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ILEARN2MAIN – AN ELEARNING SYSTEM FOR MAINTENANCE MANAGEMENT TRAINING

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Maintenance training and educational activities are increasingly exploiting technological innovations. Desktop and web-based e-learning applications offer academics and industrialists new tools to raise maintenance-related knowledge and competence. One recent initiative in this direction is the iLearn2Main project. The project employs e-learning technologies, offering customized maintenance management training, while facilitating the standardisation of competencies assessment and learning evaluation. The maintenance curriculum was designed by taking into account competence requirements for maintenance management professionals and a user survey across several EU countries. This paper provides an overview of the iLearn2Main development and system.

Key Words: Maintenance Management, e-Learning, Competence Assessment, Learning Management Systems

1 INTRODUCTION

Maintenance Engineering and Maintenance Management competences are necessary for modern enterprises [1]. Although maintenance has been researched and taught as a subject for long, the ever more demanding market needs and the rapid technological advances require a thorough treatment of Education and Training in Maintenance. Enabling technologies in the form of e-Learning, mobile learning and virtual training expand the toolset available to Maintenance training. They also have the potential to provide a structured and objective way of accessing competences, facilitating skills & competences recognition [2]. One recent initiative in this direction is the iLearn2Main project (www.ilearn2main.eu). The project employs e-learning technologies, offering customized maintenance management training, while facilitating the standardisation of competencies assessment and learning evaluation.

The Maintenance Management training curriculum was designed on the basis of the EFNMS Specification about the Competence Requirements for Maintenance Management. A user survey was contacted in 5 EU countries to identify learner and trainer needs for an eLearning system in Maintenance Management. The findings of the survey analysis have been taken into account in guiding the curriculum structure design. The curriculum comprises largely training courses related to the Basic Activities of the Maintenance function, as well as subjects related to the Improvement of the Maintenance function [1]. These are structured in three main course themes, namely ‘Asset Care’, ‘Asset Performance Evaluation’ and ‘Management/Economy of Assets’. e-Learning modules are being built on all the aforementioned course themes. These are uniformly structured, comprising fundamental course identification information, course theory, practical tips and case studies. The eLearning system is built on the Open Source Learning Management System platform, Moodle, and the learning courses are being packaged as individual and reusable learning objects.

A key requirement is related to formalizing Maintenance Management qualifications in such a way, so as to facilitate the standardization of competence assessment of personnel. In the EU, the EFNMS has produced specific guidance to this purpose in the form of Requirements and Rules to achieve a Certificate as a European Expert in Maintenance Management, as well as Regulations for the EFNMS Certificate as a European Maintenance Specialist. Building e-tools for Maintenance Management competence assessment can offer significant help towards satisfying such requirements. The e-Competence Assessment tool currently under development in iLearn2Main may function as a standardized means of carrying out the assessment of Maintenance Management qualifications. Taking advantage of the Learning Management System features, the e-Competence Assessment tool is blended with the Learning Objects in the sense that it can be used to provide feedback and guide the eLearning process.

On the basis of the iLearn2Main Maintenance Management e-Learning platform, specific examples of the course structure and content delivery are provided, along with examples of the competence assessment functionalities. The evaluation and piloting of the iLearn2Main tools is currently under way in several EU countries.

2 IDENTIFYING THE TRAINING OBJECTIVES

2.1 Target Groups & VET objectives

The iLearn2Main project aims to deliver Maintenance Management training using e-Training tools. Specifically the training target groups comprise both trainers and trainees:

Teachers/Trainers

- ✓ Personnel involved in maintenance-related training

Learners

- ✓ Managerial personnel: their needs are determined by the necessity to make rational decisions related to maintenance of industrial equipment and human resources allocation.
- ✓ Senior engineering personnel: their needs are related to the need to make appropriate choices to ensure adequate maintenance policies and technological solutions, as well as to devise plan and oversee the implementation of appropriate maintenance policies and actions
- ✓ Other technical personnel: their needs refer to ensuring adequate technical knowledge and skills to efficiently carry out planned maintenance tasks, or to perform rapid maintenance-related audits on industrial machinery.

Training Objectives

In Maintenance management training, the trainers should be able to bring enough knowledge and experience to the learners, so they will be able to fulfil satisfactory their basic function in maintenance. The fundamental areas of knowledge should cover the management capabilities having the basic activities in place and in proper use, as well as the usage of analytical procedures for improvement of the maintenance function.

The knowledge and competences can be illustrated in a hierarchical structure as seen in Figure 1 [1].

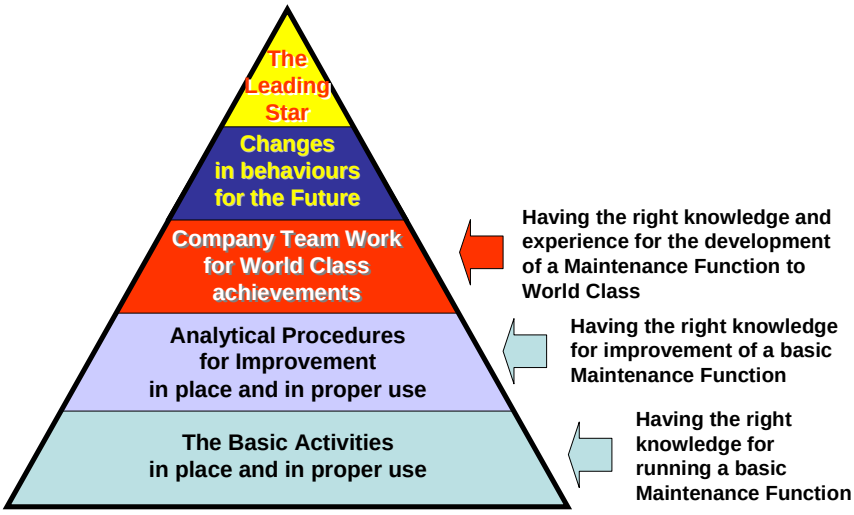

Figure 1. Maintenance Management Competences

2.2 Survey and Analysis of Training Needs

The iLearn2Main project opted to engage relevant stakeholders early on in the project. This was performed in a number of ways:

- ✓ Meetings with business clientele and research/academic liaisons
- ✓ Participation in info-days, workshops, conferences
- ✓ User survey in UK, Sweden, Latvia, Romania and Greece

Specifically, the user survey involved discussions and interviews with relevant stakeholders, distribution of project brochures and completion of a lengthy user survey questionnaire. Two versions of the questionnaire have been developed:

- ✓ one for the teachers and trainers in maintenance-related training
- ✓ one for managerial personnel, senior engineering personnel and other technical personnel

The questionnaires comprised questions on the following:

- ✓ the respondent's background, working situation and experience
- ✓ the respondent's knowledge in the field of maintenance
- ✓ the respondent's wishes for areas in the field of maintenance to learn more about
- ✓ basic computer use and literacy questions, as well as questions aimed at identifying the likely adoption prospects of an e-learning system.

The project collected 70 complete survey responses from managerial and maintenance engineering personnel (teachers & learners), as seen in Figure 2.

It is worth focusing on some statistics from the survey. Specifically:

- ✓ 49% of those who completed the questionnaire are Senior Engineers
- ✓ 31% of maintenance learners are Managerial Staff
- ✓ 12,7% of learners are Technicians

Regarding the learner interviewees experience in maintenance issues, the following can be observed:

- ✓ 67% of learners work less than three years in maintenance issues and they may not have sufficient expertise.
- ✓ 33% are more than three years in the field of maintenance and consequently more experienced.

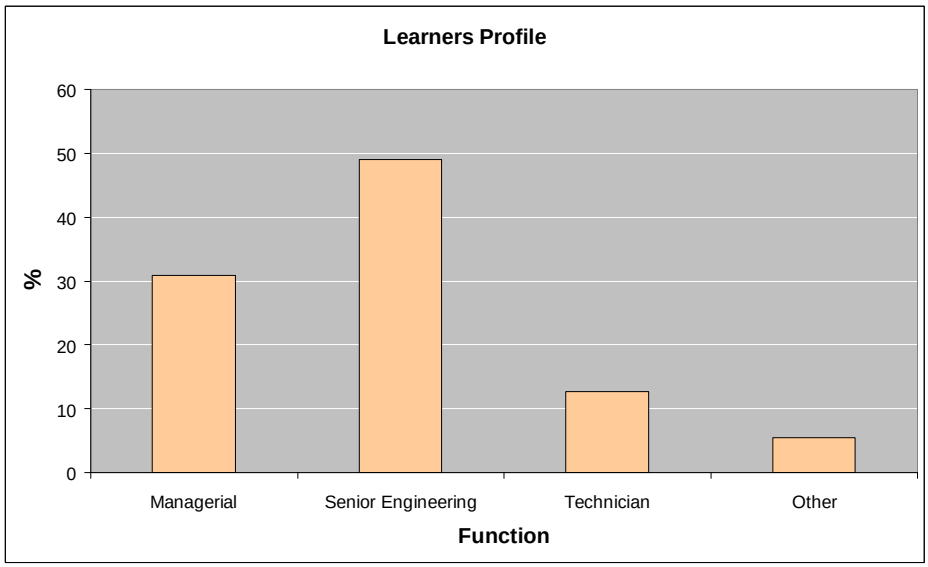

Figure 2. Survey respondent's profile

From the collected responses, it is particularly interesting to note that the teachers/trainers have between little or moderate knowledge in:

- ✓ Procurement, selling of service
- ✓ Laws and regulations

As an average they seem to have at least moderate or much knowledge in the other actual areas.

The learners have little knowledge in:

- ✓ Economical control, LCC, LCP
- ✓ Laws and regulations

As an average they seem to have at least moderate knowledge in the other areas.

Although one might expect that managers would rank their training in maintenance to be lower than technical staff, both managers and engineers (including technicians) ranked their training in maintenance to be at the same level. A significant proportion (25%) believe that their training is inadequate (low) which should be regarded as acceptance from their part that they are in need of further training in maintenance issues. As this is a snapshot of the "own view" of the respondents, it may be that the level of inadequate training among maintenance – related personnel might be even higher.

It is of particular interest to note that managers answers on 'economical control' were surprising: only 13% have "very much" knowledge on economical issues and another 13% know "much" on the same subject. In fact a very large proportion (44%) know no more than "little" on the subject, something that is not consistent with their function and highlights a very clear training need. It is therefore suggested that courses on economic issues should not only cover basic issues (for technical staff) but also more specific issues (for managers).

The fact that engineering and technical personnel chiefly do not consider that they have at least "much" knowledge on maintenance subjects is interesting. Perhaps learners with technical background consider that they have much practical knowledge on the subjects but they lack the necessary theoretical background. There may be an alternative explanation too: as they are directly involved with the technical difficulties of maintenance, they understand the considerable challenges involved in maintenance and so they provide more 'reserved' responses. A further interesting finding is that 41% of engineers and technicians do not know more than "little" about laws and regulations (this proportion for managers is just 13%). Nonetheless, knowledge on this subject is mandatory to become a Maintenance Specialist according to EFNMS. Yet, only a 13% of those responded indentified 'Laws and Regulations' as a preference topic for training. This is a clear indication that learner preferences should be interpreted with great caution and should be looked upon together with their stated knowledge on the subject and the objective requirements to become a Maintenance Specialist. In general it can be said that Engineers and Technical Personnel consider that they have much room for improvement and training on Maintenance issues, compared to Managerial personnel.

Of particular interest was to focus not only on the requirements for Maintenance Management training, but also on the adoption prospects of an e-Training system for Maintenance Management. An especially high proportion (94,5 %) uses computer in a daily basis and believes to be "very much" familiar with computers (81,8%). Furthermore, 100% of the interviewees responded that they expect to benefit "much" (40%) or "too much" (60%) from a computer based automated learning platform. There were no negative or indifferent replies on this question. These responses bond well with potential future use of e-training for Maintenance Management.

The survey responses were taken into account in designing the Maintenance Management Training curriculum, described in the next section.

3 MAINTENANCE CURRICULUM AND COURSES DEVELOPMENT

The iLearn2Main maintenance curriculum was structured on the basis of the specified VET objectives and the survey findings (Table 1), as well as by taking into account previous related activities in this area. The training content development process had as a key objective to provide both the theoretical background that trainees should possess in Maintenance Management, as well as the practical skills needed to implement the maintenance function. It is very important for a Maintenance Manager to have knowledge about the maintenance terms and their definitions, in order to avoid misunderstandings in the oral and written communication within the maintenance function – internally in the company as well as with external suppliers or customers. Correct and formal definitions are required to understand the maintenance terms used in requirements, specifications, instructions, contracts and associated maintenance standards in the maintenance function in general. Therefore, it has been necessary to produce a comprehensive structured generic maintenance glossary containing the main terms and their definitions.

Table 1

ILearn2Main Maintenance Management Learning Curriculum

CATEGORY		MODULE
Performed activities on the assets (Asset Care)	1.1	Maintenance involvement in design, procurement and operation of assets
	1.2	Preventive and inspection activities
	1.3	Repair techniques and methods
	1.4	Goal, strategies, results
	1.5	Work execution
Asset Performance Evaluation	2.1	Analysis of the technical performance of the assets
	2.2	Condition monitoring
	2.3	Measurements
	2.4	Information systems
Management/Economy of Assets	3.1	Maintenance concepts (Dependability / Availability Performance)
	3.2	Analysis of the economical results
	3.3	Documentation
	3.4	Laws and regulations
	3.5	Determination of human & material resources

The ilearn2main Glossary was produced using several sources so as to be as objective, comprehensive and as globally acceptable as possible Maintenance terms included in the Standard “EN 13306: Maintenance Terminology” were used as well as the “Terminology” module from the TrainInMain European project and other published papers, studies and scientific internet portals in relation to maintenance terminology. The maintenance terms included in the Glossary are then enriched during the training content development for each course, a process that resulted in an extended maintenance glossary. .

The main training content is structured in three basic course categories, each of which is composed by individual courses, following the curriculum structure. The above courses were firstly assigned for development to the maintenance experts of the iLearn2Main partnership. The assignment procedure was a combination of the partners’ preferences and the assignment proposal by Atlantis Engineering who led the content development effort. In order to achieve a uniform format for the courses, a template was produced that specified the structure, the content as well as the style of writing. The courses template follows the basic structure seen next:

1. Introduction (1.1 Objectives , 1.2 Learning Outcome , 1.3 Summary, 1.4 Prerequisites / Related Topics, 1.5 Keywords)

2. Theoretical Background (2.1 Prerequisites, 2.2 Main part, 2.3 Review Questions)

3. Implementation (3.1 Action plan, 3.2 Success factors, 3.3 Review Questions)

4. Case Studies

5. Assessment Questions

6. Glossary

7. List of References

The courses template foresees both review / comprehension & independent assessment questions. The review questions are placed in-between the training content and their use is for testing comprehension while learning. Some review questions are placed at the end of the training course in order to provide an overall test of how effective the learning was. The assessment questions belong to a different batch of questions and are used for the Assessment test (e-Assessment tool).

Finally, a quality control / review process for the training content was included. The quality control procedure that was performed for each course can be described as follows: for each training module made available by the author, a quality check was performed by an appointed reviewer. Then the final training module content was produced, after taking into account and acting upon the review comments.

4 THE LEARNING MANAGEMENT SYSTEM

4.1 The Learning Management System

E-learning has redefined the way education is provided in schools, academia and industry. It is defined as a technological, organizational and management system that enables and facilitates web-based learning. E-learning users, both trainers and learners, are offered integrated solutions which facilitate authoring, structuring and delivering educational content, as well as assessing the educational outcome. Such solutions are termed Learning Management Systems (LMSs). Most current LMSs include functionality to handle lesson content, often in the form of Learning Objects (LO). A Learning Object is an entity that can be used, reused or referenced in e-learning. There are many obvious advantages in web-based learning, compared with the conventional training. Typically, e-learning enables anytime, anywhere and to anyone with authorised access, to participate in the learning process. Apart from this flexibility, e-learning is usually associated with lower costs, compared to engaging a qualified teacher. On the other hand, e-learning involves extra costs in producing the actual educational content, as well as in customising it for the e-learning environment, while effort is needed for the setup and customisation of the learning environment itself.

When considering the choice for an LMS to be employed for developing a Maintenance Training Toolkit, there are several options available. Comparisons have been made against a single criterion, such as adaptation capacity [4], functional assessment or SCORM conformance [5] or against multiple criteria [6-8]. Evaluations consider both the viewpoint of those concerned with producing an LMS solution for a specific application, as well as for specific targeted teacher and learner user groups. The LMS developers are concerned with the LMS offered features for customising, extending, deploying, upgrading or for migrating the content from one platform to another. Users on the other hand are more concerned with the offered features to support the learning process, as well as with the system usability. The iLearn2Main e-training toolkit employs the open source Moodle LMS platform. Moodle is an acronym for “Modular Object-Oriented Dynamic Learning Environment”. Most evaluations cited above consider Moodle to be among the top LMS in terms of reusability, accessibility, adaptability, affordability, durability and interoperability. Furthermore, it is used and supported by a wide user community, providing new versions, FAQs and tutorials, offering SCORM support, while it remains a free and open source solution. Among other, Moodles enables us to:

- ✓ Design lessons with text, graphics, animations and video
- ✓ Incorporate comprehension and final assessment questions
- ✓ Define custom learning paths and pre-requisites for lessons
- ✓ Define meta-courses, which are aggregation of courses for specific subjects
- ✓ Include dynamic Glossaries with terminology

The iLearn2Main courses have been developed and deployed in the Moodle platform that was setup and customised at CETI/R.C.Athena to fit Maintenance Management training needs. The Learning system resides inside the project site, which is accessible at www.ilearn2main.eu. When a user first arrives at the project site, he is presented with a list of the offered learning material, as it is shown in Figure 3.

Users can have access to courses summary and check for other users online. If the user selects a course, or clicks on the login hyperlink, he is presented with a login form where he has to enter his credentials. Inside a course, under the course title, there are the different parts that comprise an iLearn2Main course (Figure 4):

- ✓ Course modules in the centre of the screen, including Lessons, Glossaries and References. This is the training content.
- ✓ Links to other participants in the course to facilitate communication, if needed.
- ✓ Links to activity types in the course for easier navigation.
- ✓ Direct access to the student history.
- ✓ List of all other courses the student has enrolled to.
- ✓ Latest news and events relevant to the course, i.e. uploading of a new module.

Figure 3. ILearn2Main training home page

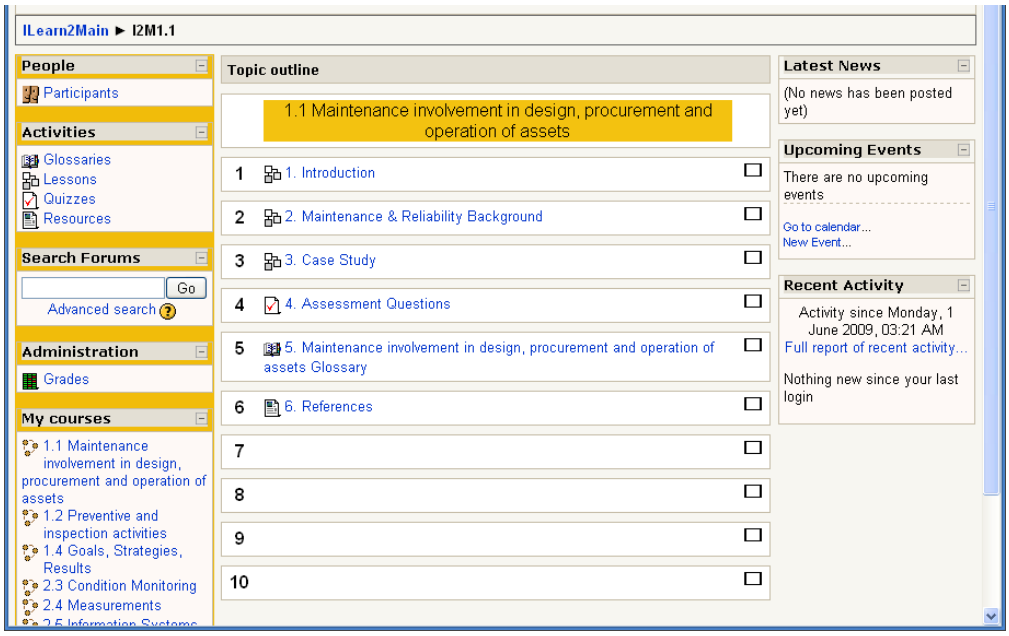

Figure 4. Example of ILearn2Main course page

The courses content includes pointers to references so that trainees can seek additional information or resources, should they wish to do so. References can be accessed as a separate web page, which is convenient for direct linking from the courses but also as a collective reference for external material. Adequate training requires familiarisation with the typical terms relevant to the course content. This is supported by the use of an e-glossary. The e-glossary provides links to definitions for all the terms that have been used inside the course. This Glossary is integrated with the training content so as to provide direct and easy access to any of its terms. These terms are automatically linked everywhere they exist in the lessons, and comprise a full and analytic reference guide of all maintenance terms.

4.2 Maintenance Management Competence Assessment

In modern industry it is of fundamental importance that personnel involved in the maintenance function have the right knowledge and skills to perform their intended function. This is necessary in order to attain excellence in productivity and cost effectiveness for the benefit of the company. It is of particular interest to note that training is important at different stages for all professionals, before and during their working life, as seen in Figure 5 [1].

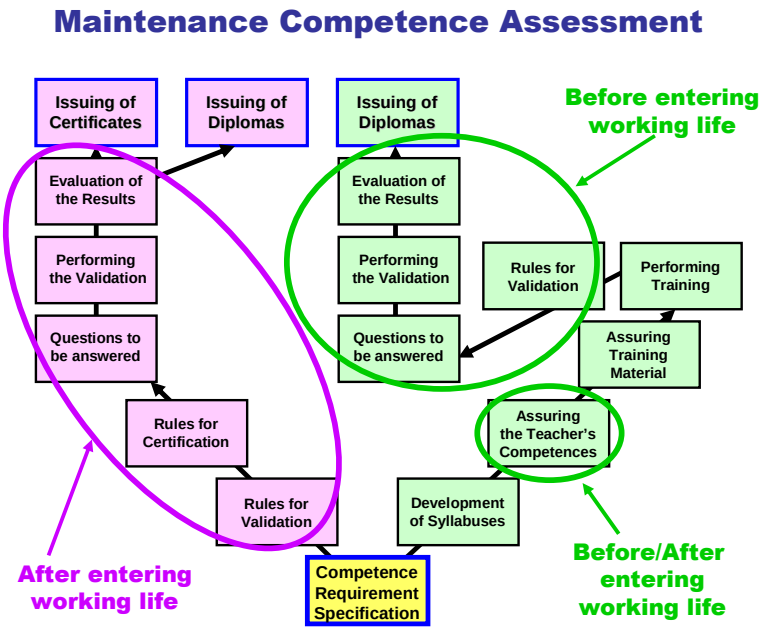

Figure 5. Maintenance Competence Assessment

The training content, ported in the form of Learning Objects and delivered to the trainees through the LMS, is an essential tool to deliver Maintenance Management e-training. One of the key advantages of employing e-training, as opposed to conventional training is the ability to customise training according to the circumstances and the progress achieved by each learner. In that way it is possible to personalise e-training, on the basis of user roles, performance and recognition of knowledge and competence gaps. This is not to say that conventional training cannot aim at achieving personalisation. Nonetheless, the additive value offered by the ability to automatically process training history data and the interaction of the trainee with the LMS is that the e-training can make a systematic, automated and independent assessment of each individual training case and thus seek to customise the offered training accordingly.

Through the use of comprehension and review tests, it is possible identify knowledge and skills gaps. Furthermore, it is possible to divert the learning sequence to better address the identified gaps, by encouraging the trainee to focus its training in areas that he seems to need additional training on. In this way different trainees can follow distinct training paths, making the whole training procedure more efficient and tailored to individual needs. It is worth noting that conventional training require much more substantial effort by the trainers to achieve a similar level of customisation, thus the LMS, equipped with knowledge testing becomes a powerful tool for trainers too, in their function to provide adequate training. Maintenance Management training involves knowledge and skills which are multi-disciplinary by the very nature of the Maintenance Management function. Therefore, the ability to offer this level of customisation by e-training and knowledge assessment tools is particularly beneficial for the delivery of Maintenance Management training. A typical example of testing during the e-training is shown in Figure 6.

While knowledge testing constitutes an essential function that is blended with the e-training delivery and facilitates efficient e-training and personalisation of the way this is delivered to each trainee, there is a clear need for an independent assessment of Maintenance Management competences. This independent assessment is needed in order to support an objective assessment of Maintenance Management competences. In iLearn2Main, this independent assessment is designed to be offered by a separate and stand alone tool. The underlying design consideration is that a number of tests are created, to cover the breadth of the iLearn2Main curriculum courses. These tests are placed in a competence assessment tests pool and the e-Assessment tool randomly picks a subset of those each time to offer a different competence assessment test. Although the choice is random, care is taken so that the chosen tests cover the range of topics an courses that are deemed essential to successful perform the Maintenance Management function (Figure 7).

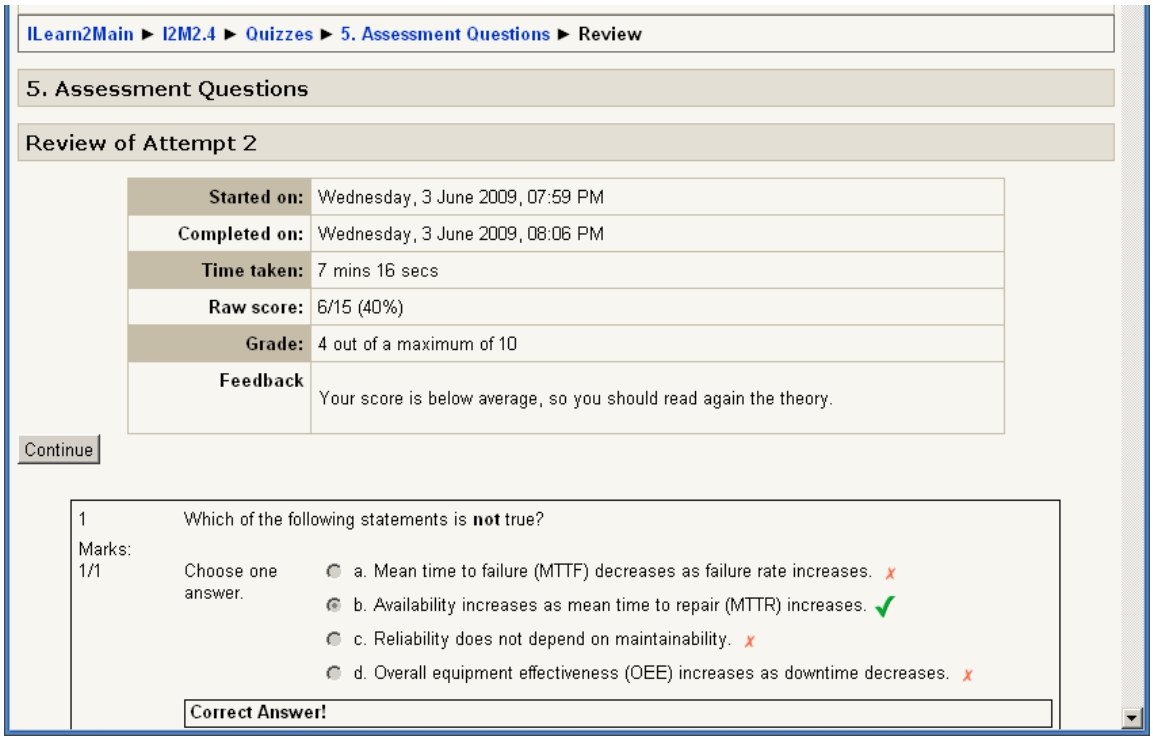

Figure 6. Example of training review testing.

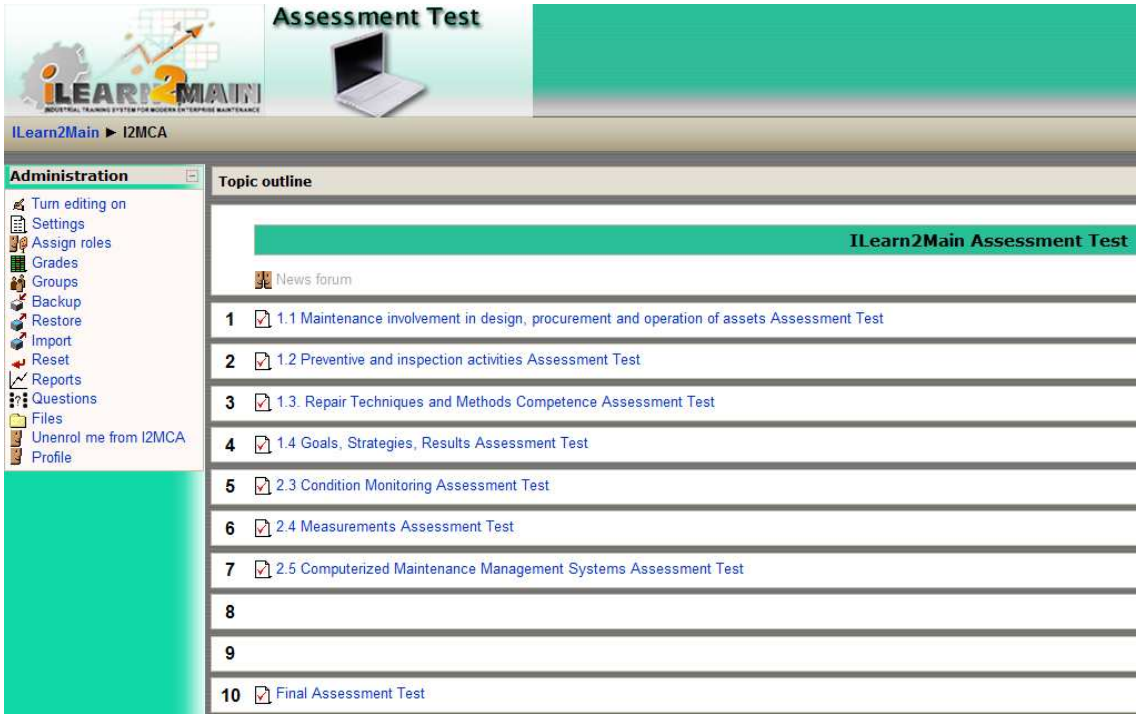

Figure 7. The e-Assessment Tool

5 FUTURE STEPS

The next steps in the development of the iLearn2Main e-training for Maintenance Management are:

- ✓ Enriching the training content with additional training modules
- ✓ Completing the development of the e-Assessment tool
- ✓ Piloting and Evaluation

Training courses. All training courses specified in the iLearn2Main Maintenance Management Training Curriculum will be included in the iLearn2Main e-training platform. The curriculum can expand to incorporate additional training content, case studies and tests. Additional courses can also be included. In this way iLearn2Main may offer courses about both the essential knowledge for Maintenance Management basic training as well as for targeting the improvement of the Maintenance Function. In the future it may be beneficial to employ as much multimedia training content as possible, in the form of images audio, video or animation. Such content can offer enhanced training experience and user engagement during the training process.

e-Assessment Tool. The e-Assessment Tool is offered separately from the e-training toolkit. It comprises hundreds of questions and tests on the taught subjects. A subset of tests is chosen in random order each time, so that different competence assessment tests can be offered. As tests are linked to specific taught module subjects, the e-Assessment tool is not only employed for overall competence assessment, but also to identify specific weaknesses of the assessed trainee, so as to guide future training on specific Maintenance Management subjects. The e-Assessment tool will be extended to include test from all courses included in the iLearn2Main curriculum.

Evaluation and piloting. iLearn2Main employs ex-ante and ex-poste evaluation, so as to engage stakeholders at different stages. The ex-ante evaluation focused mainly on performing a user survey, while the ex-post evaluation comprises different piloting activities, such as training workshops. The piloting events seek participation and feedback from both academia and industry. Participants have the opportunity to use the Learning and the e-Assessment Toolkit. Evaluation questionnaires are being designed to assemble feedback from participating stakeholders. This feedback will be particularly useful in driving improvements and next development steps for the e-Training and e-Assessment toolkits. Piloting activities organised as workshops are intended to include presentations, interactive training, case study analysis and tests.

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Acknowledgments

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