IMPACT OF DIGITAL LITERACY ON THE ENGINEERING CURRICULUM

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ABSTRACT

As most of engineering activities lies today in the Digital World, today engineers have to be confident in the use of the 21st century digital environment. Digital Literacy includes critical localization, evaluation and use of information in the digital environment. This environment (including the Web) is evolving into a set of community spaces and communication tools that enable collaborative activities like discovering, exchanging, commenting, criticizing and building information where future engineers will have to collaborate as professionals. Hence Digital Literacy is becoming a key set of competencies for the 21st century engineer. It encompasses digital extensions of many personal, professional and interpersonal skills included in the CDIO syllabus, such as Knowledge Discovery, Critical Thinking, Curiosity and Lifelong learning or Communications. Therefore, we claim that it shall be transversally included in engineering curricula, as practice of standard digital engineering skills.
Wikis, blogs are nowadays state of the art tools for social learning. They encourage analytic and synthetic work on ideas. Hence they represent good tools for active learning practice as basis for integrated approach. We present three progressive experiments conducted in our institution, where such tools have been used to foster such digital skills and scientific knowledge at the same time.
Lastly, the main difficulty to introduce such tools is definitely the faculty adoption of such tools as faculty may still be reluctant to use digital tools in education. We discuss our approach for faculty development in numerical skills, based on a mix of: early adopters support, communities of practice, institution requirements, animations and practical workshops.

KEYWORDS

Active Learning, Integrated Digital Literacy, Web2.0, blog, wiki.

INTRODUCTION

For an engineer in the 21st century, the so-called *Digital Literacy* (including localization, evaluation and use of information in digital environments [1]) has become a critical set of competencies. Somehow, these competencies are related with the digital counterparts of several personal, professional and interpersonal skills included in the CDIO syllabus, such as Knowledge Discovery, Critical Thinking, Curiosity and Lifelong learning or Communications. However, these skills do not totally capture many common usages that have recently emerged on the Web. Whatever it is called (Web 2.0, Read/Write Web, Social Web, etc.), the Web is evolving into a set of community spaces and communication tools that enable collaborative activities like discovering, exchanging, commenting, criticizing and building information. We

claim that mastering these new usages, especially in a professional context, is crucial. Therefore they should be inserted in any graduate engineering education as standard digital skills.

In an educational perspective, recent Web tools, especially *blogs*, *wikis*, and *rich media sharing*, fit well with socio-constructivist learning approaches because they provide spaces for collaborative knowledge building and reflective practices. In general, the use of these Web tools also requires to develop active learning practices, and to work at high cognitive dimensions in the Bloom's taxonomy. On one hand, these tools are commonly used by most students in informal learning settings outside any formal nor institutional learning environment [2], on the other hand, these usages have to be integrated in authentic contexts in order to engage students in actual Digital Literacy processes. In Section 2, we survey the various definitions of Digital Literacy, and then we explore connections to engineering skills and active learning. In particular, we show that those dimensions are strongly related with personal and interpersonal skills.

In this paper, we describe three examples where Digital Literacy is integrated in the curriculum. First we used a *forum* for constituting collaboratively a bibliography. Second, we used a *wiki* for writing a collaborative notebook. Finally, we used *blogs* for developing active learning in a classic course. Interestingly, these tools have been exploited in three different contexts, respectively project-based learning, taking into account new professional needs, or as support of collaborative writing and active learning in technical or project-based learning. In Section 3, we give details about these classroom experiences. We emphasize that the inclusion of Digital Literacy in an engineering graduate curriculum is done in a progressive way. Indeed, Digital Literacy usage occurs here in a professional context, which allows acquisition of competencies.

Finally, we deal with the impact of the inclusion of Digital Literacy in the curriculum on the Faculty members. In particular, we highlight three critical points, which appear to be fundamental basis for a successful adoption of Digital Literacy teaching: awareness of state-of-the-art collaborative tools, development of communities of practices, and animation as vector for exchanges. In Section 4, we develop these three aspects.

2. DIGITAL LITERACY, ENGINEERING SKILLS AND ACTIVE LEARNING

In this Section, we define Digital Literacy and show how it relates with engineering skills as detailed in CDIO syllabus. We detail three levels of Digital Literacy, and then we explain why Digital Literacy encourages active learning.

Digital Literacy

To our point of view [3], the development of Digital Literacy is of vital interest for future engineers. Competencies related with Digital Literacy have been recognized as transverse skills for Master level by European Union in the so-called Dublin's descriptors [4]:

> "*Having the ability to integrate knowledge and handle complexity, and formulate judgements with incomplete or limited information, but that includes reflecting on social and ethical responsibilities linked to the application of their knowledge and judgements …*"

The eLearning Programme of the European Commission [5] highlights also the importance of Digital Literacy in our societies:

> "*The ability to use ICT and the Internet becomes a new form of literacy – "Digital Literacy". Digital Literacy is fast becoming a prerequisite for creativity, innovation and entrepreneurship and without it citizens can neither participate fully in society nor acquire the skills and knowledge necessary to live in the 21st century* ".

Creativity, innovation, entrepreneurship, and leadership are competencies that are expected from engineers in the 21st century. Typically, such competencies have been proposed for an extension of current CDIO Syllabus [6]. We share this vision, which motivates in our opinion the inclusion of Digital Literacy in the curriculum of graduate engineering students.

Interestingly, Gilster emphasizes critical thinking rather than technical competence as the core skill of Digital Literacy [7]. Beyond technical tools, Digital Literacy refers to high levels of proficiency of knowledge. DIGEuLit project [5] proposes the following definition of Digital Literacy:

> "*Digital Literacy is the awareness, attitude and ability of individuals to appropriately use digital tools and facilities to identify, access, manage, integrate, evaluate, analyse and synthesize digital resources, construct new knowledge, create media expressions, and communicate with others, in the context of specific life situations, in order to enable constructive social action; and to reflect upon this process.*"

CDIO as context

This definition can be linked to the CDIO syllabus, notably to following skills: Knowledge Discovery, Critical Thinking, Curiosity and Lifelong learning or Communications. Hence, Digital Literacy may be considered as transparent at the syllabus level. However, some agencies, such as the eLearning Programme of European Commission, or French Ministry of Education with its "Internet and Computer Science Certificate for engineers" (C2iMi in french) [8], have clearly decided that it should be explicitly mentioned in the syllabus.

In DIGEuLit project, three levels are proposed for Digital Literacy development:

- Digital competence is level I. This level encompasses skills ranging from basic visual recognition and manual skills to more critical, evaluative and conceptual approaches. It also includes attitudes and awareness in the context of life situation. This clearly refers to skills such as 2.2 - Knowledge Discovery or 3.2 Communications.
- Digital usage is level II. It corresponds to application of digital competence within specific professional or domain contexts (communities of practice). In communities of practice, learning becomes a communal activity intimately linked with everyday practice. Digital usages become embedded within the understandings and actions, which evolve within the community and cause the community itself to evolve; the community of practice is thus also a community of learning. According to CDIO Syllabus, it clearly refers to skill 2.4.6 - Curiosity and Lifelong learning.
- Digital Transformation is level III. It is achieved when the digital usages that have been developed enable both innovation and creativity, and stimulate significant changes within the professional or knowledge domain. These changes may happen both at the individual scale and the group (or organization) scale. Whilst many digitally literate persons may achieve a transformative level, transformation is not a necessary condition of Digital Literacy. Activity at the level of appropriate and informed usage would be sufficient to describe as digitally literate. This level clearly refers to the leadership extension of CDIO Syllabus.

Digital Literacy for active learning

Digital Literacy offers the opportunity to work on these skills in an active learning way. Leveraging digital tools allows the development of new active learning techniques, either as support of lecture, or as engineering tools in experimental courses. Siemens [9] has recently proposed a handbook of practice, exhibiting the diversity of possible approaches. He especially encourages peer work at a class and event at a university scale. Christine Bruce [1] shows that high level in Digital Literacy enables high level of competencies according to Bloom's taxonomy.

Recent Web tools do not engage to active learning *per se*. Level II of DIGEuLit project recalls that this literacy has to be integrated in a professional context to fully operate. Hence authentic activities have to be adapted to CDIO engineering context.

3. EXPERIENCES OF FORUMS, WIKIS AND BLOGS IN A CLASSROOM

After a short survey of the utilized Web tools, we propose three emblematic experiments showing that such tools with appropriate instructions may be provided in integrated learning experiences, and stimulate learning as well in engineering courses and projects. Those three experiments also follow gradual progression, concurrently with Digital Literacy and engineering skills, and covers following process:

- Bibliography construction and discussion in multi-groups projects, based on a classical *forum* ;
- Collaborative notebook writing in a computer science lecture, based on a *wiki*;
- Synthesis of lectures and complementary practices and web search in a computer science lecture, based on *blogs*.

We outline how engineering knowledge and transversal skills are addressed in such activities. We will cross those outline with corresponding learning outcomes.

A Brief Survey of Common Tools

The Centre for Learning & Performance Technologies [10] proposes a comprehensive list of tools for learning. In this paper, we describe experiments where we just use three of them:

- *Forum*, which is a classic tool, enables participants to define subjects or to answer existing subjects with textual posts;
- *Wiki*, which is a type of website, allows any subscriber to easily create or edit any page. Pages are interlinked, which allow dynamic structuring of the content. They are dedicated to collaborative content construction. Wikipedia is the most well known Web site based on a *wiki;*
- *Blog*, which is also a type of website, allows individuals or groups to add entries or comments. Entries are commonly displayed in reverse-chronological order. Other users are free to comment or to add links related to another entry.

Wheeler [11] has stressed the difference between *wikis*, which encourage collaboration and synthesis, and *blogs*, which facilitate self-reflection.

Bibliography Construction and Discussion as Digital Competence Acquisition

Projects proposed to our students are in some ways open at new pedagogical sequences, as long as they fit to the authenticity of the situation. Typically, the subject of the first project of our curriculum is given simultaneously to all the students, *i.e.* 146 students merged into 18 groups. We expect thus to develop a collective interest on a common subject.
The awareness of existing related engineering issues is an important issue in the conception stage of the subject. Unfortunately, it is also often a missing step, as stakeholders are mainly headed to the solution.

We have proposed two *forums* with a three-round process. One *forum* is dedicated to technical solutions, either similar systems or subsystems candidates, while the other is dedicated to potential impact of the system. For example, the initial question last semester was about how supportable is mobile technology (the project was about delivering multimedia content during seaside walk).
Three rounds were proposed to ensure the pace and the maturation of ideas:

- First round: find valuable sources, and discuss them in groups. Students had to cite them properly, justify why they found it valuable and provide a summary. Technically this was achieved by group posts on each *forum;*
- Second round: cross references and make critical comparison between solutions or relevance of social arguments. Technically, this was ensured by post answers on *forum;*
- Third round: produce a small report on potential influence of those readings on the future system.

This exercise corresponds to the definition of Digital Literacy as described in [5]. It is based on a basic, well known tool, but with some professional standards. However, as it is included in an introductory project, related outcomes stay at the first level of Digital Literacy, *i.e.* abilities to apply procedures for data collection, synthesis and communication, with basic numerical tools.

Please note that, during this project, groups have to manage all their documents on digital shared spaces. This practice is common for all student projects, with various tools according to specific needs.

Collaborative Notebook Writing as Digital Usage

Note taking is getting harder for our students, while massive use of Slideshows tends to prevent it. Sharing understanding on a common notebook is expected to inverse this negative trend.

We tested out a *wiki* as notebook for a course (http://oer.enstb.org/wiki/index.php/Accueil), which is given in both fall and spring semesters, with respectively around 70 and 24 students. During the first semester, we focus on note taking along lectures, while we develop concept entries in the second semester. A third step could be to deliver a reusable notebook, but it has unfortunately not been done yet. Whenever existing communities of foreign language were possible, students were entitled to write pages in the corresponding language. Students were asked to regularly add contents, connect with existing entries and, if necessary, correct existing one. Different behaviours depending on student personality and their level of confidence with *wikis* were noticed. They globally correspond to those described in [12]. According to them, it may be even open between course across institutions if schedule correspond and duration is sufficient.

Our experiment has confirmed that it may be applied to technical course ("Concurrency Programming" in our case), and may be reused among year in a certain extent. Foreign students were happy to contribute in their own language, and make content available for future students. Moreover, it prevents problems for people who are not fluent in French to be embarrassed by language issues.

Such an exercise is more complicated than the former, because the resource is here shared, and actual collaboration has to be achieved in order to reach synthesis. It encourages a certain community of practice because some concepts are handled together. This exercise is also quite frequent in today engineering practice, for example collaboration for resource creation, and communication.

Lecture Synthesis and Further Practice as Digital Transformation

Defining the impact of new technologies on existing or future systems is an important step in the process of innovation. This can only be achieved by acquiring a sufficient level of confidence of these technologies.
For a course on Semantic Web, which is given in the last year of the graduating curriculum, we have proposed an innovation process as organisation of the sequence. *Blogs* were used as support for individual and group reflection.

During the course, which alternates problem solving in group for concepts discovery, and lectures for concept synthesis, a short summary was asked on *blogs* at each step. This means that those results are made available to other students, and encourage comparison and refinement of understandings.
At the end of the course, students were asked to apply new acquired knowledge to redesign an existing information system of their choice. Potential benefits and drawbacks were to be detailed.

This course is dedicated to advanced engineering knowledge, and covers the three levels proposed for Digital Literacy in DIGEuLit project. Digital competence is necessary for *blogs* management, which are used in the social environment of the classroom. But more important, they reinvest the results of the whole classroom to transform existing systems, which are information systems in our case.

Synthesis

Through those three examples, we can notice that we traverse the different levels of our analysis. Digital Literacy is tackled in a progressive way, allowing our students to gradually use those environments professionally. All those three experiments were integrated learning experiences, as introduction of web2.0 tools permitted to address transversal personal and intrapersonal skills in courses dedicated to technical knowledge or CDIO skills. They may even invest innovation process in technical course. According to active learning, students are clearly engaged in manipulating concepts proposed in the course in various ways. Interestingly, those experiments were possible in rather large groups (up to 150 students), as exchange in digital environment may be improved as participants size increase.

But in all those experiences, situation definition, rhythm of exercise, collaboration dynamics have to be well managed by lecturers to enable real interactions to happen. This means that lecturers have to be confident with those new tools and their usage in professional situations. Next section will develop our approach to share this knowledge between Faculty members.

4. FACULTY DEVELOPMENT FOR DIGITAL LITERACY

Enhancement of faculty teaching skills is known as the 10th CDIO standard, and is essential for enabling new pedagogy methods and teaching tools. However, digital transformation of Faculty members encounters some difficulties. On one hand, most of web tools have to be experienced in groups. On another hand they are technically mostly easy to work with. A Faculty member is qualified in fundamental of scientific literacy, mainly in their research activities, but does not necessarily transfer it to teaching activities.

The main resistance lies in reluctance to change. Faculty members do not want changing tools for similar features, and sometimes because lacks of confidence with ICT tools. Despite their literacy competencies, they feel sometimes a disadvantage in front of so-called digital natives.

We have adopted to enhance digital competence some principles from communities of practice development:

- Starting activities are proposed by early adopters;
- Development of communities of practice;
- Animations, trainings and workshop to organize exchange.

Those three axes of development work complementary for discovering, appropriation and adoption of ideas, tools and methods related to Digital Literacy teaching.

Early Adopters

In every community, some people are open to new ideas. Tests of such ideas have to be welcome, as long as they are correctly engineered, evaluated and, if positive, diffused. As innovation and e-learning are part of expertise fields of our Faculty, some colleagues were aware of new opportunities and professional development offered by Web2.0 tools. Experiments proposed in this paper were tested in classrooms by such people, discussed afterwards, and proposed to other colleagues.

Early experiments may be advertised to foster changes. Social use of web 2.0 tools has been subject to creativity, and examples of potential ideas are numerous to make such advertisement. In our institution, one week seminar on Web2.0 and post Web2.0 issues and tools (http://2010isweb2.pbworks.com/) has been proposed for three years to both students and faculty members. The closing of this seminar was an animation in our main hall, where groups of students (around 8 groups) were to present one concept and one tool in 5 minutes, showing how-to begins with such tools. All people crossing this area was proposed to attend a few presentations.

Communities of Practice

Thanks to our project framework along the student curriculum [13], we have developed interdisciplinary communities, where experience sharing and collaboration tools (mailing-lists, file sharing, *etc.*), are of common use. Interestingly, the fact that people are coming from different laboratories guaranties broader diffusion of tools, and the dimension of the working group fully justifies use of such tools. Integration of such tools in daily work of colleagues is the easiest way to make them adopt them, with the risk of preventing introduction of extra tools.

Additionally, introduction of Learning Management Systems, such as Moodle, have helped to develop digital usage in our faculty. Technical support is ensured to help all faculty members to participate. Share of learning experience feedbacks were organised between interested Faculty members in order to allow appropriation of the environment. Use of such systems, became also after time for adoption an institution requirement, in order to make last reluctant to adhere to such tools.

Animations as Vector for Exchange

Aside previous example, we have organized different kind of animation to enable exchange of practice:

- External expert came to present their experience;
- Some half-day training mixing technical and pedagogical issues have been proposed;
- Half-day seminars to exchanges on faculty experiments were organised;
- Organization of national events such as French Moodlemoot (users, developers and administrators of Moodle conference) or conferences on pedagogy are good ways to convince local faculty members of importance of such issues. Moreover, it is a good kick-start to promote efforts in pedagogy;
- Participation in users and researcher networks (on web and between representatives of institutions).

Variety of animations is important to let people participate in different ways and at different levels. It also helps to organize formal and informal exchanges, to enable wide adoption of principles, tools, and methods.

Basic digital competence is then achieved for the whole faculty. Integration in project-based-learning is an ongoing process, and some faculty members experiment in their exchange with students whenever possible.

5. CONCLUSION

As outlined, Digital Literacy may be considered as key skills for the 21st century engineer. Even if they are implicitly embedded in the CDIO syllabus, their importance justifies introducing them explicitly in the curriculum and the learning outcomes.

Equally, it is a convenient set of tools to develop active learning, and foster integration of personal and interpersonal competencies in scientific and technical lectures. Examples proposed in this paper show enabling of deeper understanding of scientific and technical knowledge thanks to writing and collaborative exercises. Some argues [12] that it may even goes up to the objective to publish scholar work available on Web, which is quite a proper goal for leadership achievement.

Whatever important may be Digital Literacy for future professional engineer activities, or useful as support for active learning, tools and methods are new to the majority of Faculty members, except for lecturers dealing with innovation or e-learning expertise. Hence, based on exploration of some experts, spread of use of web2.0 based methods has to be based on communities of practice inside the Faculty and various animations for cultural change and training.

At the time we are writing this paper, we are getting used to such tools and skills in an explicit way. Next steps will be to define a progression along the whole program, as some activities need more confidence than other. Participating in a class *forum* being much easier than getting active in a big community like Wikipedia.

Innovation is becoming a key notion for future engineers. Digital Literacy has been identified as a key competency to achieve innovation. Therefore the open question will be now to define relative place in the curriculum of Digital Literacy, social learning, project based learning in front of more classical lectures.

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