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The Application of System Thinking in Curriculum Design

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ABSTRACT
As a part of scientific system, any course and any knowledge in a course are not isolated. Based on the principle of system thinking, this paper puts forward a method of teaching and curriculum design. In classroom teaching, teachers want to teach a new knowledge topic. They first build a connection between the new knowledge and the knowledge they have mastered, and then analyze the differences and connections between the knowledge topics. On this basis, the new knowledge is taught and the mapping knowledge domains is constructed. The students can learn, review and consolidate knowledge simultaneously which improve the effect of course teaching. This paper takes *Fluid Mechanics* course as an example to demonstrate this method.

Keywords: *System Thinking, Teaching Method, Curriculum Design.*

1. INTRODUCTION

As the saying goes, "Every sand makes a tower", but can sand grains pile up together to make a tower? This is not necessarily true. Quantitative change does not necessarily produce qualitative change. Uncemented sand grains could form a sand pile, or desert, but they cannot become a solid "tower". We learn a rich variety of knowledge through various channels, keep learning and accumulating. If we cannot digest and integrate it, it is just an isolated piece of knowledge, which can only be used to solve specific problems, rather than deal with unknown and complex problems. In the process of teaching, teachers hope that students can "draw inferences from one example and apply what they have learned", but in practice it is often difficult to achieve.

2. OVERVIEW OF SYSTEM THINKING

System thinking refers to the way of thinking that uses system concepts to recognize objects and organize thoughts[1]. The origin of system thinking can be traced back to the ancient times, when people had understood the objective relations between things in a certain degree and scope. By the 1940s, modern system theory science with system concept as the center was gradually formed. At present, system thinking from system theory has been widely used in the field of cognitive research. For example, the popular associative memory method [2-5] is an application of system thinking in teaching, which is the product of the combination of system thinking and the law of human memory forgetting. Mind map and concept map are also visual "non-linear diagrams" formed by making full use of the concepts of systematic thought connection and combining with the laws of human perception [6]. Knowledge graph is a network knowledge based on the connections between knowledge[7-8]. These learning methods with system thinking have shown very good results in practical application. However, these methods are mainly aimed at human memory cognition, focusing more on enhancing people's memory ability, so that people can accumulate more knowledge topics faster. Although the accumulation of these knowledge topics can bring the improvement of learning effect, it is still not enough to understand the connotation of knowledge, construct the knowledge system and delve into the nature of science.

From the perspective of systematicness of knowledge, a course is a collection of knowledge that solves some common problems and the same kind of problems. As an integral part of a subject, it has inextricably links with other courses. If we ignore these connections and carry out teaching for each course as an isolated content and pile up knowledge, we will get nothing but "sand heap". If the connection between knowledge can be used as a link, and the knowledge topics of different courses can be linked together to associate and inspire each other, we can achieve twice the result with half the effort and bring infinite potential for knowledge exchange and learning. This is also the principle of system thinking.

Of course, in the process of learning, we can also do this naturally after mastering some knowledge, but the process will be relatively long, and it is difficult to achieve without careful consideration and hard work. In the teaching process, the teacher integrates the system thinking, on the basis of fully understanding the course, penetrates the knowledge topics, forms the three-dimensional knowledge system teaching, which has a great significance in accelerating this process.

3. THE APPLICATION OF SYSTEM THINKING IN CURRICULUM DESIGN

From the teaching of a course, the connection between the knowledge topics of the course can be divided into external connection and internal connection. External connection is to establish the connection and mapping between this course and the knowledge of other courses. By learning the difference and connection between existing and unknown knowledge, the existing foundation is consolidated, and then upgraded, expanded and deepened to form a higher level of knowledge. The internal connection refers to the connection of the knowledge topics of the course itself to form a three-dimensional framework, mutual support and association, and the use of the connection between the knowledge topics of the course to consolidate and strengthen memory. So what can we do?

This paper takes *Fluid Mechanics* course as an example to expound the connection framework of course knowledge.

During undergraduate study, the core content of *Fluid Mechanics* course is the embodiment and application of Newton's three laws and physics' three conservation laws in fluids. Newton's three laws and three conservation laws (conservation of mass, energy and momentum) have been studied deeply in middle school physics and college physics. By analyzing the differences between solids and fluid, as well as the unique phenomena of fluid, the knowledge of fluid mechanics is grafted to the knowledge tree of physics.

For example, the motion equation of the fluid, the usual teaching method [9] is to take the infinite-element body in the fluid and obtain the motion equation of the fluid (N-S equation) through force analysis of the infinite-element body, as shown in Fig. 1.

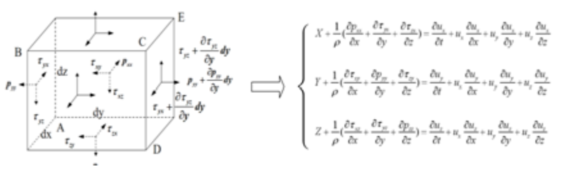

Figure 1 Derivation of the differential equation of fluid motion

This derivation method has no problem from the perspective of logic and theory, but from the micro analysis, this method gives the students a feeling of "only see the trees, but not the forest". They have difficulties in keeping up with the teacher's ideas. At the same time, this teaching method takes the equation of motion of fluid as an isolated knowledge topic to teach, which lacks the construction of knowledge system and is not conducive to students' in-depth understanding of the connotation and source of knowledge.

If using system thinking, the teacher can teach with the method of the "equation connotation - object characteristics - new expression".

Starting from Newton's law of motion that students are familiar with, the teacher can differentiate the difference between fluid and solid, review the knowledge topics, such as shear stress (Newton's law of internal friction), pressure (the basic characteristics of static pressure), fluid acceleration (the meaning of acceleration by Euler's method), whereby students can understand the basic composition of Newton's equation of motion for fluid.

As solid, the motion state of each particle in the object has a certain identity. The shape, volume and density of the object do not change with the motion. The force of a certain point is the force of the object, so as to change the physical motion state. As fluid, fluidity and viscosity are the force and motion of fluid which are much more complex than that of solid. In the stress point, liquidity and viscous fluid force through the interaction between fluid micelle. The micelle stress is not the same, and the motion state is different too. Force and flow of fluid shows a kind of "individually on the micro and macro coordinated action" on the mode of movement. The fluid physical properties and the motion state are described to be "small group" as a general object expression. For example, force, energy and momentum are depicted in the forms of "quality of per unit area, unit or unit weight". The interaction force between fluid microclusters appears to be viscous force, and its acceleration takes different forms owing to the particularity of the fluid, as shown in Fig. 2.

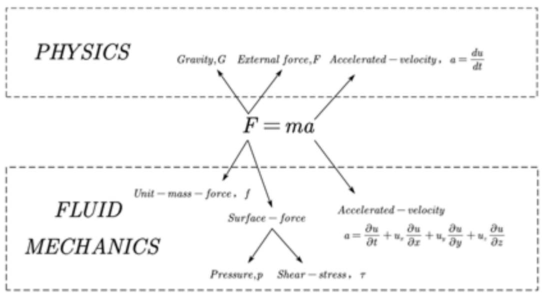

Figure 2 Hydrodynamic analysis of Newton's equation

Using various forces in fluid mechanics, Newton's equation of motion is constructed:

$$\vec{f}-\frac{1}{\rho}\nabla\vec{p}+\nu\nabla^2\vec{u}=\frac{\partial u}{\partial t}+u_x\frac{\partial u}{\partial x}+u_y\frac{\partial u}{\partial y}+u_z\frac{\partial u}{\partial z} \quad (1)$$

Then, analyze the meaning of each item in the formula:

$\vec{f}=\frac{m\vec{f}}{m}$ is the mass force on a unit mass fluid, m/s^2

$\frac{1}{\rho}\nabla\vec{p}=\frac{\rho As}{m}\frac{1}{\rho}\frac{\vec{p}}{s}=\frac{A\vec{p}}{m}$ is the pressure applied to a unit mass fluid, m/s^2, A is the cross-sectional area of the selected fluid volume, s is the length of the selected fluid volume, $\frac{\vec{p}}{s}$ is the pressure gradient between the two sections of the selected fluid, $A\vec{p}$ is the pressure on the selected fluid volume.

$\nu\nabla^2\vec{u}$ is the viscous force on a unit mass fluid, m/s^2

$\frac{\partial u}{\partial t}+u_x\frac{\partial u}{\partial x}+u_y\frac{\partial u}{\partial y}+u_z\frac{\partial u}{\partial z}$ is the acceleration of the selected fluid, m/s^2

This method design of this course has the following advantages:

(1) At the beginning of learning, the learning object -- Newtonian motion equation in fluid is defined, and the existing knowledge basis is activated for students to build a new knowledge system based on it.

(2) In the learning process, the teacher continues to deepen his/her understanding of Newton's equations of motion, such as the differences between different research objects and formulas, and the reasons for their differences, which also demonstrates the in-depth study of a certain theory for students.

Thus, Newton's three laws connect the knowledge topics of concepts and forms in physics, mechanics and fluid mechanics. In the course of teaching, the equations in fluid mechanics can be reduced to a form that students can understand, so that these knowledge can be truly connected together.

When designing courses with system thinking, the focus and center of classroom teaching is no longer the explanation, derivation and analysis of the knowledge topics of the course alone. But more importantly, the teacher should highlight which knowledge topics develop from those in the leading courses, and what are the differences between them, what are the reasons and the conditions of their applicability, etc., so as to fully activate students' acquired knowledge.

4. CONCLUSION

To sum up, as a part of the scientific system, any course and any knowledge topic in the course are not isolated. Teaching and learning based on system thinking can better grasp the context of knowledge, understand the connotation and extension of knowledge, and grasp and use knowledge to solve practical problems. Therefore, based on the theory of system thinking, this paper proposes the link between leading knowledge and the course, so as to activate students leading course knowledge foundation. The teacher establishes the relationship between curriculum knowledge, build its framework and mapping knowledge domain. The students can utilize this method to study, review and reinforce simultaneously. The demonstration of *Fluid Mechanics* course has been carried out as a case study of this method to provide a little reference to the teaching research for the teachers in colleges and universities.

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