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Application of Case Studies in Education: Panel Presentation for Session 11, Friday, Aug 15

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Case study analysis is considered as one of the most efficient approaches teaching geotechnics. Plenty of papers published in journals and conference proceedings can be selected to meet educational purposes. Nevertheless, there are faults and shortcomings hindering us from using them effectively. At least two recent challenges demanding more conscious preparation, selection, application and development of case studies to be used for educational purposes in geotechnics are to be considered here:

a) The Bologna process launched in Europe and discussed for introduction in other parts of the world induced worldwide debate about questions such as:

- How practical should bachelor's programs be?
- To what extent should bachelor's programs prepare for the master's one in the basic sciences?
- What financial quota should be allocated for bachelor's and master's programs?
- What optimal enrollment numbers can be assigned to each education level?

In this environment, on the professional level of scrutiny, the role and application of case studies arise. Their selection must fit the levels of BSc and MSc competence.

b) Sophistication of structural and geotechnical engineering knowledge is converging. Functional diversity and multipurpose character of structures makes it unavoidable to understand each others designing principles, modeling considerations and simplification constraints. Instead of prescribing forces and displacement restrictions at interfaces the computational models are extended to count with the soil-structure interaction. Case analyses are the best conveyances to disseminate prompt information about the experiences gained in this developing area of geotechnical engineering.

Large part of the case studies published recently does not support adequately the higher education to face the challenges. Some of them are simple narratives, others miss the signs of background knowledge and serve as examples for structural engineers to qualify geotechnical engineering as a technology-driven profession using simple models with poor mechanical education. Papers appear in professional journals, conference proceedings and corporate PR folders or leaflets distributed at exhibitions with shortcomings such as:

- data of marginal importance are given ("the site was at a distance of 4 km northwards from the capital");
- function, importance or attractiveness of the structures involved in the case are stressed ("the runway was highly wanted by the regional industry");
- statements are made about safety, economic evaluation or efficiency without comparison with other similar constructions or alternative solutions ("the method we had applied gave a sound solution to the problem");
- calculations are referred to inadequately ("displacements were computed with the finite element method"),

A few of the case studies written by geotechnicians stress only an essential issue related to the convergence of structural and geotechnical perspectives.

- The structural engineer's goal is to identify an optimal model (structural arrangement) for a function and find the best construction technology to realize it. Case studies provide examples of technology development serving the application of the best theories.
- Geotechnicians are anxious about their models extended beyond the engineering structure to its surrounding. Proceedings of geotechnical conferences open large space for case studies explaining their modeling considerations.

Researchers investigating the learning and experience building mechanisms found that different levels of professional knowledge and preparation can be suitably described by the number and complexity of cognitive structures associated with each, as well as their organization. It is sufficient here to introduce some basic concepts and considerations only to understand our message using chess as an example.

Individuals with chess skills all see the same board, the moves of the pieces are governed by strict and unambiguous rules.

Nevertheless, because of the variety of possible positions, knowledge, experience, mental state etc.of the players, using the conceptual framework of cognitive psychology different knowledge levels can be distinguished.

The *beginner* chess player is familiar with the rules and recognizes the possible moves in a given position. He knows and uses a few dozen simple schemes. An advanced, *second class* chess player is familiar with low-degree-of-freedom positions, the number of the schemes he is employing is a few hundred. The *master candidate* is familiar with position improving options. The number of his schemes is several thousands, a large percentage of which is complex. The *grandmaster* formulates strategic plans that encompass entire games, utilize several tens of thousand complex schemes embedded in one another.

Classification criteria for chess players

	Beginner	*Advanced*	*Master candidate*	*Grandmaster*
Quantity of schemes	some 10	some 100	some 1000	some 10,000
Problem solving method	according to common logic	illogical because mixed	according to professional logic	Synthetic
Professional language	none	clumsy/awkward	professional	“mothertounge”
Time of maturation	-	a few years	approx. 5 years	minimum 10 years
What is needed for it?	interest, some learning	continuous learning	school diploma	“talent”

Studying or learning chess *via* case analysis is a common exercise. Beyond the professional books and magazines daily newspapers publish chess game analyses written by acknowledged masters, as well.

The measurable differentiation between various levels of chess playing competence is an important starting point for cognitive psychology. The results can, in an analogous sense, be transferred to very different fields from medicine to the command of a language. For example, by and large the master candidate level can be equated to a university (10 semester MSc) degree.

In the case of professional knowledge in the natural sciences, a whole group of concepts parallel the chess concepts of position, analysis and move in terms of a problem:

- observation, recognition, understanding, and anticipation of the phenomenon, situation, and process;
- recognition and description of tasks related to the progression;
- identification and analysis of the necessary and possible interventions;
- clarification and handling of expectable consequences;
- the determination and technical execution of intervention steps.

For the technical “jargon” *model* is probably the best expression analogous with the concept of scheme. and are also used by professional languages. *From this perspective the essence of advanced education in the engineering fields is the introduction of technical models of phenomena and processes. The curriculum includes theories and relations that more or less describe reality, explores the validity and applicability of these models, and discusses the prerequisites, methods and steps of application.*

It is worth differentiating between levels of professional expertise from the perspective of their relationship to the *inventory* of models. It seems practicable to accept a four level classification system with respect to the relationship to recognizing phenomena and processes, and to the models used for their understanding and intervention.

Apprentice – ASc

- Understands the main characteristics of models conveyed by the bachelor or master, participates in the application of models under guidance with simple steps.

Bachelor – BSc

- Recognizes frequently occurring phenomena.
- Is familiar with the profession’s simpler models and their application.
- Is able to involve the apprentice in model application by creating simple subtasks, understands and executes the steps according to the model selected by the master.

Master – MSc

- Recognizes phenomena and their complexity.
- Knows the profession’s inventory of models with the limitations of their applicability.
- Is aware of the bounds of her/his own competency.
- Cooperates with masters of other fields in the solution of a complex problem.
- Is able to select optimal model to solve a particular problem.
- Incorporates in particular steps the expertise of the apprentice and bachelor according to their skills.
- Recognizes phenomena that require the development of the model inventory, understands the way doctors think.

Doctor – PhD

- Is able to identify and analyze complex phenomena.
- Knows the profession’s model inventory and the limitations of their precision and applicability.
- Expands the range of validity of models.
- Attaches models to new phenomena, and if necessary, supplements or creates new models.

Four level classification of professional expertise

Common language	Apprentice	Journeyman	Master	Doctor
Professional language	Assistant	Technician	Professional	Top-notch consultant
Chess	Beginner	Advanced	Master candidate	Grandmaster
Educational level	Associate	Bachelor	Master	Doctor of Philosophy
Abbreviation	ASc	BSc	MSc	PhD

Obviously, there are significant points to be taken into consideration when specific areas such as structural and geotechnical engineering are at stake.

The implementation procedure of *structures* with complex purpose involves

- learned selection in the treasury of standardized loads, sophisticated mechanical models and powerful computational techniques at the level of designing,
- the best possible constructional realization of the structural arrangement in accordance with the assumptions and limitations of the selected model.

Problems of planning in *geomechanics* are paradigmatically different. Considerations related to the functional arrangement of the object are constrained by the subsoil conditions and geotechnical construction technologies. Prudent assumptions are needed to derive a model describing the soil-structure interactive behaviour both in space and time. Importance of monitoring and interactive construction is stressed as a regular component of planning practice in geotechnics.

Because of this highly complex character, perception and identification of the geotechnical phenomena, selection and application of the adequate models assume MSc competence. Iinterdisciplinary skill is the entrance to be gained for coping with the challenges in this field. Consequently, higher education must deliver all its geotechnical courses at all levels consciously and openly stressing this compound demand.

During the higher education term, case studies are at hand to illustrate all points and arguments of the subjects engaged with model creation and application. Analysis of case studies must be an indispensable part of engineering courses at both levels.

Through scrutinizing case studies, *undergraduates* can better prepare themselves to

- recognize frequently occurring facts and events,
- select correctly the models that can be applied for simple phenomena,
- understand, and execute instructions given by a master.

Case studies at the BSc level serve more or less as *examples* highlighting the essential features (concepts, relationships, simplifying assumptions, solution techniques) of a model.

Students of *master* courses can accelerate and improve their development with case studies helping them to

- recognize and correctly appraise complex problems,
- select the optimal model to solve a particular problem,
- comprehend the complete process of intervention,
- understand the way doctors think, and utilize their recommendations.

On the master level *case studies* induce and frame considerations about alternative models, selection principles, verification and validation issues, highlight the essential features of modeling..

This perception of case studies, of course, is neither a new development nor a consequence of the Bologna paradigm. Yet, it needs to be stressed, as did a report released by the US National Academy of Engineering recently [2005].

Obviously, adaptability and efficiency of a case study can highly depend on many conditions:

- Cases can be presented either as narrative descriptions or instructive explanations. The first alternative works well for BSc students, the second one for MSc students.
- Hegemony interests and employment positions can distort correct narrative descriptions or instructive explanations.
- Case studies can convey very simple business messages ("we are skilled masters of our technology", "you can trust us to fulfil all your demands").
- Several case studies are overloaded with veiled prejudices about technologies or methods other than their own ones.

There is a general interest in increasing the number and improving the quality of case studies edited and written with attention to educational demands. Efficient engineering case studies are characterized with features such as:

- essential data are illustrated properly and quantitatively for understanding the problem;
- kinematics of the mechanical behavior is commented as clearly as possible;
- applied computational methods are described explicitly, with their assumptions and essential characteristic;
- failures, mistakes made in selecting and applying adequate models are considered and discussed openly.

Having surveyed several international conference proceedings of the ISSMGE with more than four hundred case studies the author estimates that not more than 20% of them can be used efficiently for educational purposes. The academic world has valuable reserves for creating and using better case studies in higher education. Authors (often members of faculty) can improve the quality of their papers about cases with some effort and more attention if they are aware their own needs as users of such studies in higher education. Students of BSc and MSc courses would benefit from these effort.