ON-LINE COMPETENCE BASED LEARNING IN HYDROINFORMATICS AT UNESCO-IHE

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The present paper presents the on-going work of one of the Hydroinformatics on-line course, “Flood Modelling for Management” designed for competence based learning.

INTRODUCTION

Hydroinformatics is broadly defined as the application of modern information technologies to the solution of problems associated with the aquatic environment. In their future working and professional environment higher education graduates are expected to effectively work in the “Information Society”. Implied there is a change from application of disciplinary topics to competence based working where knowledge, skills and attitudes are integrated across separate disciplines. Students in higher education need a learning environment in which they can learn to operate at the level required for starting a professional career. The learning environment therefore should take realistic account of the future working and professional environment with the main focus on development of professional competences of students. The students learn to apply knowledge in professional situations; their competence development is measured and assessed. This is the characteristic of an educational concept which is often termed as ‘competence-based education’.
EUROPEAN CONTEXT OF LEARNING

The Bologna Declaration was accepted in 1999 as an agreement between 29 European countries and as a commitment to reform the structures of the countries higher education systems in a consistent common way. The commitment is freely taken by each signatory country, and leads to an action programme searching for answers to common European problems:

“The process originates from the recognition that in spite of their valuable differences, European higher education systems are facing common internal and external challenges related to the growth and diversification of higher education, the employability of graduates, the shortage of skills in key areas, the expansion of private and transnational education, etc. The Declaration recognises the value of coordinated reforms, compatible systems and common action.”

The declaration fits the EU strategy to become “the most competitive knowledge based society in the world”… “capable of giving its citizens the necessary competencies to face the challenges of the new millennium”.

Following the Bologna declaration there were other Communicates regarding the way the declaration should be implemented. The one of lifelong learning, was issued in 2001 in Prague and it is important for the future of the knowledge society:

“Lifelong learning is an essential element of the European Higher Education Area (EHEA). In the future Europe, built upon a knowledge-based society and economy, lifelong learning strategies are necessary to face the challenges of competitiveness and the use of new technologies to improve the quality of life and provide equal opportunities. Promoting the attractiveness of the European Higher Education Area Ministers agreed on the importance of enhancing attractiveness of European higher education to students from Europe and other parts of the world. The readability and comparability of European higher education degrees worldwide should be enhanced by the development of a common framework of qualifications, as well as by coherent quality assurance and accreditation/certification mechanisms and by increased information efforts.” [12]

Since the implementation of the Bologna standards there are a lot of changes in the European Higher Education. The main changes can be summarised as follows:

- A European Credit Transfer System (ECTS) has been introduced and is nowadays in use in most European Universities. One credit stands for 28-30 hours student study load, including contact hours, preparation, assignments and assessment. A credit also should reflect the expected learning outcomes of a student and is of value for lifelong learning.
European Higher Education has minimum 2 levels: Bachelor and Master. The Bachelor level has 180 to 240 credits and the Master has 60 to 120 credits. The Bachelor level has to give direct access to the labour market and employment, whereas Master degrees should be a specialization. Doctoral studies (PhD) have been introduced as a third level.

Learning outcomes and the competencies associated with them are the basic parameters in order to be able to compare higher education between different universities and different countries. They are used as a reference for transparency, benchmarks for quality assurance and accreditation, and for employability as a tool for better communication with the stakeholders in the field.

As the result of this process, the most important change is the concept of competence based learning, which is a new learning concept.

A CHANGED LEARNING CONCEPT

One of the changes, which comes with the Bologna declaration, with the most impact on the educational process, is the shift from a teacher perspective into a student perspective. By defining learning as a student-centred activity, which has to be facilitated by the teacher and have its effects measured in terms of students’ learning outcomes, a totally different learning process has to be set up. If the education is defined by aims and objectives, the emphasis is on the input. What the teacher intends to cover is the most important. If the education is defined by students’ learning outcomes, the output is central and a different perspective is introduced, student-centred. The main challenging questions are how to measure “students’ learning” and how to set up such a system where students’ learning is facilitated. The present paper describes a pilot application, which tries to find answers to these questions.

Figure 1. The didactical triangle and the interaction between its components (a modification of Hopmann's didactical triangle).
The traditional learning concept (Figure 1) is defined by three main components: the teacher, the student and the content. This is called the didactical triangle. A detailed explanation of this learning process is a combination of fitting to each other: students’ characteristics, students’ background, students’ abilities, the aims and objectives of the course, the classroom context, the transfer of knowledge, the assessment and the practised skills. This learning process is focused mainly on transfer of knowledge.

Nowadays new learning paradigms are developed, paradigms in which the classical triangle has been updated so that the teacher becomes a facilitator or coach, the student becomes a learner and the content is replaced by competencies. Students’ abilities are completed with acquired competencies. Objectives are replaced by educational and professional competencies. Transferring knowledge, in this context, is extended with a range of methods. Next to practising skills, attitudes need to be developed.

The first steps in setting up such a complicated didactical process is done in a context in which subjects became modules. A module contains a cluster of subjects, which brings learning to a sum of studying different subjects. The module aims to integrate the subjects during the learning process and does not only leave the integration as a task for the student.

Examples of modules in hydroinformatics programme at UNESCO-IHE are:

- Computational intelligence and control systems, which integrates data driven modelling, optimisation and real time control;
- Flood modelling for management module integrating modelling theory, hydraulics and flood simulation.
- Decision support systems module integrating system analysis, decision support system theory and model integration.

A module should facilitate the development of students’ competencies. The module is outcome based and the assignment and assessments are sometimes replacing exams.

**HYDROINFORMATICS EDUCATION**

The concepts of Hydroinformatics as a new and distinct academic discipline were conceived and implemented by Professor Michael B. Abbott [1]. Broadly hydroinformatics can be defined as:

“the study of the flow of information and the generation of knowledge related to the dynamics of water in the real world, through the integration of information and communication technologies for data acquisition, modelling and decision support, and to the consequences for the aquatic environment and society and for the management of water based systems.”

Hydroinformatics focuses on applications to all areas of integrated water management, and especially to river basins, aquifers, irrigation systems, urban water systems, estuaries, and coastal waters. It is as much concerned with the management of the environment (as an asset) from a planning and design perspective or from a real time
forecasting and warning point of view, as it is with the simulation and analysis of extreme events: floods, surges, droughts, pollution and significant morphological and ecological changes.

The Hydroinformatics course at UNESCO-IHE aims at enriching traditional engineering practice by introducing innovative approaches in order to open up for the students much broader perspectives. The course introduces students to the process of developing mathematical models as a means for solving real problems, by looking at several different modelling situations that utilize a variety of topics, but with continued reference to their use in finding the solutions to problems.

There are three major goals for the hydroinformatics course taught at UNESCO-IHE: to establish the underlying principles of hydroinformatics, to reinforce students’ modelling skills through investigation of applications involving those skills, and to give students the opportunity to develop projects and assignments for later use in their career as water professionals. The course focuses heavily on the use of technology to solve problems in the aquatic environment.

Organisationally, the Hydroinformatics specialisation in the first 12 months is divided into fourteen modules. Each module has duration of three weeks. After every two modules there is one week reserved for examination. This modular structure of the programme means that during the period dedicated to a particular module, students are intensively focusing on one group of thematically interrelated subjects. The last six months are dedicated to the MSc thesis research.

The volume of information that hydroinformaticians are called upon to know is increasing far more rapidly than the ability of engineering curricula to “cover it.” Now the graduates are increasingly finding employment in non-traditional (hydraulic engineering) fields as computer engineering, environmental science, health and safety engineering, and even business and finance. To be effective across this broad spectrum of employment possibilities, the graduates should understand concepts in physics, mathematics, ecology, geography, computer and software engineering that are well beyond the range of the traditional hydraulic engineering curriculum. At the same time, the work done by any one engineer tends to occupy a relatively narrow band in the total spectrum of engineering knowledge.

For these reasons, structuring the curriculum that meets the needs of most students appears to be an increasingly elusive goal. The solution is to institute multiple tracks for different areas of specialization. Due to this the content of the course, has one module, for which the content vary depending on the interests of the participants. They can choose between “Urban systems modelling”, “Coastal systems modelling” and “Flood modelling for management”. Later on in the course, during the writing proposal of the MSc research topic, they can go even further into the topic of their interest.

The course has in its curricula fieldtrips, during which students are exposed to a wide range of applications and problems involving hydroinformatics.

Water problems usually cut across boundaries and it is becoming more and more frequent to build alliances that link professionals at many locations. The growing
complexity and the increased interdisciplinary nature of engineering projects require a wide academic education and practical training of modern-day engineers. Therefore the demands of teaching hydroinformatics today are substantially different than they were as recently as 10 or 15 years ago.

Hydroinformatics teaching nowadays consider new methods of transferring knowledge, like group learning via collaborative engineering as well as on-line courses, not previously found in the curricula.

A new approach to be tested in teaching is the competence-based learning, which is part of the current research in Hydroinformatics, regarding the use of new technologies and methodologies in teaching and in education. Currently TENCompetence is a 4-year EU-funded project that develops a technical and organisational infrastructure for lifelong competence development. The infrastructure uses open-source, standards-based, sustainable and innovative technology. With this freely available infrastructure the European Union aims to boost the European ambitions of competence based, lifelong learning. UNESCO-IHE is partner in the project, testing the methods and models developed within the TENCompetence project, by testing two pilots in water management field: Flood modelling for management (FMM) and Decision support system (DSS).

COURSE DESIGN BASED ON COMPETENCIES

The word competence in the educational context is rather new. To be competent means to be good at something; it refers to a professional ability. “Being competent” means that he/she “disposes the ability to select within a specific context from a range of available actions and handles in order to reach a certain aim”.

Water resources management has become a field where computer-based techniques are expected to facilitate the complex process of decision making which involves several stakeholders with varied interests and various socio-economic objectives, of the natural resources. The decision-making related to water resource management is a process that requires water resources engineering expertise combined with suitable use of hydroinformatics models.

Formulating competencies for hydroinformaticians, acting as flood modellers for river and urban floods is not an easy task as it demands a thorough knowledge in the core elements of the profession. A curriculum built on competencies is one of the cornerstones for educating learning professionals. A first pitfall is to reduce competencies too much to skills (can), without really taking into account the attitude and/or the motivation. This limitation occurs by focusing knowledge only in function of “can”. A second pitfall has to do with the interpretation of knowledge. In some competencies the understanding is rather insights (has insight in…, understands…), which is too narrow for defining a competence.
Related to the modularisation process there are also some difficulties which can become a pitfall. If a module is not broadly enough conceptualised it can be reduced to a subject to be taught or to a mixture of some related subjects.

The essence of a module is the integration of different disciplines in relation to research, methodology and practice. The TenCompetence concept approach entails – besides the integration of different competence development tools - an understanding and transformation of the content of a topic driven course into a Competence development Based course. Competences are modelled in the TENCompetence project as follows: each learning network has a competence map which contains a series of competence profiles for roles, functions and jobs. A competence profile, which is an instance of a certain competence model, contains one or more competences, which must be attained, in order to meet the demand of the profile. Moreover, each profile has several levels.

The competence model adopted by UNESCO-IHE, to build a flood modelling community, is the Cheetam and Chivers model. This model stresses the importance of developing professionals in four well-balanced and integrated domains: the cognitive, the vocational skills, the personal competencies, and the ethic / values domains.

THE FLOOD MODELLING FOR MANAGEMENT ON-LINE COURSE

With the growing scarcity and quality deterioration of water resources, in many developing countries, in addition to the current trends of increasing floods and climate change, the contribution and role of modellers in river basins has increased and become a necessity as well. The users of Hydroinformatics tools, and of river basin models in particular, need a substantial experience to develop models, which will in the end built organisations capacity to manage and protect water resources in order to optimise their utilization.

The overall goal of the “Flood Modelling for Management” (FMM) course is to teach water professionals that by using catchment, river basin and urban flooding models they can maximize economic and social well-being in an equitable manner without compromising the sustainability of their ecosystem.

Based on the above described competences, currently at UNESCO-IHE, an on-line pilot is set-up to test the lifelong learning based on competences. The competence based model used in the Flood modelling for management pilot is based on the Cheetam and Chivers model. Each constituent material has a letter in front indicating if it is Compulsory (C), river (R) or urban (U) related, or both (RU) for river and urban. There is also the General (G) indication. To fulfill one competence all the C components must be selected and at choice R or U components. The G components are advisable to be selected, however some of them, depending on student choice can be skipped. SLU stands for study load units and represents the estimation on the number of hours needed to study a particular topic.
The FMM constituents for the proposed model are
1. Knowledge / Cognitive competence
   a. Tacit/Practical (knowing in action)
      i. G-Identification of a problem to be solved:
      ii. G-Find minimum two solutions to the identified problem in 1-a-i
      iii. G- Analyse the best economical solution from 1-a-ii
      iv. G- Predict which is the best engineering solution from 1-a-ii
      v. G- Identify possible future problems in the case defined at 1-a-i
   b. Technical/ theoretical (linked to underlying knowledge base)
      i. G- Introduction to the course
      ii. G – Flood management and information technology (18SLU)
      iii. Flood processes (26 SLU)
         1. C-Meteorological inputs (6 SLU)
         2. C- Rainfall-runoff processes (6 SLU)
         3. RU-Free-surface flow (8 SLU)
         4. U-Flooding in urban areas (6 SLU)
      iv. Flood modelling methods and techniques
         1. C-Rainfall-runoff modelling (8 SLU)
         2. C- Catchment modelling (6 SLU)
         3. C-Hydrological modelling (with HEC-HMS) (16 SLU)
         4. R-Flood routing (10 SLU)
         5. R-Hydrodynamic modelling (with MIKE11) (12 SLU)
         6. U-Urban flood management (10 SLU)
         7. U-Urban flood modelling (with MOUSE) (12 SLU)
      v. C-Flood modelling- advanced features (62 SLU), includes Data-driven modelling, Flood modelling and DSS, Uncertainty in flood modelling, Flood forecasting and warning
   c. Procedural (how, what, who, when)
      i. G-Modelling protocols
      ii. Best practices for flood management
   d. Contextual (sector, industry, organisation, profession)
2. Functional Competence
   a. Occupation –specific (range of occupation specific tasks)
      i. CRU- Problem position and analysis
      ii. C - Data analysis
      iii. C - Model selection (HEC-HMS, HEC-RAS, MOUSE, SWAT)
      iv. CRU - Model building- step by step
      v. CRU - Running simulations
   b. Organisation process (planning, monitoring, implementing, delegating, evaluating)
      i. G- Calibrate, validate the model run in 2-a-iv
      ii. G- Report/Interpret the result of the model
iii. G- Field work, where possible

c. Cerebral (literacy, numeracy, IT literacy, diagnosis)
   i. G- Write an article for a conference on a chosen topic
   ii. G- Write an article for a journal
   iii. G- Write an essay on a given topic
   iv. G- Assess existing resources (internet, library, news)
   v. G- Create a selected list of own resources, identified in 2-c-iv,

d. Psychomotor (manual dexterity, keyboard) NONE, NOT RELEVANT

3. Personal behavioural competence
   a. Social/ Vocational (self-confidence, thinking on feet, calmness, control of emotions, interpersonal, listening, task-centredness, presentation)
      i. G – Public presentation (article presentation to a conference or a lecture, based on the essay from point 2-c-i, or 2-c-ii, or 2-c-iii)
      ii. G- Attending a HI or IAHR conference or seminar
   b. Intra-professional (collegiality, sensitivity to peers, conformity to professional norms)
      i. CRU – Groupwork
      ii. CRU- Opening a discussion on the forum
      iii. CRU- Answering a question of a colleague on the forum
      iv. CRU-Share the list created in 2-d-i, with a group of colleagues

4. Values/ Ethical competence
   a. Personal (adherence to law, social/ moral sensitivity, adherence to personal moral/ religious codes) NONE FOR THE CURRENT IMPLEMENTATION
   b. Professional (adherence to professional codes, self regulation, environmental sensitivity, client centredness, ethical judgement)
      i. C- Water resources sharing
      ii. C- Water related problems
      iii. G-Conflict resolution and- Transboundary issues
      v. G- Water law, local and international

CONCLUSIONS

Hydroinformatics, initially established as the field of study of numerical modelling and information flows related to aquatic systems, has increasingly transformed its focus from improving the numerical modelling tools, into developments in application, placing more effort on user interfaces, visualisation, parameter controls, structured database facilities and knowledge management systems, systems engineering, optimisation, and computational intelligence. It has largely contributed to the development of generic modelling systems of the so-called fourth generation which enabled the increase of potential users of hydroinformatics tools from the restricted group of numerical modellers to large number of specialists in hydraulics, hydrology and water resources, who became distinct group of model users. By taking advantage of the latest technological developments in the areas of instrumentation, real-time data transmission, data
assimilation, remote sensing and seamless model-GIS interfaces, it is nowadays recognized as a field which continuously seeks synergic combination of such diverse technologies for the purpose of development improved modelling tools and services. Following the developments in ICT, the models became increasingly embedded into larger systems for decision support or impact assessment. Through these developments the user base of hydroinformatics tools has been expanded even more.

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