics. Indeed, the possibilities are indefinite. The tutor creating new exercises will have the ability to specify the type of exercise by selecting the solution-creation tool with which that exercise will be solved (check back Figure 7). The drop-down box will be populated by the names of other integrated tools in addition to StudentUML. Specifying the tool for creating solutions to an exercise also ensures that solutions created in one notation cannot be opened with tools that don't support that notation, as this might result in unexpected errors.

For a more comprehensive guide on developing and integrating further tools, please refer to Section 6 in Deliverable *D4.4 – System Description: PENCIL, PINBOARD, and StudentUML*. This section lists the general requirements that tools must fulfil to be interoperable with PENCIL, and describes the steps to follow to develop, modify, and integrate such tools.