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Applying Whitehead's process philosophy to engineering-oriented practical education

Jianjun Wang, Chongming Ma, Shao Huang, Liqun Yu & Ruoan Xia

Hunan First Normal University
Changsha, People's Republic of China

ABSTRACT: Alfred North Whitehead, the renowned mathematician and philosopher, advocated combining theory and practice in education, emphasising methods by which to grasp and use knowledge. Education has both regular and irregular characteristics and these are reflected in how individuals develop and grow naturally. Individuals should be taught based on their abilities and circumstances, and these vary by individual. An example is given in this article, to demonstrate the contemporary significance of the Whitehead process in education. This example refers to applying Whitehead's process philosophy to engineering-oriented practical education in communication major at Hunan First Normal University, Changsha, PRC.

INTRODUCTION

Alfred North Whitehead (1861-1947), a distinguished educator in England, believed that above all things education should integrate theory and practice. Education should produce a student who not only has knowledge but applies excellence to the way they carry out practical tasks [1]. Theory and practice should be incorporated into education and supplement one another. Knowledge is relevant only when it is applied in practice.

Whitehead encouraged people to be motivated about *practice*. He believed that when a student acquired theory without practice, then, such knowledge was a waste. Knowledge is important only when it is applied practically and only, when, it is understood by people. Knowledge's worth totally depends on who masters it and what he/she uses it for. The truly valuable education is one that teaches students to understand thoroughly some universal principles, which then, can be applied to dealing with various, specific situations. Practice originates from, and is closely tied to, daily life; and knowledge ought to serve daily life.

The quality that education should impart is a deep recognition that power, theology and organisation lie in knowledge and, as well, there is a special kind of knowledge having to do with who knows it well. He further believed that another aspect of education is to pass on wisdom. Wisdom involves an approach to learning and knowledge. Wisdom is essentially the ultimate freedom that one can acquire. Education should be targeted to make individuals wise and the only path to wisdom is freedom of knowledge, where *freedom* means an individual can learn, understand knowledge and, then, apply it in practice.

THE EDUCATION PROCESS

In Whitehead's theory, teaching is a process that follows a number of rules manifested by certain steps in the process of education. Intelligence develops in steps, each of which contains a few cycles or iterations that intertwine, while the whole process is a small eddy of individual growth as part of a bigger cycle or iteration. The steps reflect certain, universal rules that are rational and reasonable [2]. Learners develop their knowledge gradually and iteratively. The teaching process should be advanced iteratively and the steps should not be rigid.

Whitehead strongly criticised the common viewpoint prevailing at his time, that a student's progress was a steady, unvarying development irrespective of the type of student. He thought education was a challenge that could not be solved by a simple formula. Whitehead, mathematician and philosopher, also thought it was impossible that there were any abstract rules that suited all subjects, students of all kinds or that could be used to teach the *right* knowledge to each student. Each student at each stage in education is unique.

A Process for Developing an Individual's Intelligence

Whitehead divided the education process into three stages: the romantic stage, the precision stage and the application stage. The romantic stage is when students begin to comprehend, but knowledge is not systematic; the precision stage is the period where students gain more knowledge to increase and supplement their earlier learning, and where they acquire facts in an organised way and expand the general learning of the romantic stage. The application stage is the ultimate goal: to comprehensively apply knowledge after learning the concepts and the pertinent skills [3].

The growth of knowledge is the result of the ordered, harmonious and iterative development through the three stages. A learner, in the process of study, should be assigned tasks matching the stage he/she is in, or his/her development will be affected. If viewed by age, the three stages correspond to infants and young children, teenagers and university students, with each stage requiring the right courses and in small steps.

The *right* content should be taught based on the stage, the level of knowledge and the intellectual capacity of each student. No student can tackle the three stages concurrently. Whitehead emphasised that teaching content requiring diverse comprehension should be put into different, subordinate cycles. Through this a harmonious pattern takes shape in the student's mind. Meanwhile, teaching quality should improve as education adapts to the stage that a student has reached. He believed that ignoring the pacing and factors that influence education was the main cause of poor and inefficient education.

The Education Process is not *Lifeless*

Whitehead criticised the view that treats the brain as a kind of *lifeless tool* and the most dangerous view that persists in education theory. He thought the human brain has never been passive and negative but is constantly active, receiving and responding to external stimulation in a fine and acute way. As with tools sharpened before use, the human brain keeps developing. An infallible law in education, also a hard law to follow, is that teachers should motivate their students, regardless of the response by students to the teaching [4]. This requires teachers to show great patience and to make a huge effort.

The challenge here is to recognise intelligence and to motivate the drive to achieve, which cannot be awakened just by words. Any teacher with experience knows that education is a demanding process requiring much patience in delivering detail in an iterative manner day after day. Therefore, to Whitehead, when teachers analyse the central mission of education, they would find that achieving the mission depends on making an optimum adjustment to a number of variables.

The reason is that educators are dealing with live human brains. For students, the thirst for knowledge, their judgement and their mastery of complexity, must be developed to enable them to apply theoretical knowledge to particular situations. These abilities cannot be delivered through one fixed approach, e.g. as implied by the current examination system. So, teachers must implement the educational process in the right way for individual students and at the right time.

ENGINEERING-ORIENTED PRACTICAL EDUCATION

Whitehead believed that students' study in different stages is an iterative process; each stage contains cycles which contain smaller cycles. Therefore study is progressive. This educational paradigm is also applicable to college students who major in engineering and, especially, in practical education, which develops application-based engineering talents. In this article, an example is drawn from Hunan First Normal University's communication major in developing application-based engineering skills. This exemplifies the development and improvement in students' ability, through practising Whitehead's process.

A student majoring in communication engineering needs to study for four years: common basic courses in the first year, specialised basic courses in second year, specialised courses in third year and specialty-based field work in fourth year. Using Whitehead's process concept, the entire four-year study is deemed a large cycle, with each academic year as a step of the cycle, as shown in Figure 1.

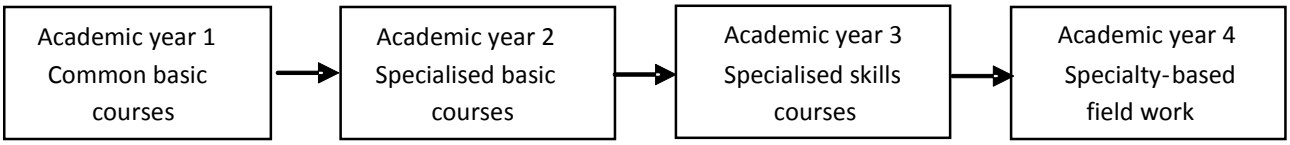

Figure 1: Steps in the communication engineering course.

In light of the developing trend in communication technology, the communication engineering course is positioned so as to develop application-based skills in technologies for the development and production of mobile smart communication terminals. For the communication engineering course, the ultimate goal is to train and cultivate talents

in the design and development of mobile wireless communication terminal products (e.g. card readers). The module is divided into three: the design of communication circuits, modern communication theories and the development of communication protocol software. The basic structure is shown in Figure 2.

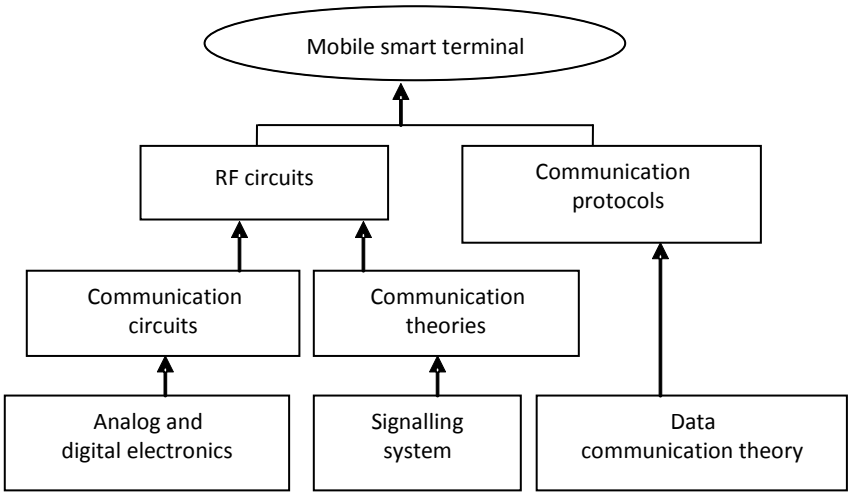

Figure 2: Structure of the teaching of communication engineering.

The ability to program in the C programming language is essential, whether for use in radio-frequency circuits in mobile smart terminals or for the development of communication protocol software. In the programme plan for the communication engineering course, the 72 class-hours course for C language starts only at the beginning of the second academic year. Theoretically, it would take a minimal 700 class-hours to develop a student's skills in C, based upon the experience of previous students. This includes 200 class-hours for lectures, 200 class-hours for practical instruction and 300 class-hours for self-learning and exercises. Therefore, the 72 class-hours for C specified in the programme plan is far from sufficient. Concentrating 700 class-hours into one window, for example, a semester or an academic year, would affect students' learning, and reduce its efficacy. A long-term feasible plan for learning C and its application would need to run through the entire four-year period, in a number of small closely related cycles, as shown in Table 1.

Table 1: Teaching C Programming in cycles.

Academic year	Stage for C learning	Class hours for lectures	Class hours for instructions	Class hours for self-study
Year 1	Basic knowledge	72	72	100
Year 2	Basic application of specialised skills	54	54	80
Year 3	Comprehensive application of specialty skills	72	72	80
Year 4	Comprehensive training and field work	0	0	40
Class hours	Subtotal	196	196	300
	Total	692		

This mode of teaching is challenging to organise since it requires familiarity with the detailed points of knowledge required at each step. The teachers should be allowed to exercise flexibility of approach during teaching; as well, previous and current teachers should work closely together so that previous experience can be shared. The end result should be one whole body of knowledge. The organisers should be required to pay due regard to the whole teaching process and to survey the results of teaching. Then, if necessary, the organisation may be modified, e.g. adjusting the teaching content taking into account feedback from teachers.

During the first year, in delivering the syntactical knowledge of the C language, teachers at Hunan University choose examples to trigger students' interest in learning and to increase their learning efficiency. This was done by having the students themselves program in C after being taught the language. After about 200 class-hours learning the theory and with practice, the results show that this method of teaching has contributed well to cultivating and developing application-based skills in the following ways.

An improvement was shown in recognition of the course. For example, before reform, the institution was viewed as oriented toward the teachers and their development. Students did not recognise the course that well before enrolment; and the level of enrolment in the course at that time was too low. However, through reform, students feel they have achieved in the subject and are able to apply their learning. This has led to an improvement in the recognition of the course and increased enrolment.

The rise in recognition of the course has gone up, from 60 per cent at the beginning of the academic year to 85 per cent after one year for students enrolled in 2012; it was 78 per cent for those enrolled in 2013. A significant increase was recorded when comparing the enrolment figures to the start of the academic year. Of the students enrolled in 2013 for the course, 30 per cent had transferred from other specialities, compared with just 10 per cent in 2012. Admissions resulting from original applications and total admission have both increased significantly.

Academic scores also have increased substantially. A large increase was recorded in the academic scores of students enrolled in 2012, after just one year of reforming the practical teaching. Throughout the academic year, the teaching organisers followed up the results of students enrolled in 2012 and have made two comprehensive investigations. The first investigation held was to instruct the teaching organisers to gather verbal feedback from students to establish their intellectual competence and efficacy in learning.

The teachers who participated in this investigation were rated satisfactory by the students, whose scores in general were considered better than their peers in other courses. In the second investigation, an examination was given to the students. It was found from the results that 70 per cent of students were rated good and 20 per cent were rated excellent. This indicated, with the practice-oriented learning of the C language, that students had acquired more knowledge, with their interest in C spilling over into other courses, resulting in a ripple effect.

CONCLUSIONS

Alfred North Whitehead's process philosophy on education advocated combining theory and practice. It also placed weight on learning from practice. He upheld that education should be implemented progressively in stages and that teaching should follow the *law* on an individual's personal development. He believed that knowledge should be taught with passion to motivate students to learn. This practice has demonstrated that Whitehead's process philosophy on education meets the need for reforming Chinese higher education.

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