Advances in Social Science, Education and Humanities Research, volume 402
Third International Conference on Social Science, Public Health and Education (SSPHE 2019)

Considerations in the Preparation for Teaching Tunnel Engineering

Jianqin Ma
School of Highway
Chang'an University
Xi'an, China
majq@gl.chd.edu.cn

***Abstract*—Teachers, who are in the field of civil engineering at a university in China, are increasingly confronting new challenges in teaching, mainly due to the modernization and globalization, which require the college students being well qualified with problem solving capacity. Of the problem-solving capacity development, systems thinking is indispensable in both learning and teaching a complex subject, such as tunnel engineering. As a good preparation for teaching is necessary to an effective learning and teaching process, this contribution presents the key factors under considerations in the preparation for teaching tunnel engineering, with special reference to the application of systems thinking in information sampling, execution planning and evaluation design in a dynamic mode.**

Keywords: considerations, systems thinking, teaching preparation, dynamic mode, tunnel engineering

I. Introduction

Modernization and globalization require well-qualified workforces. To meet this challenge, a revolution in engineering education is in process [1]. Of the quality of college graduate in the field of civil engineering, problem solving capacity is essential and systems thinking is needed in capacity development [2, 3]. Teachers, in the field of civil engineering at a university, are increasingly confronting new challenges in teaching to develop students' problem solving capacity. In the problem solving capacity development, systems thinking is indispensable in both learning and teaching a complex subject [1], such as tunnel engineering [4]. In terms of complex problem solving, systems thinking is an effective tool [5, 6], so is in teaching a subject including complex topics. At the beginning of the 21st century, the importance and benefit of the application of systems thinking in civil engineering education were underlined in terms of professional quality development [7, 8]. Systems thinking is applied as a tool, such as in teaching preparation [9], course design [10]. More recently, systems thinking is used in planning course execution procedure in details, such as in terms of test [11], group work [12, 13] and program evaluation [14]. But there is no report on the application in the teaching preparation of tunnel engineering.

Considering well-planned preparation is one of the prerequisites to make a learning and teaching process effective [9], this contribution presents the key factors under considerations in the preparation for teaching tunnel engineering, with special reference to the application of systems thinking in information sampling, execution planning and evaluation design in a dynamic mode.

II. General Requirements for Teaching Preparation

In the teaching preparation for tunnel engineering, the educators are generally confronting the following situations: (1) The planned period and lecturing time of the classical subjects, such as professional courses, are reduced to allow new subjects being presented in a predefined time schedule; (2) There are increasing learning information and means available for students choosing; (3) The requirements to meet the basic professional quality are increasing since more complex infrastructure projects will be built in the future. These situation are the background of the teaching preparation for tunnel engineering, nowadays. On the other hand, to meet the requirements of the modernization and globalization, one of the major tasks of the learning and teaching at a university is to develop students' problem-solving capacity. Considering the complex features of tunnel engineering, the application of systems thinking is necessary and beneficial for teaching preparation.

A. Considering the Complex Features of Tunnel Engineering

Tunnel engineering is a subject, which is related to the planning, design, construction, operation and management of a tunnel or underground structure. As a tunnel is built, it is then open to use. The performance of the tunnel will have a strong influence on the situations of operation and management. In terms of behaviors of a tunnel, various factors (Fig. 1) including the features of the tunnel, requirement to tunnel construction and environment confinement, are considered in the planning and design of a tunnel project. For each of the major factors under consideration, several parameters will have influence on the natures of the factors. On the other hand, the parameters are, at least conditionally, co-dependent in a project. And therefore, a tunnel project is always a complex system. In terms of learning and teaching, tunnel engineering is a complex course.

B. Students' Problem Solving Capacity Developing

A well-qualified graduate should have the capacity of problem solving based on information sampling and decision-making (Fig. 2). The capacity should be cultivated in an ordinary course study, especially in main subjects learning and teaching procedure. Of the learning of a subject with complex

features, systems thinking is necessary [6] and beneficial to develop students' problem solving capacity [5]. There need systems thinking in the problem solving capacity development of the students involved in tunnel engineering course (Fig. 3), such as following the rules of systems thinking, through information sampling, knowledge constructing and problem solving to develop their capacities. In the information sampling and learning process, analysis is needed to make the information distinctive. And then, students should assemble the information of different parts and identify their relationships in terms of system to achieve knowledge constructing, which is necessary to take perspectives and apply in problem solving.

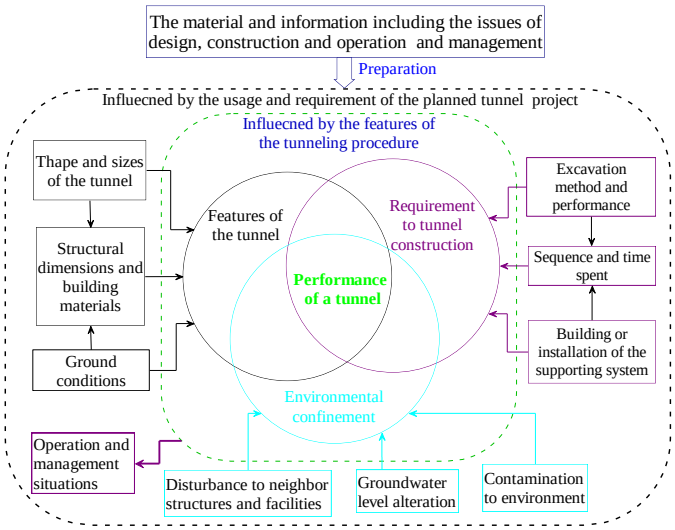

Fig. 1. Information and material preparation in terms of tunnel performance.

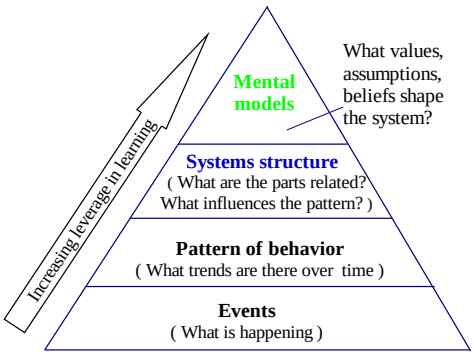

Fig. 2. General features of learning process.

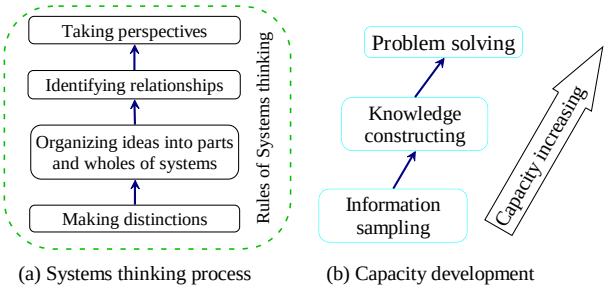

Fig. 3. System thinking in problem solving capacity development.

III. Considerations in the Teaching Preparation

In general, a student's learning performance at a university depends on: what has been taught; how the content is taught; how to learn and response to the instruction or teaching activities and requirements; what and how the skills of problem solving capacity are being developed. In the teaching preparation for a complex subject, such as tunnel engineering, the features of learning process with students' problem solving capacity perspectives should be under consideration. The application of systems thinking is necessary.

A. General Principles

Actions with high efficiency features require a proper plan. Teaching preparation needs a holistic design with, at least, the general features of tunnel engineering and the learning process with problem solving capacity development being under consideration. Based on the above general requirement, in the teaching preparation for the tunnel engineering, the following principles are followed: (a) Present the course syllabus in a comprehensive style, such as with systems thinking application; (b) Place students in the center of the execution plan; (c) To teach both content and thinking; (d) Try to make the learning procedure to be fun; (e) Try to make the students' involvement in every layer of the system of teaching and learning; (f) Implement the course syllabus in a dynamic mode.

B. Content Sampling and Assembling

In the content sampling, the general problems should be considered in terms of a subject of tunnel engineering, such as the topics of planning, design including site investigation and structure designing, construction, operation and management. The sampled contents are assembled with the help of systems thinking and being beneficial to the realizing student-centered intention. For example, the information and learning material sampling in terms of tunnel performance is shown in Fig. 1.

As shown in Fig. 2, in a learning process, there needs knowledge transferring from the open shared information to personal mind stored information. It can not be directly applied in problem solving, which need skills of reconstructing the information and developing personal ideas of coping with a specified situation, with complex features. For example, tunneling is of complex and nonlinear features and the situation of a tunneling project is always unique. The information we meet is not totally same as what we remembered in mind. What the situation is depended also on the dynamic features of tunneling. The information sequence and response time lasting will have a strong influence on the result of the decision making and problem solving. There needs systems thinking in both learning process and practical problem solving (Fig. 3).

As the above-mentioned, there is relatively shorter time schedule for the subject. This means the sampled content for the teaching preparation is relatively smaller. This means that the content assembling should be well designed, such as in terms of execution. Considering the characteristics of the students involved, the classroom activity design should be of diversity and inclusion.

The information should be helpfully organized as a reference guide. Students can easily consult chapters or

sections as needed. It is easy to find targeted suggestions to enhance performance or remedy a problem in a specific area. On the other hand, although we consider that teaching is in part an art, teachers also need the help of tools to effectively perform their roles. For example, thousands of tools, tips, and methods [9], with special reference to ideas and strategies grounded in research and best practices of faculty, are well accepted for college teaching [6].

In content assembling, the basic concepts and general principles presentations are at the primary stages, while information application is executed in the higher stages, in which knowledge constructing is required in the learning process, as shown Fig. 2 and Fig. 3. On the other hand, teaching tools, such as assignment, quiz, test, and question asking, should be planned in coordination with the content learning and teaching process.

C. Execution Plan with Dynamic Style

Effective teaching practices are founded on well preparation of teaching information and materials, as well as well-designed execution procedure, including tools application, and student thinking capacity development and response action performance.

In general, the efficiency of students' capacity developing is related to both how to learn and how to teach, as well as to the interaction between the learning and teaching. This means that the efficiency of a student's learning is not simply a personal affair. Indeed, it is also heavily depended upon the performance of the teaching, and the interaction between the learning and teaching. Considering the features of problem solving capacity developing, the learning and teaching, as well as their interaction, should be considered, with the help of systems thinking, in the course plan execution design.

Following the four rules of thinking [5], including distinctions, organizing ideas into parts and wholes of systems, identifying relationships, and taking perspectives, the execution plan should be beneficial to building knowledge. As an educator we need integrate systems thinking into what we are teaching. Thinking is a process that people build knowledge from information, such as using systems thinking skills guidelines [5]. A teacher can help students to build their thinking skills, provided that our thinking and knowledge of issues are well mapped in the teaching and learning interaction, with dynamic features. Here is the application of systems thinking in tunnel engineering teaching at Chang'an University presented briefly, with key points shown in Fig. 4.

In terms of learning and teaching interaction, the both the information presented and how to be mastered in a teaching and learning procedure need a well planned system thinking. In the process of teaching, the means, such as good content preparation and well designed execution, well organized classroom activities, well chosen assessment modes, proper feedback to students' task accomplishing in time, will trigger students' learning and improve the quality of teaching [7]. Teacher's good performance will increase students' learning motivation (Fig. 4). On the other hand, a well prepared and performed lecturing is not only an effective means of information and knowledge presenting, but also a way of leading students to devoting their time or even life to the subject.

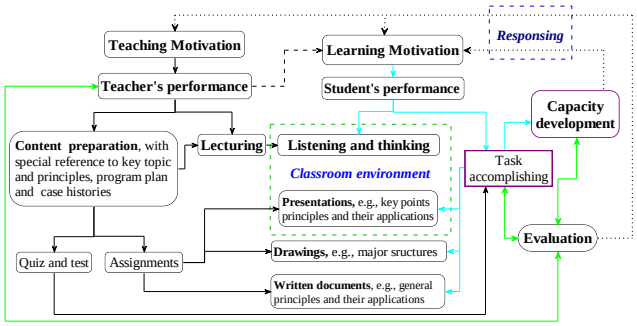

Fig. 4. Execution plan for teaching preparation with dynamic features.

Active interaction between teacher and students will improve classroom environment. Similarly, well-organized presentation by students in classroom is also an effective and practical way to encourage and actively develop students' learning skills. As the speaker is presenting, the classmates are parts of the environment. The presenter expresses the capacity of playing a social role in a group. This is similar to that a person needs to be admitted and respected where and when hard working is performed. On the other hand, who plan to present some topic or idea before others, should prepare related information and materials for it, which is a knowledge constructing and skill developing process. The presentation is a powerful way to deepen students' understanding. Presentation and discussion make our thinking transparent and is a way of building shared mental models of an issue. These skills are vital to a qualified professional engineer to cope with complex situation in practice.

On the other hand, the students' actively responses to a teacher's question and assigned tasks are extremely important in the execution of a course. An active response implies that the responder is not only actively involved in the process, but also skillfully constructs personal knowledge.

D. Application of Group Working

As the above discussed, the time schedule for the subject in side classroom is relatively limited. The design for the student activity outside the classroom is vital to the teaching preparation. For example, to apply the discussion and group working outside the classroom, there need a well execution plan to avoid social loafing.

Group work is an undeniable priority in a context that encourages communicative activities in the classroom. Individuals who are highly inclined to team work and who have potentiality to become part of a group will be well qualified students nowadays. As such, facilitating group work properly not only secures students' academic achievement, in particular language learning, but it also equips them with the ability to avoid self-centeredness and inculcate professional grooming.

Collaborative learning environment is considered one of the collective endeavors in the spirit of a student-cantered teaching execution [12]. Through effective collaborative learning, the

involved students learn from each other. On the other hand, collaborative learning is beneficial to students' problem-solving capacity developing, provided that students receive frequent assistance from the group members.

In a well planned and organized group working, we should design the execution procedure and personal performance evaluation tools to avoid social loafing. Each student should be encouraged to play an active role in the task accomplishing process. First, the personal role is well designed and their contributions are well valued and responded by course instructors. For example, Barkle (2011) [13] accumulated the strategies for the trajectory of success in group work. Students should be well informed about the aim and objectives of the project, well-known to the learning objectives, well-equipped with the skill required to perform group work, familiar to constructive criticism, and devise a plan of action to accomplish the task. On the other hand, instructors should also inform students about the benefit of group work and create ways to handle unproductive members.

E. Well-designed Evaluating Plan

In the above execution plan, a timely evaluating plan is also necessary in the learning and teaching dynamic process. As the above discussed, the one of the focuses in teaching at a university is to improve student's problem-solving capacity. Considering the features of the learning and teaching at a university, such as to accomplish a course in a semester, timely evaluating students' task accomplishing, including quiz and test, assignments, presentation and instant response to instructor question (Fig. 4) is necessary for both learning and teaching. A feedback of the evaluation to students is beneficial to trigger students' learning [7], in terms of strengthening learning motivation and interactions between learner and instructor (Fig. 4). Timely evaluating is one of the well-organized course environments, which strengthens the commitment and involvement of self-motivated learners. On the other hand, the results of the evaluation also act as indicator of teaching quality. The students' good performance will also strengthen the teaching motivation (Fig. 4) and the teaching plan should be implemented in a dynamic style.

On the other hand, the evaluation modes in the system should also be well-designed. As the above mentioned, it is necessary to apply systems thinking in tunnel engineering learning and teaching. Systems thinking is also beneficial in program evaluation design [14]. In general, a well-designed evaluation mode is with the following features: the key points of assessment should match the teaching content; the modes of evaluation are flexible, diverse and incentive; the execution of assessment is planned in the teaching time schedule. For example, the style of the questions testing the application of the principles with systems thinking needed should not be in standardization form. The presentation style of the evaluation results of students' performance should serve the capacity-developing plan. To encourage student's positive and active response to the assigned tasks, relatively high score is timely recorded to well-performed presentations. Volunteer is praised, such as with 25% to 30% plus in score, to make it an example.

IV. CONCLUSIONS

Based on the discussion on the general features of the new challenges in teaching a professional course of tunnel engineering nowadays, as well as the complex features of the subject, two general requirements and five considerations in teaching preparation are presented and the following conclusions are drawn:

(1) To meet the requirements of problem solving capacity development in course implementing, the complex feature and system thinking application should be under consideration in teaching preparation design.

(2) Of a student-centered teaching preparation for subject tunnel engineering in details, the general principle in design, the content sampling and assembling, designing a dynamic execution plan, with group working and evaluation plan included, are presented, with special reference to the application of system thinking.

REFERENCES

[1] M. W. Milke, "The distinctiveness of civil engineering in engineering systems thinking and in new models in engineering education," Civil Engineering and Environmental Systems, vol. 34, no. 1, pp. 78–87, 2017.

[2] P. Morgan, "The idea and practice of systems thinking and their relevance for capacity development," Maastricht, the Netherlands: European Centre for Development Policy Management, 2005.

[3] R. M. Yawson, "Systems Theory and Thinking as a Foundational Theory in Human Resource Development-A Myth or Reality?," Human Resource Development Review, vol. 12, no. 1, pp. 53–85, 2013.

[4] J.-Q. Ma, "Application of Systems Thinking in the Teaching of Tunnel Engineering," Proc. of the 2019 Int. Conf. on Advanced Education and Management, in press.

[5] D. Cabrera, L. Cabrera, "Systems thinking made simple: new hope for solving wicked problems," Ithaca, NY: Odyssean Press, 2015.

[6] J. Solin, "Book review of systems thinking made simple: new hope for solving wicked problems," Journal of Sustainability Education, vol. 12, pp. 1–4, 2017.

[7] G. Midgley, "Systems thinking for the 21st century," in: Systemic intervention, Contemporary systems thinking, Springer, Boston, MA, pp. 1–17, 2000.

[8] M. Nehdi, R. Rehan, "Raising the Bar for Civil Engineering Education: Systems Thinking Approach," J. Prof. Issues Eng. Educ. Pract., vol.133, no. 2, pp.116-125, 2007.

[9] B. G. Davis, Tools for Teaching, 2nd ed., San Francisco, CA, US: Jossey-Bass, 2009.

[10] N. J. Hayden, D. M. Rizzo, M. M. Dewoolkar, et al, "Advances in Engineering Education Incorporating a Systems Approach into Civil and Environmental Engineering Curricula: Effect on Course Redesign, and Student and Faculty Attitudes," Advances in Engineering Education, vol. 2, no. 4, pp. 1–27, 2010.

[11] T. N. Hrin, A. F. M. Fahmy, M. D. Segedinac, D. D. Milenković, "Systemic synthesis questions [SSynQs] as tools to help students to build their cognitive structures in a systemic manner," Res Sci Educ, vol.46, no. 4, pp. 525–546, 2016.

[12] T. Ferdous, A. Karim, "Working in Groups outside the Classroom: Affective Challenges and Probable Solutions," International Journal of Instruction, vol. 12, no. 3, 2019, in press.

[13] A. Burke, "Group Work: How to Use Groups Effectively," The Journal of Effective Teaching, vol. 11, no. 2, pp. 87–95, 2011.

[14] M. A. Torres-Cuello, L. Pinzon-Salcedo, G. Midgley, "Developing a systemic program evaluation methodology: a critical systems perspective," Syst. Res., vol. 35, pp. 538–547, 2018.