APPLYING METHODS OF CONSTRUCTIVIST PEDAGOGY IN THE TRAINING OF ENGINEERS. QUESTIONS OF METHODOLOGY IN DEVELOPING COURSE MATERIAL

Prof.dr.hc.,dr. SZEPES ANDRÁS
adjunct associate CSORDÁSNÉ MARTON MELINDA
University of West Hungary, Faculty of Geoinformatics

ABSTRACT: *In this article we point out a cutting edge method of teaching that is not very wide-spread as of today. We wish to draw attention to the fact that traditional methods are apt to fail when applied to students reaching higher education with greatly varying levels of existing background knowledge to build on. We need to find methods that can effectively grab the attention of students, inspires their creativity and involves them in the process of teaching/learning.*

For this end, we find the methods of constructivist pedagogy highly expedient. The range of possibilities can be further widened by applying features of web 2.0. Applicability of the methods is demonstrated through two examples, one from the field of basic courses, one from specialised studies.

Key words*: method of teaching, traditional methods, methods of constructivist pedagogy.*

For the University of West Hungary's Faculty of Geoinformatics (GEO) – as for all educational institutions – the development of learning material is a task of crucial importance. Universities in this field usually publish either course books, or lecture notes. Our institution usually opts for the latter, as it suits our relatively smaller number of students. The life-cycles of various lecture notes can differ greatly. Basic parts of study material for mathematics, for example, will not change very often, as new results and methods usually appear outside the scope of our curriculum. Study notes for technical subjects on the other hand are less static. If we take measuring techniques for example, GPS technology has re-written everything in this field. The teaching of computer science and geoinformatics are even more sensitive to progress, some lecture notes can be outdated already as they leave the press. That's why we prefer to compile study notes that can follow change more dynamically.

Education at GEO has been changed profoundly by the implementation of the so-called Bologna process.

Basic college training (BSc) has been changed, and courses aiming at a master's degree (MSc) have been introduced. Some subjects remained intact, but their contents and schedules were changed. For the newly implemented masters' courses we obviously did not have any teaching material prepared. A chance to develop these is now opened up by a tender announced within

Operative Program for Social Renewal, titled Development of Course Material and Content for the Higher Education of Mathematics, Natural Sciences, Computer and Technical Sciences.

The tender coincides with times being ripe for a change in methodology. This change is a natural effect of development in pedagogical methods. The direction we take must be one that corresponds with the needs of technical studies, answers the challenge of the times, and also attracts the interest of our students.

Before we embark on a project of this magnitude, some theoretical principles need to be laid down. This is no different in the case of development of study material.

What is our current situation?

- We are aware of the professional requirements for the contents of each subject;
- We are familiar with the latest scientific achievements and are aware of the needs and expectations of the profession/ industry as for the knowledge of graduated students;
- We have appropriate knowledge of quality management. Many of our staff have completed the "Quality Management in Distant Learning" course in Leuven and at home, organized by SZÁMALK.

What are the aims?

- To facilitate easier preparation of students for BSc and MSc courses, with study material of up-to-date content.
- To provide students with easy access to study material over the Internet, so they can prepare at the place of their choice.
- To ensure – by means of a modular structure – that students have access to all study units necessary for a given task, regardless of their specialisation subjects.

By now we all have some experience using so called **web 2.0** applications, and we have made the initial steps to apply these in education.

Web 2.0 is a collective term for internet services where members of a community add content to a site, or share information with each other, as opposed to earlier services where content was exclusively provided by the party operating the site (as e.g. portals). In the case of a web 2.0 service, administrators only provide a framework; content is created, shared and commented on by the users themselves. Users interconnect and communicate with each other. As of today we can hardly find any site without a community built around it. This is important as it shows us a tendency that breaks with the traditional ways of transferring knowledge, and will lead to a more creative, learning by teaching, teaching by learning approach. [1]

Drawing analogies between web 2.0 and pedagogy leads us to constructivist pedagogy, a relatively new-born paradigm of pedagogy. Earlier methodologies of teaching put emphasis on the quantity of facts transferred, their storage and application. This can be called the era of objectivist epistemology. The 1980ies saw the emergence of a learning theory of constructivist education from among the paradigms of cognitive psychology. This can be viewed as a critique of earlier methods.

At the core of constructivist pedagogy is the principle that human cognition is not just the storage and accumulation of information in the mind, but rather the creation and expansion of knowledge taking place in the cognitive mind, as an active and personal process of interpretation, based on already internalised knowledge. [2]

The central role in constructivist theories is that of the human being who interprets his/her experiences. Experience is important in constructivist pedagogy, but it is not an exclusive defining force of the resulting knowledge; the structuring, interpreting mind is at the centre. [3]

The changing of paradigm in methodology was preceded by research in psychology that put the constructive process of cognition in the foreground, and showed how effective it could be. Countless surveys and research have shown that learning with an active and creative mindset results in deeper and more recallable schemata[1] than traditional authoritative learning, or mechanical and often utilitarian 'swotting'; as the mind is highly motivated and is rewarded by the success of exploring new knowledge that it feels useful, applicable and interesting.

[1] In general psychology a schema is a mental codification of experience. Schemata integrate existing knowledge, and they serve as tools to acquire new knowledge.

From among these surveys, let us cite the results of Richard R. Skemp[2] [5]:

Table 1[3].
The table shows effectiveness of recall in percentage of persons surveyed after learning according to cognitive schemata and in a mechanical manner.

	directly after studying	after 1 day	after 4 weeks
Constructivist learning	69	69	58
Mechanical 'swotting'	32	29	8

[2]Obviously, prospective authors will need serious methodological preparation if we are to apply these principles[3]. This methodological preparation is part of our plans, with the participation of outside lecturers as well as our colleagues.

According to the above, it seems expedient – if not outright necessary – that we develop textbooks and other learning material that accept and apply these principles. This is the only way we can achieve long-term success, positive feedback and acceptance from the users.

Now what makes the work of a lecturer constructivist? What elements need to be included in such a curriculum? Constructivism has requirements concerning content, form, and system of evaluation. A relevant requirement of content is to convey precisely the exact facts of the profession. This is a basic requirement of teaching, regardless of the methods applied, so from now on we will take this for granted and concentrate on methodology.

Let us utilize one of the advantages of distant learning: that the user can choose alternative routes in the material according to their personalised schedule. This would be difficult to accomplish on contact[4] classes where the lecturer presupposes a level of preparation and motivation, and tailors the course accordingly. In an optimal case the schedule can be changed on the go, but it is impossible to find a pace that suits all participants. A well-built distant learning material, on the other hand, is able to arouse the learners interest, inspire them to acquire deeper and more precise knowledge, while letting them progress in their own pace.

Let us see two examples for the application of these principles:

PHYSICS: Our students will all use GPS systems during their studies and later on in their work. When we embark on teaching them the physics background of GPS systems, we have to face the fact that they intend - and are able to - reach varying levels of understanding, and also they start from different levels as well. The model outlined below tries to flexibly cater to different needs of students, and according to varying levels of pre-existing knowledge it makes it possible to acquire either basic, or much more advanced proficiency.

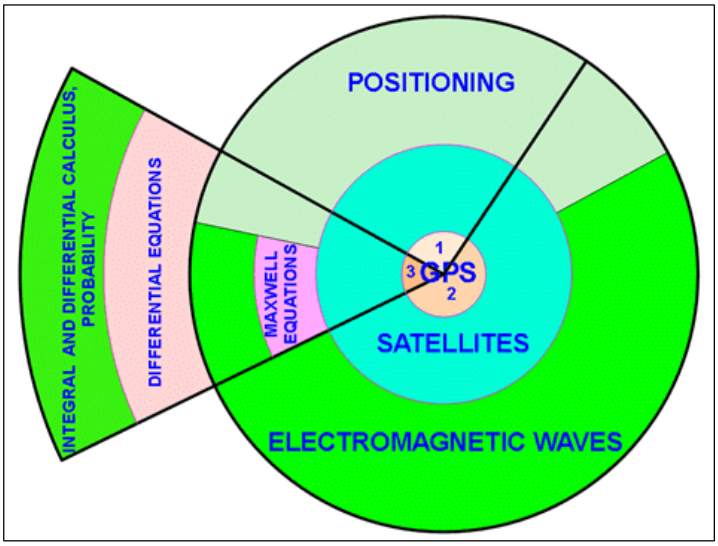
The learning process starts with outlining the aims. We expose what we are about to demonstrate and why, give some cultural background as eg. how the system is involved in everyday life, and how we will later use what we learn now.

After this introduction we offer different options. By direct questions and indirect enquiry we get to know - and make the students realize – what their existing knowledge-bases are, that can serve as a basis for future learning. (The concept of positioning, what GPS is used for, how it works, what are the applications, how accurate is it, does the student own a device,

[2]Richard R. Skemp mathematician, psychologist, he analyses thought processes of mathematical problem-solving from a psychological point of view.
[3]Richard R. Skemp: Psychology of Learning Mathematics. Page 57.
[4]Contact Class: The lecturer imparts study material to the students in person. Contact classes are usually frontal lessons

etc.) The questions that are posed lead the student to corresponding panels of learning material (represented by pie-slices and slice sections on the diagram, referred to as 'panels' from here on). The aim of the introduction is to inspire at least an initial step. From then on there are several routes to other panels. One can progress towards general notions to have a more precise view, or choose instant processing of the facts for faster progress. The goal is to develop a customised path that eventually leads to merging the panels into an organic whole, thus accomplishing the course material.

For this end it is necessary to mobilize schemata previously learned, and insert the themes awaiting exploration into the existing cognitive framework.



1. USER OR POPULAR SCIENTIFIC (PASS GRADE) LEVEL:
I WILL APPLY GPS IN MY WORK

2. DEEPER USER LEVEL (GRADE B, C):
FOR THOSE WITHOUT SUBSTANTIAL SKILLS IN MATHEMATICS AND PHYSICS

3. SCIENTIFIC (GRADE A) LEVEL
FOR THOSE ABOUT TO GET ACQUAINTED WITH THE UNDERLYING MATHEMATICAL AND PHYSICAL PRINCIPLES OF GPS.

It is advisable to apply up-to-date formal requirements to match the content requirements.

Some formal requirements:

- Clear-cut, perspicuous arrangement of material
- Easy to read pages
- Colourful, illustrated pages
- Interactive pages
- A pleasant study surface, colour and sound effects, music
- Informal tone

Some study questions and tests are integrated into the material, which helps students realise the depth they have managed to learn the given section. Evaluation should not be inquisitorial or obtrusive, it should be connected directly to the panel at hand, and be solvable by covering it. Gradualness and

the possibility of self-correction are advisable. Immaterial and captious questions are beside the point, as they would encourage swotting lexical facts instead of realising meaning and context. Whether an answer is correct or not should always be decided by content, no word-by-word answers should be expected. Even the best written material can lead to frustration if the spirit of our evaluation does not match that of the subject matter. The feeling of success is necessary to motivate students of all age groups.

DATA INTEGRATION

The task of this subject is to build a database for a complex system of spatial informatics. For this we need to evaluate the data set available for solving the task, examine the data structure of the sources, and check the quality of each data as for reliability and topicality.

How can this whole process be worked out if we are to manage the human resources allocated to the task economically? It seems most suitable to create a network of connections between persons who can manage parts of the task on their own, and can also control each others' work. The process of solution can be followed all the way through this way, and individual experience can also be shared.

The network of connections can be direct, when each member of it has two-way communication with others. Knowledge is adding up and accumulating this way, but participants only see each other's activity in pairs.

Let us start a chat room (e.g. MSN, Skype) where information can be exchanged in a conference-call manner and each person can show his or her progress in the task, comment on others' propositions, and work out solutions together. The only disadvantage is that all participants need to be on-line.

Let us start a **wiki** page on one of the suitable portal systems.

The name originates from Hawaiian 'wiki wiki', meaning fast, or swift. Wiki is a type of hypertext systems a simplified markup language, or the software that is use used to create such systems.

A **wikiwikiweb** is a website that works according to a wiki system or using one. It allows editors (that is, in most cases anyone) to add new pages or edit existing ones.

Wiki is a program with multiple implementations. It can be used to operate whole websites (not necessarily dictionary-like applications), or it can also be used in place of traditional forums, for a more structured display of users' opinions.

Ward Cunningham, the developer of the first wiki software, WikiWikiWeb, originally described it as "the simplest online database that could possibly work.

"Wikis are often used to create collaborative websites and to power community websites. The collaborative encyclopaedia Wikipedia is one of the best-known wikis. [6]

We upload a general framework of the task onto this system, for the participants to fill it with content. They will upload descriptions of how to solve parts of the task, and also the data gathered. Their peers who join the task can both see and edit the uploaded descriptions, or initiate the discussion of additional points of view. The wiki page will thus be continually appended and augmented, until the final solution emerges. In the meanwhile, participants keep acquiring new knowledge from the articles their peers add or edit.

The wiki page can of course be moderated as well, so the lecturer who assigns the task can also be part of the solving process. He/she can follow the information as it is uploaded, can be the amending hand to avoid the solution going astray, and can direct the joint work by adding advice or new articles.

Modular curriculum

Traditional textbooks, coursebooks and study notes are usually comprised of chapters

and sub-chapters. When necessary, these sections referred to precedent and antecedent chapters, so by turning to the right page one could interpret the questions posed. When one was only looking for clues to solve one particular problem, they still needed to procure the whole book.

Module: A smaller part (practically 2-4 hours worth of study) of a learning process, in the case of which learning goals interpretable from the point of view of the learner can exactly be defined. Thus, dividing a learning process into modules is not apportioning it by volume, but rather dividing the goal of the whole learning process into partial goals that are interpretable from the point of view of the learner. [7]

The modules built upon each other form the 'examinable' curriculum of a subject, while independently, or connected with modules of other subjects they can form a specialisation course.

The structure

Experience shows that students prefer learning material based on the methodology of distant learning. An obvious explanation for this is the more personal approach. Also, these 'books' contain much more diagrams, references and tasks that help interpretation and make learning easier and more likable. The structure of each module is the following:

- Introduction – drawing up learning goals, demonstrating the skills and abilities that will be achieved by processing the module.
- sub-chapters – these include the core of the learning material, and additionally:
  - ask questions and check the answers
  - propose ideas for the reader for further thinking
  - present example tasks, some with their solutions, some left open for the reader to elaborate.
  - pose further tasks for the reader to post their answers to.
  - summary, that shows the results achieved
  - self-check questions that help better imprinting of the finished area of study

Depending on the theme of each module, tests can be appended to the end. Through the portal's services these have instant evaluation. The main function of these tests is to provide feedback as for the safe and thorough acquirement of the module, but results can also be stored to help evaluation of the learner.

The whole curriculum is built up as a succession of these modules. The modules are naturally cross-referenced with each other, so they can refer back to knowledge gained in earlier phases of the learning process. This helps freshen up earlier studies, and fill up potential gaps in knowledge.

Constructivist pedagogy can only build on autonomous action that defines the framework for construction, and innovative solution. Constructivist pedagogy needs to rely and build upon the actual environment, and real-life context, as new knowledge is constructed by assimilation to, and accommodation of the existing cognitive structure. This works stronger the more directly it is related to the life experience of the learner. Accordingly, at the proper phase of processing the material certain tasks should be incorporated that do not have a fixed outcome, but rather are born out of the student's activity. (Similar to the problem of a cargo that has to reach destination 'B' starting from station 'A', overcoming obstacles on the way. These obstacles are questions related to the material at hand, where the further direction of the cargo depends on the answers given. Students on-line at the time can take turns in answering questions, which facilitates genuine group-work.

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