HARDWARE, SOFTWARE AND PEOPLEWARE

UNISA

SAICSIT 2001

Edited by
Karen Renaud
Paula Kotzé
Andries Barnard

HARDWARE, SOFTWARE AND PEOPLEWARE

South African Institute of Computer Scientists and Information Technologists Annual Conference

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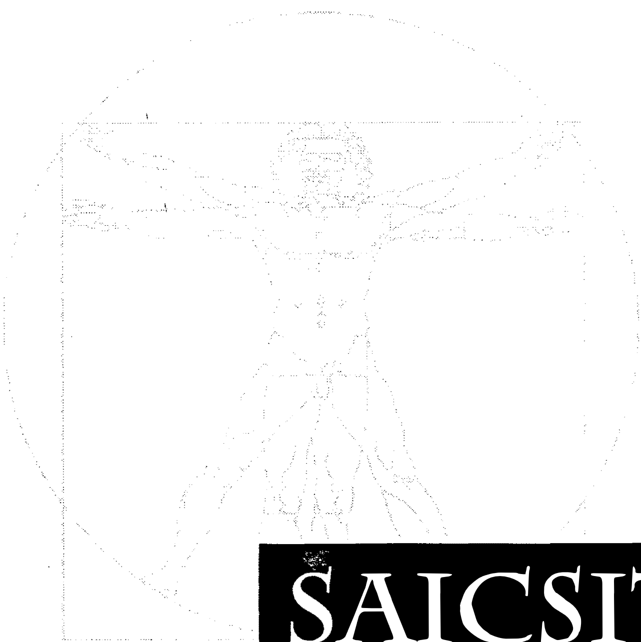

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Message from the SAICSIT President

The South African Institute of Computer Scientists and Information Technologists (SAICSIT) was formed in 1982 and focuses on research and development in all fields of computing and information technology in South Africa. Now in the 20th year of its existence, SAICSIT has come of age, and through its flagship series of annual conferences provides a showcase of not only the best research from the Southern-African region, but also of international research, attracting contributions from far afield. SAICSIT does, however, not exist or operate in isolation.

More than 50 years have passed since the first electronic computer appeared in our society. In the intervening years technological development has been exponential. Over the last 20 years there has been a vast growth and pervasiveness of computing and information technology throughout the world. This has led into the expansion and consolidation of research into a diversity of new technologies and applications in diverse cultural environments. During this period huge strides have also been made in the development of computing devices. The processing speed of computers has increased thousand-fold and memory capacity from megabytes to gigabytes in the last decade alone. The Southern African region did not miss out on these developments.

It is hardly possible for such quantitative expansion not to bring a change in quality. Initially computers had been developed mainly for purposes such as automation for the improvement of processing, labour-reduction in production and automation control of machinery, with artificial intelligence, which made great strides in the 1980s, seen as the ultimate field to which computers could be applied. As we moved into the 1990s it was recognized that such an automation route was not the only direction in the improvement of computers. The expansion of processing power has enabled image data to be incorporated into computer systems, mainly for the purpose of improving human utilisation. For most computer technologies of the 1990s, including the Internet and virtual reality, automation was not the ultimate purpose. Humans were increasingly actively involved in the information-processing loop. This involvement has gradually increased as we move into the 21st century. Development of computer technology based not on automation, but on interaction, is now fully established.

The method of interaction has significantly changed as well. The expansion of computer ability means that the same function can be performed far more cheaply and on smaller computers than ever before. The advent of portable and mobile computers and pervasive computing devices is ample evidence of this. The need for users to be at the same location as a computer in order to reap the benefits of software installed on that computer is becoming an obsolete notion. Time and space are no longer constraints. One of the most discussed impacts of computing and information technology is *communication* and the easy accessibility of information. This changes the emphasis for research and development – issues such as cultural, political, and economic differences must, for example, be accommodated in ways that researchers have not previously considered. Our goal should be to enable users to benefit from technological advances, hence matching the skills, needs, and expectations of users of available technologies to their immense possibilities.

The conference theme for the SAICSIT 2001 Conference – *Hardware, Software and Peopleware: The Reality in the Real Millennium* – aims to reflect technological developments in all aspects related to computerised systems or computing devices, and especially reflect the fact that each influences the others.

Not only has SAICSIT come of age in the 21st century, but so has the research and development community in Southern Africa. The outstanding quality of papers submitted to SAICSIT 2001, of which only a small selection is published in this collection, illustrates both the exciting and developing nature of the field in our region. I hope that you will enjoy SAICSIT 2001 and that it will provide opportunities to cultivate and grow the seeds of discussion on innovative and new developments in computing and information technology.

Paula Kotzé
SAICSIT President

Message from the Chairs

Running this conference has been rewarding, exciting and exhausting. The response to the call for papers we sent out in March was overwhelming. We received 64 paper submissions for our main conference and twelve for the postgraduate symposium. We had a panel of internationally recognized reviewers, both local and international. The response from the reviewers was impressive – accepting a variety of papers and *mostly* returning the reviews long before the due date. We were struck, once again, by the sheer magnanimity of academia – as busy as we all are, we still manage to contribute fully to a conference such as SAICSIT.

After an exhaustive review process, where each paper was reviewed by at least three reviewers, the program committee accepted 26 full research papers and 14 electronic papers. Five papers were referred to the postgraduate symposium, since they represented work in progress – not yet ready for presentation to a full conference but which nevertheless represented sound and relevant research. The papers published in this volume therefore represent research of an internationally high standard and we are proud to publish it. Full electronic papers will be available on the conference web site (http://www.cs.unisa.ac.za/saicsit2001/).

Computer Science and Information Systems academics in South Africa labour under difficult circumstances. *The popularity of IT courses stems from the fact that IT qualifications are in high demand in industry, which leads in turn to a shortage of IT academic staff to teach the courses, even when posts are available. The net result is that fewer people teach more courses to more students. IT departments thus rake in ever-increasing amounts of state subsidy for their universities. These profits, euphemistically labelled "contribution to overhead costs", are deployed in various ways: cross-subsidization of non-profitable departments; maintenance of general facilities; salaries for administrative personnel, etc. Sweeteners of generous physical resources for the IT departments may be provided. We have yet to hear of a University in South Africa where significant concessions have been made in terms of industry-related remuneration. At best, small subventions are provided. As a result, shortages of quality staff remain acute in most IT departments – especially at senior teaching levels. What is even worse is that academics in these departments have to motivate the value of their conference contributions and other IT outputs to selection committees, often dominated by sceptical academic power-brokers from the more traditional departments whose continued survival is underwritten by IT's contribution to overhead costs.* [1]

The papers published in this volume are conclusive evidence of the indefatigability and pertinacity of Computer Science and Information Systems academics and technologists in South Africa. We are proud to be part of such a prestigious and innovative group of people.

In conclusion, we would like to thank the conference chair, Prof Paula Kotzé, for her support. We also specially thank Prof Derrick Kourie for his substantial contribution. Finally, to all of you, contributors, presenters, reviewers and organisers – a big thank you – without you this conference could not be successful.

Enjoy the Conference!
Karen Renaud & Andries Barnard

[1] This taken almost verbatim from Professor Derrick Kourie's SACLA 2001 paper titled: "*The Benefits of Bad Teaching*".

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Keynote Abstracts

Structured Mapping of Digital Learning Systems

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Abstract: *In this paper we consider the consequences of e-learning design and implementation on the working processes and on the roles to be fulfilled in the usually cyclic process of course development and -exploitation. We analyse generic course design according to the principles of competence-oriented education and present a framework in which digital learning systems can be designed and implemented in such a way that it is possible to maintain course quality, reuse course components and simplify course maintenance.*

Keywords (TNR 8pt, B): *Systems Modelling, E-learning, Educational Markup Language*
Computing Review Categories: K.3.1, H.1.0

1. Introduction

Successful integration of e-learning into the teaching model of an institution involves more than implementing communication technologies and e-learning systems. E-learning programmes often originate from disjointed experiments and implementations by a few individuals in different departments, each applying their own preferences and interpretations of what acceptable virtual course or digital courseware should look like. Many of these experiments are valuable research inputs towards well-designed virtual learning environments, but as these implementations do not conform to some *de facto* or *de jure* standard, chaos in e-learning systems develops as fast as the number of implementations. This chaos not only contributes negatively to the so-called image of e-learning as method of learning, but also makes it extremely difficult to (1) lay down conformance guidelines for e-courses, (2) exercise quality control over e-course content and presentation, (3) reuse course components that are repeated (or referred to) in different courses, (4) maintain course contents, and (5) design and maintain background infrastructures through which the learners can access the e-courses. One only need to think of the current chaotic state of indexing on the Internet, to get an idea of where unstructured e-learning programmes are going if they do not conform to some standard of e-learning. Unfortunately, as it is with the adoption of most new architectures, standards for e-learning design do not yet exist.

In a current research effort, we are working with the Open University of the Netherlands towards such a standard, with the aim to systematically model courses in digital environments. Examples of other similar research efforts include the efforts of IMS Global Learning Consortium, Inc. [4] and Advanced Distributed Learning (ADL) [1]. It is beyond the scope of this paper to compare the various research efforts. The objective of this paper is to describe the structures and frameworks under consideration in mapping a course onto a digital environment and show some of the early results that were achieved with the implementation of this effort to set a standards.

2. EML as modelling language

As explained in the first section, the need for standards in e-learning systems is urgent. EML (Educational Modelling Language) is a notational method for describing electronic learning environments. As an application of XML, it is a predefined markup language that allows course designers to wrap course information in meta tags so that information is content-sensitive and also reusable. The tagged information is formatted separately for presentation through a specific delivery medium. EML is considered *medium-neutral* with respect to the pedagogy and mode of delivery, for example, one may use EML to model a competence based pedagogy, problem based learning, performance support, self study packages or even traditional face-to-face teaching; EML allows one to deliver learning materials on different media. EML merely records the way in which the various elements of a particular educational setting are related in order for them to be interpreted by a computer.

As a notational system, EML makes it possible for different experts in a course designer team to systematically work together on various, high-quality instructional methods irrespective of the delivery medium, whilst maintaining the quality of education through explicit notation, reusing course components.

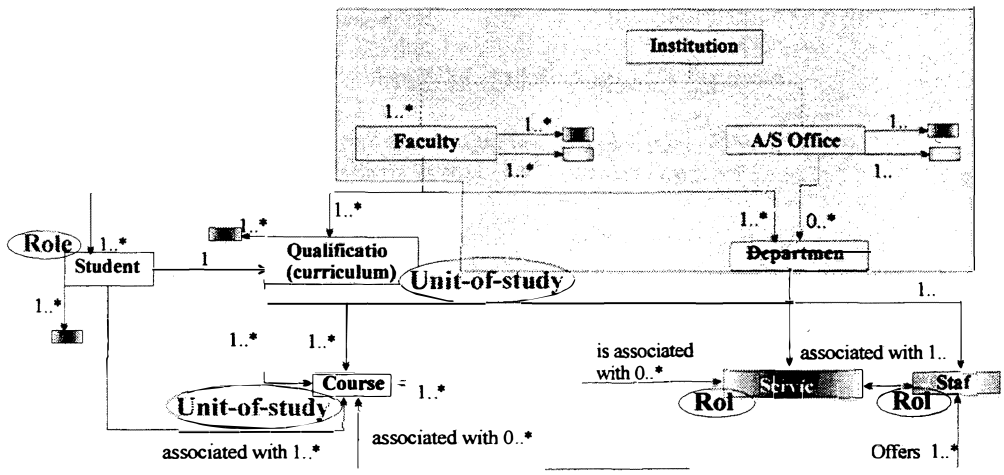

Figure 1 Structural overview of learning institution components that play a particular role in e-classrooms

Also, interchanging the components that have already been developed and implementing guidelines for uniformity. The notations that are used to describe a course form part of a standard that is accepted and known by different individuals, experts and institutions, so course design and meta-information can be understood and interpreted by all, which enables continuity.

Course designers can use EML to design courses in traditional ways, or design courses that provide customized learning programmes for specific learners, taking into account their learning styles, experience, knowledge and learning goals. It allows the designers to reuse existing information instead of starting from scratch for each new design. It not only provides for uniformity and standardization but also has the potential to reduce cost and time to build interesting and effective learning units.

3. Course design with EML

To understand how EML maps a course to a digital learning environment, it is necessary to first look at an overall view of the of relevant components of an institution. Figure 1 illustrates the relevant structures within a tertiary institution. (The components in the shaded area are not relevant to the mapping process.) A tertiary institution can broadly be categorised into two objects namely faculties and administrative or support (A/S) offices.

Any faculty offers qualifications such as degrees, diplomas or certificates and consists of departments that offer one or more courses. Students register for a qualification in a particular faculty or simply enroll for one or more courses for NDP. Associated with a faculty or department are services that can either be used or offered. Each faculty and department also have staff associated with it.

Staff members within a department are associated with courses that are related to that particular department. The A/S offices also have staff and use or offer particular services. Each A/S office consists of zero or more departments which have, once again, staff and use or offer particular services.

The parabolas on the components depict the respective EML mappings. For example, in EML, both a course and a curriculum are regarded as units-of-study, since both share certain inherent structures which we explain subsequently. In an EML representation of a learning environment, we describe all objects, contexts, behaviours and actors who play a role in the development, execution and evaluation of the learning environment. It makes for a well-structured, and well-planned design in which it become possible to anticipate and intercept potential problems if we compile a logically classified collection of tasks or instructions for different people in the learning environment that makes it clear which activities are expected in which roles. As shown in Figure 1, the actions of learners, staff and services are captured in EML roles.

Curriculum and Content modelling

A qualification (curriculum), as portrayed in Figure 2 can be a degree, diploma or certificate, each with standard structures that describe such a qualification. Figure 2a depicts the standard structures that are inherent to a qualification. Under *specific information* is the qualification detail, for example its name (eg. B.Comm Informatics), its home faculty, etc.

A qualification usually has certain *prerequisites* such as senior certificate, a D symbol in maths, mathematics II (as for

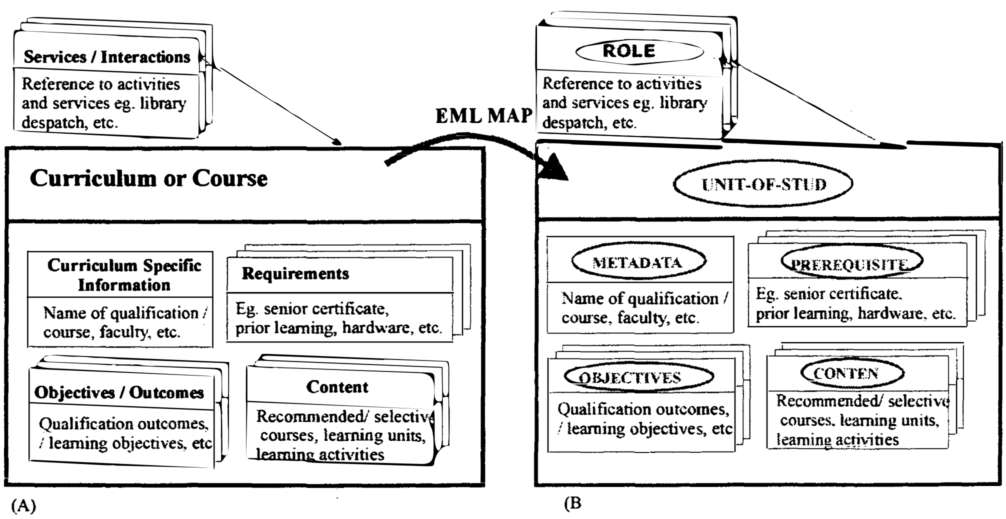

Figure 2 Curriculum modelling

mathematics III), etc. Each qualification also has predefined *outcomes or objectives* indicating what the learners will be able to do after obtaining the particular qualification. Furthermore, a qualification consists of a number of courses or modules, of which some may be compulsory while others may be recommended or selective. No qualification functions on its own, but students enrolled for a particular qualification interact with certain institutional *services* that are available for that qualification. In some cases, it might be general services, such as the library, while in others it may be more faculty-specific, like chemical laboratories. Figure 2b shows how the basic structure of a curriculum remains unchanged when described by EML elements.

Similar to a curriculum, the structures in courses can be categorised and described by descriptors such as specific course information, requirements and prerequisites, objectives and outcomes, content and other course information. These structures are portrayed in Figure 2. In the case of a course, the *content* is composed of learning unites (LUs) made up of knowledge units (KUs), the way KUs are communicated to the learners and activities and interactions between the learners and facilitators, as well as between the learners themselves. (Each LU can be compared to a lecture.)

In the EML context, course design is directed by the identification of activities, that is, activities are regarded as fundamental to teaching. EML assumes that instruction should consist of providing students with a coherent set of activities including specific learning environments before learning can actually take place. Activities are also used to assess whether learning objectives have been achieved [3]. Because of this assumption, EML provides a rich set of notations for activities and the activity environments. Example 1 shows as extract from a course wrapped in EML[1] notation.

4. Early Results

The Open University of the Netherlands has several pilot courses that was designed with EML. Currently we have designed one pilot course with EML, namely Telecommunication Networks which is being evaluated by different users. Designing the local course was not easy, because of the flexibility, richness and also complexity of EML. Furthermore, XML authoring tools are fairly new on the market, and EML authoring tools are non-existent. (This is one of the sub research projects that is currently under development.) Therefore the course designers had to work with raw tags which cluttered the design issues a bit. Because of EML's flexibility, it is possible to design a course around a personal didactic model or interpretation. However, the presentation of the course is currently restricted by the style sheets being used to publish the EML wrapped material. (This is another sub research project that is currently under development.) One of the disadvantages of the Edubox publishing process is the impossibility to do real-time design. That means that the

[1] EML is a notational modelling language designed and developed by the Open University of the Netherlands.

WYSIWYG effect that can be achieved when using for example an HTML editor for Web authoring, is not possible for course authoring. As a result, one has to go through the entire publishing process, before the designed course can be viewed, and this makes it inconvenient for even small changes. (With the current sub research projects under way, this problem will also be addressed in the near future.) However, due to this lack of WYSIWYG talent, the initial publication of the Telecommunications Networks course was not too appealing, and we went back to the drawing board to redesign the course. Unfortunately even the second publication, was still 'unfriendly' and users made comments like 'I eventually found all the information that I needed for this course, but navigating my way to find it, took some energy'

We must emphasise at this stage, that the strength of EML is not in its presentation capabilities - that is not even an objective of EML, but in its search potentials, reuse, structured design etc. The current problem lies with how the design is structured before it is wrapped in EML notations, as well as with the presentation style sheets. Since we had to return to the drawing board for the third time, we took a long and hard look at integrated course design for electronic environments, and will subsequently describe a structured framework for course designers when designing for electronic-based learning environments.

5. Generic course design

It is often the impetus of market forces, availability of progressing technologies, customer demand and competition that are the instigators for e-learning. Unfortunately these do not guarantee positive acceptance and usage of e-learning. It is only thorough planning and design that can ensure successful implementations because an electronic course is much more than just study material or courseware. In the same way that contact lecture sessions do not simply imply the lecturer reading the textbook out loud, e-learning does not simply involve dumping study material on learners at the start of a course and assessing them again at the end of the course. Lectures or learning units (LUs), irrespective of communication or delivery media, consist of knowledge units to be shared, the method and aids by which they are chosen to be shared, activities to enhance understanding of the shared knowledge unit, and often also assignments or tests to assess whether the knowledge was indeed shared in a such way that understanding took place. We all know that presenting knowledge units in a way which enables learning and interaction with learners about the learning situation or their involvement in the learning situation, demand planning. When we use complex, but exciting technologies to assist us in this learning process, the planning becomes more complex.

The design of an e-classroom system involves identification and analysis of e-classroom and courseware components with their associated technologies. This design process is portrayed through two interweaved design life cycles, namely the pedagogical and the technological life cycles, that form two concurrent processes that interject and support one another [2]. The identification of the course objects forces the course designers to consider all facets of the e-classroom and become steeped in the shoes of the facilitator during the course. In many less-successful e-learning efforts, not all relevant course components were considered during the design, resulting in courses being run on crisis management. It is beyond the scope of this paper to focus on specific course components, but the objective is rather to provide a generic overview. (Research work that focusses on specific course components and the design thereof has been submitted for journal publication.)

Figure 3 portrays a generic model for course design, irrespective of the delivery medium of the course, in which three distinct phases occur namely the declaration phase, study process phase and consummation phase. (This model is a simplification of a complex process that has been successfully modelled through many detailed models in the past. The purpose of this simple model is to lay the background for modelling a course in a digital learning environment.)

The *declaration phase* consists of two processes namely the *definitions process* and the *course information process*. In the *definitions process*, predefined course specific information is described. This information is independent of study material, lecturer or target group, and include information such as course name, course code, course objectives, course outcomes, required prior learning, etc. The role of the learner in the *definitions process* is to take notice of its content for future references.

Information integrated in the *course information process* includes study material components, course communication details, assessment matters, content layout, etc.

Definition of these components clearly depends on specific entities such as the specific prescribed textbook, the target group, the lecturer and situational factors.

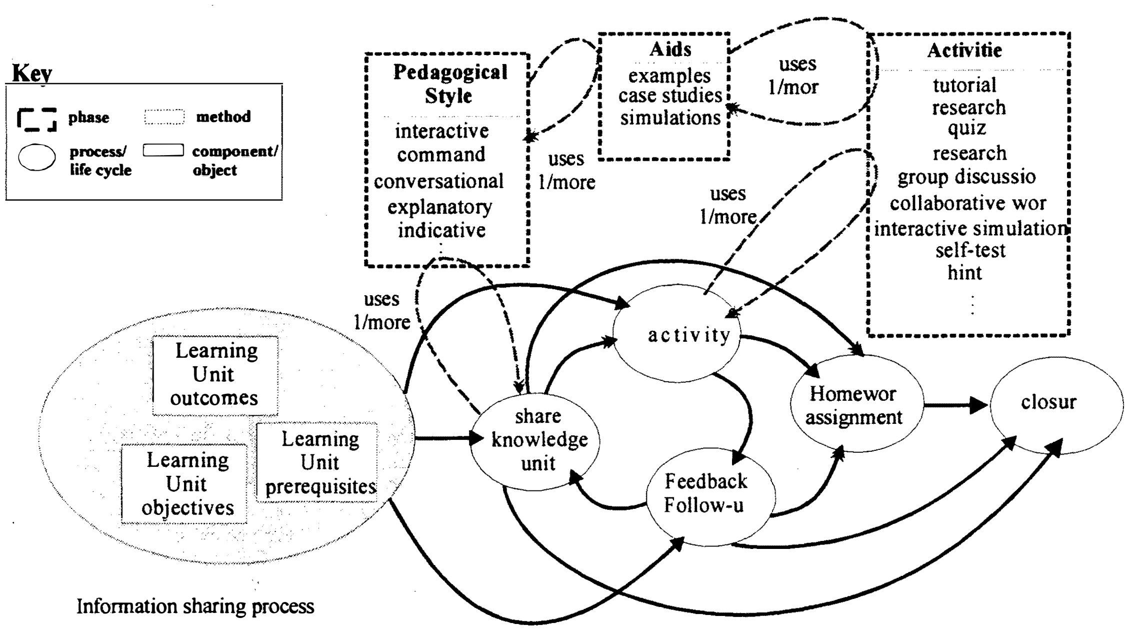

Figure 3 Life cycle in the design of a *Learning Unit.*

The role of the learner in the *course information process* involves reading (taking notice of) the given information to enhance his or her comprehension of his or her learning environment.

The second process in the generic course design method involves the design of the learning content. The content is composed of learning units (LUs) made up of knowledge units (KUs), the way they are communicated to the learners and activities and interactions between the learners and facilitators, and amongst learners. Each LU can be compared to a lecture. Sharing the LU objectives, outcomes and prerequisites may be straight forward with little deviation in the method of how these are shared between various units. However, when sharing content with the learners, a sequence of sharing a KU, completing an activity, and feedback or follow up on the activity is common, where any particular action may be omitted. The course designer team develops the LU according to a preferred pedagogical strategy and chooses a pedagogical style and aids to share the particular KUs, the type of activity, as well as the method by which follow-up activities are pursued. It is clear that, depending on the type of KUs to be shared, many pedagogical styles can be build into a single learning unit, and also into the various learning units. Figure 4 illustrates the design life cycle of learning units.

In the final phase of course design, a *closure process* implies the final summaries, and concluding remarks for the course, after which students are usually assessed in the *final assessment process*, which may be in the form of a written exam or some auto-assessment computerised system. Both these processes are influenced by the specific study material that the learners use, the specific group of learners, the lecturer, etc.

6. Conclusions

Despite the increase in published results on e-learning with the advent of the Internet, it seems that the implementation of e-learning systems has not been as indicative as the advancement of technology allows. Progressing technologies could potentially draw large numbers of students to institutions that incorporate e-leaning into their core business. However, in many instances, the complexity of e-learning systems is underestimated, which results in frustrating experiments and discouraging learning experiences. Standardizing electronic educational processes is a prerequisite to successfully enter the market of e-learning.

In this paper, we have described our collaborative research efforts with a European university to set an open standard for designing courses for electronic education. Our research efforts have lead us to consider the consequences of e-learning design and implementation on the working processes and on the roles to be fulfilled in the usually cyclic process of course development and -exploitation. We have analysed the assignment to develop a course: with respect to content, didactical and educational technological aspects and from a managerial point of view, and presented a framework in which digital learning systems can be designed.

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<Role-ref Id-ref = "AllLearners">
<Activity-structure-ref Id-ref = "AssignmentStructure"></Play></Method>
</Unit-of-study>
```

Example 1: Extract from a course wrapped in EML notation