# Network autonomous learning based on computational thinking

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ABSTRACT: Computational thinking is one of the major trends in the field of computer education. The study and development of computational thinking greatly matter to the ongoing growth of computer education. Based on the theory of computational thinking and network autonomous learning, described in this article is a network autonomous learning model, with computational thinking at its core. The authors apply the model to the teaching of a college computer basics course. The application of the teaching model to teaching practice is illustrated by taking the course, *Multimedia Basics and Courseware Creation,* as an example. It was found that the teaching model proved effective and successful. Furthermore, it cultivates learners' computational thinking ability.

INTRODUCTION

Computational thinking takes an approach to solving problems, designing systems and understanding human behaviour that draws on concepts fundamental to computing. The study and development of computational thinking is of great importance to the development of computer education itself. The teaching of college computer basics courses has a significant role in general education in college. It also contributes to cultivating learners' overall abilities, while promoting innovative ability. Since key to computer education, the teaching direction of computer basics courses should adapt to the needs of society. Therefore, a key point for computer science teaching should be to strengthen the computer basics courses and to determine the direction for the teaching of computer basics.

Incorporating computational thinking into the teaching of computer basics courses is one of the most effective methods for enhancing teaching. It not only fulfils teaching aims, it also influences the learner subconsciously. It can enable the learners using computational thinking to solve technical, professional and problems in daily life. Furthermore, it can internalise and enhance their advanced thinking ability, such that it stimulates creativity.

Based on the theory of computational thinking and network autonomous learning, in this article is described a network autonomous learning model with computational thinking at its core. The model is, then, applied to the teaching of a college computer basics course. The teaching model achieved a good teaching result, which validates the model. Compared with the traditional teaching model, the autonomous learning model based on computational thinking can cultivate learners' ability to think creatively, as well as to help them to construct self-knowledge and enhance their computational thinking ability.

THE CONNOTATION OF COMPUTATIONAL THINKING

Professor J.M. Wing, Head of the Computer Science Department at Carnegie Mellon University, points out in her article *Computational Thinking,* for *Communication of the ACM* (Association of Computing Machinery) journal: *Computational thinking is taking an approach to solving problems, designing systems and understanding human behaviour that draws on concepts fundamental to computing. Computational thinking includes a range of mental tools that reflect the breadth of our field* [1]. In her opinion, computational thinking is not confined to computer science, it is the fundamental skill used by everyone world-wide. In cultivating a child's analytical ability, one should make them learn computational thinking, as well as possessing abilities in reading, writing and arithmetic [2].

Abstraction and automation are the essence and mark of computational thinking. Computational thinking is a type of feasible, constructive thinking. It is based on programming, hierarchy and mechanisation. It exemplifies the type of mathematical thinking that is needed for problem-solving.

As with skills in reading, writing and arithmetic, computational thinking is a process not confined to computer science; it should be a fundamental skill used by everyone world-wide.

BUILDING A NETWORK AUTONOMOUS LEARNING MODEL BASED ON COMPUTATIONAL THINKING

Theoretical Basis of Network Autonomous Learning

In network autonomous learning, the participation of the teacher is important. But the teacher's role shifts from that of transmitter of knowledge into that of designer of learning resources, organiser of the learning process and evaluator of the learning. In the teaching, the elements interact with each other to form a teaching model. The network autonomous learning model is a systematic and theoretical teaching tool.

Generally speaking, the learning process in a network environment consists of four elements: teacher, learner, network teaching resources and network learning environment. In order to express the relationship among the four elements quantitatively, the following mathematical model is employed [3]:

$$Q = F(A_T, A_S, E, R) \tag{1}$$

In the equation, $Q$ represents the network autonomous learning model, $F(\ )$ is a function, $A_T$ is the teacher's set of actions, $A_S$ is the learner's set of actions, $E$ indicates the network environment of the teacher and learner, and $R$ indicates the network resources provided by the network environment. The network autonomous learning model based on computational thinking, relates to the learning effect and the teaching. Generally, the better the environment, the easier it is for the teacher to teach since learners can make full use of the network for autonomous learning.

Construction of a Network Autonomous Learning Model Based on Computational Thinking

The network autonomous learning model based on computational thinking combines teacher's teaching with the learner's autonomous learning. It uses teaching strategies and learning strategies based on computational thinking. The effect is for learners to construct their knowledge autonomously, to internalise the knowledge, increase their learning and enhance their thinking ability. The learning model can be represented by the following mathematical model:

$$Q_{CT} = F(A_T', A_S', E_{CT}, R_{CT}) \tag{2}$$

In the equation, $Q_{CT}$ represents the autonomous learning model based on computational thinking - CT means computational thinking. The connotation of $F(\ )$ is the same as in Equation (1), $A_T'$ represents the teacher's sets of actions, and $A_S'$ represents the learner's sets of actions, $E_{CT}$ indicates the teaching environment based on computational thinking and $R_{CT}$ indicates the network environment using the computational thinking method.

In the teaching method based on computational thinking, teachers choose the suitable network learning resources using the computational thinking method. Using the four elements of the learning process in a network environment, the authors constructed a network autonomous learning model based on computational thinking. The learning model is shown in Figure 1 [4].
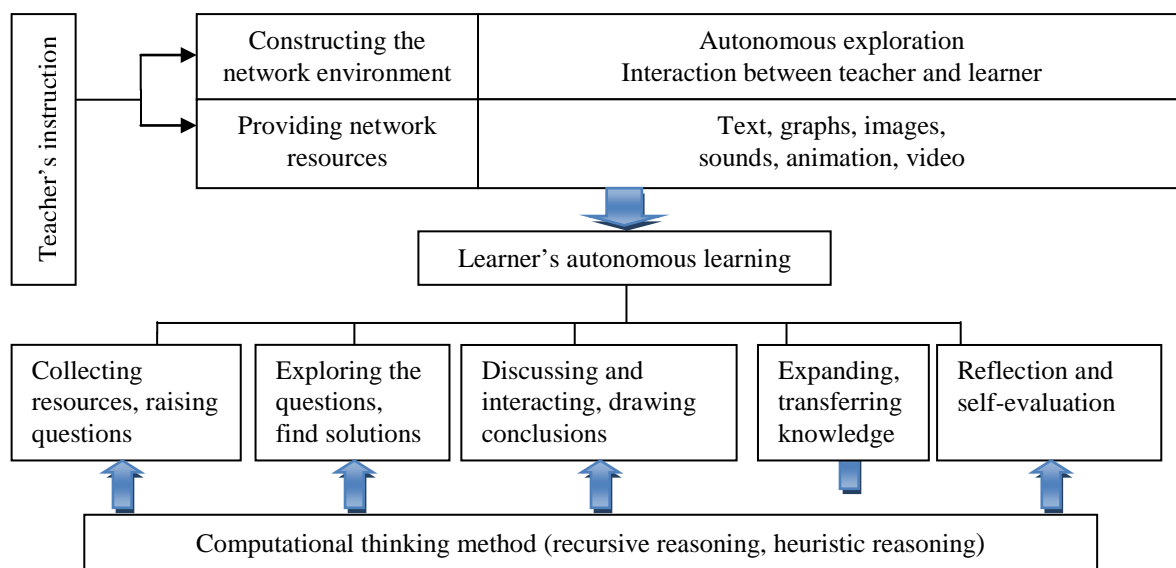


Figure 1: The network autonomous learning model based on computational thinking.

# THE NETWORK AUTONOMOUS LEARNING MODEL BASED ON COMPUTATIONAL THINKING USED IN TEACHING A COMPUTER BASICS COURSES

The network autonomous learning model based on computational thinking can motivate learning and make the learner construct knowledge given the abundant network resources. It also can cultivate abilities in computational thinking. The course, *Multimedia Basics and Courseware Creation*, is one of the operational computer basic courses offered to students in normal schools (i.e. teacher's colleges) taking non-computer majors.

The course has information literacy at its core and emphasises the learner's practical ability. It enhances learners' information literacy in the process of courseware creation, as well as cultivating their computational thinking. Using the network autonomous learning model above, the authors used this course as an example, and addressed two aspects: improvement of the teaching and cultivation of the learner's computational thinking ability. In order to show the effect quantitatively, in this article $I_*(*=1, 2)$ is used to represent the teacher's teaching effect, and $S_*(*=1, 2)$ to represent the learner's computational thinking ability.

Collecting Resources; Raising Questions

The first step in learning *Multimedia Basics and Courseware Creation* is important in that it involves collecting the network resources, so that learners have the raw materials for making courseware. The raw materials include multimedia materials, such as text, sounds, graphs, pictures, animation and video. These resources will include excellent courseware; thereby, enabling learners to understand, which aspects they should concentrate on. Meanwhile, learners may raise some questions, such as: *How to draw scenes using the courseware? How to recombine the audio? How to achieve animation?* The teacher should also set some exploratory questions based on computational thinking to cultivate learners' computational thinking and to motivate their learning [5]. The teaching and learning situation can be described by the following equation:

$$I_1 = F_1 (m) \tag{3}$$

$$S_1 = G_1 (p) \tag{4}$$

In Equation (3), *m* represents the learning resources collected by the teacher and the questions proposed by the teacher. The learning *p* relates to the instruction of the teacher, the learner's uses of computational thinking to raise questions. $G_1 (\ )$ is the computational thinking ability quality function. This shows the effect of computational thinking in the first stage.

At this stage, the teacher should ensure there are enough network resources available and that the network runtime environment is functional. Learners should be familiar with computational thinking, be able to preview relevant knowledge, know a series of methods of computational thinking and possess autonomous learning and knowledge construction ability.

The *Multimedia Basics and Courseware Creation* course is mainly about learning how to use Flash to make courseware. During the process of learning the courseware, teachers can instruct learners to compile questions. Take the making of mask animation as an example. Mask animation is a process where e.g. an archetypal character may be created on a detailed photographic background. Mask animation is a very flexible process, with many different forms.

On the basis of this, the teacher can use the heuristic reasoning of computational thinking within a question-posing setting. To illustrate this: if a student wants to know how to make a mask animation, first the mask layers should be distinguished from the masked layers and, then, the student must find which layer has the animation.

Next, the student will need to determine whether the animation is shape-tweening (i.e. an animation process leading to the effect; whereby, one shape morphs into another) or motion-tweening (where a shape is moved to create the effect of animation), and how to make shape-tweening animation or motion-tweening animation, and so on. Using heuristic reasoning, one can get closer and closer to the key point of the question.

Exploring the Questions; Finding Solutions

The second stage is key to the whole learning process. Here, the teacher should help learners to resolve questions guided by computational thinking methods. The process includes instructing learners how to learn, providing relevant learning materials and learning methods, as well as finding solutions to questions. Under the instructions of the teacher, learners can determine how to answer questions by making use of the computational thinking methods. The teaching and learning situation can be described by the equations below:

$$I_2 = F_2 (k) \tag{5}$$

$$S_2 = G_2 (h) \tag{6}$$

The equations represent the learner's learning function. It is the learner's optimisation of the network information resources under the instruction of the teacher using the numerous network resources, and the analysis of the solutions under the guidance of the computational thinking methods. $I_2$ represents the learning effect of the second stage, and $h$ represents the process of using computational thinking for analysing questions and finding solutions under the instruction of the teacher. $G_2(\ )$ is the quality function of computational thinking. $S_2$ represents the effect of computational thinking at this, the second stage.

Discussion and Interacting, Drawing Conclusions

The third stage mainly is about encouraging learners to participate actively in discussion and to help learners to draw conclusions guided by computational thinking. In this process, learners make use of computational thinking to find solutions to the questions, under the instruction of the teacher.

Referring to the example earlier of making mask animation, learners would find that a stronger visual effect can be achieved by adding a background layer to a simple mask animation. The masked layer need not be confined to one. It is possible to not only mask motion-tweening animation, but also to mask the shape-tweening animation, as well. By such considerations, it is possible to enhance the learner's ability to make animations, as well as to cultivate autonomous learning and computational thinking.

Consolidation and Practising; Expanding and Transferring Knowledge

The fourth stage concerns teachers leading learners to consolidate knowledge, and to draw inferences about other cases from one instance. The depth and breadth of knowledge are expanded, so as to achieve a firm grasp, while being able to flexibly use it. The course, *Multimedia Basics and Courseware Creation,* requires a lot of practice and learners should make use of the network platform for this practise. In the process of such practice, learners can consolidate and upgrade the knowledge they have obtained.

Meanwhile, learners can benefit by further learning from network resources, broadening their thinking and deepening their understanding. In the whole process, the teacher should incorporate computational thinking methods into the questions set for the learners and help them to cultivate subconscious computational thinking. For example: in learning mask animation, the teacher could set a number of questions to expand the topics, such as: *Can the route guidance animation be masked? Can the mask animation and the route guidance animation be merged into one piece of work?*

Reflection and Self-Evaluation; Internalisation and Upgrading Knowledge

After learning, the key to the fifth stage is to review the knowledge gained and to sum-up the learner's learning and experience, so as to internalise the knowledge and to apply it in practice. The teacher should encourage and help the learners to build on their understanding.

In teaching network autonomous learning based on computational thinking, the teacher should provide plenty of network resources for learners and instruct them to raise questions to explore and solve. The teacher should also set questions to guide learners in computational thinking. Learners should construct their own learning model using the knowledge gained as a basis. They should learn autonomously, while evaluating themselves on fulfilling the tasks required by the teacher. Through this learning model, learners are able to make full use of computational thinking to learn autonomously. Then, they can share their learning experiences and internalise the knowledge.

CONCLUSIONS

As a new mode, computational thinking has a profound impact on computer teaching. In this article, computational thinking applied to the course, *Multimedia Basics and Courseware Creation* was discussed as an example. This illustrated that, in computer course teaching, computational thinking can be employed to solve various problems.

The essence of computational thinking is abstraction and automation. In order to highlight the role of computational thinking in teaching and learning, examples have been used to show the process in the context of a network autonomous learning model.

It is viewed that incorporating computational thinking into teaching college computer basics courses can not only enhance the teaching, but can also influence learners subconsciously, as well as cultivate their computational thinking ability. By doing so, the learners, then, can use computational thinking methods to solve technical problems, professional problems and problems in daily life. It can further provide excellent information resources and more efficient learning methods as a base for lifelong learning.

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