Using Information Media-Based 3D Mathematical Stories to Facilitate the Education on Mathematical Culture

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Abstract. With the advancement of information technology, mathematics and science have enriched the meaning of vocational education. The researchers developed 3D-animated teaching materials about mathematics that include stories about two mathematicians, Leibniz and Pascal, and upload them onto the website of a mathematical education system. The teaching materials were developed with the software called 3D MAX. The stories show how Leibniz improved Pascal’s design of the calculator and developed the calculator by combining such functions as addition, subtraction, multiplication, and division, how he proposed the algorithm of the binary system, and how he created the calculus signs that are now widely used throughout the world. We incorporate the above-mentioned mathematical culture into Education and Communication Sciences, the mathematical education system’s website established herein, so that students can get acquainted with Leibniz’s exploration and how his achievements changed the thought and life of humans. The goal is for Leibniz’s contribution to stimulate students’ passion for innovation and develop their own practical abilities so as to reveal practical significance. This study employs information technology, mathematical education, and the “integrated” feature of the teaching of general education subjects to create life-like teaching situations that help stimulate students’ enthusiasm for exploration.

Introduction

In the fields of science and technology, Taiwan prides itself on computer technology. Mathematics has profound effects on the development and competition of high technology, but in the scientific domain, mathematics is the mother of science: mathematical algorithms are required in the design of the most popular smartphones and tablets today; mathematical precision calculations are also needed in Google’s search engine as well as the manufacturing of automobiles, naval vessels, and planes [1]. Therefore, the combination of mathematical technology, information technology, and vocational technology has played a key role in the cultivation of top innovation-oriented interdisciplinary talents.

The knowledge of technology derives from people’s demands during their daily life and their use of wisdom. Reading stories about the wisdom of famous people in history can inspire innovation. As mathematics is the mother of science, stories about how mathematicians in early times accumulated wisdom through discussions on mathematics and science can serve as the foundation for modern-day people to innovate mathematical tools. The accumulated wisdom and knowledge throughout history have advanced information technology, facilitated people’s lives, enhanced their enjoyment, and made substantial contributions to society.
Motivation

When students study mathematics, a bridge must be built between the abstraction of mathematical knowledge and the visualization of students’ thinking. Information technology can play the role of such a bridge. Mastering modern information education technology and applying it to teaching in an appropriate and rational way is an essential way for promoting innovation in mathematical teaching.

Examining mathematical teaching in secondary schools from the perspective of activated teaching, research [2] showed that teachers recognize the importance of activated mathematical teaching and are willing to make a change. However, teachers believe that activated mathematical teaching could be achieved through active teaching, life-based teaching materials, and sense-based learning. It is obvious that math teachers are interested in promoting life-based mathematics by using active teaching materials of mathematics. Their finding thus motivates the authors to adopt animated stories and dynamic teaching materials of mathematics to facilitate the learning of (3D-spatialized) mathematics.

According to Leibniz, “everything in the world is governed by mathematical rules.” Such a profound “natural concept of mathematics” shares the same meaning with the famous words from Galileo (1564-1642), “Nature’s great book is written in mathematical language” [3]. Hence, this study creates 3D dynamic stories about mathematicians so that learners can read animated stories about famous mathematicians before they start the mathematical learning. Taking the stories about the mathematician Leibniz as an example, the authors incorporates animated stories into the teaching concept of a flipped classroom, so as to enhance the effect of mathematical learning and general education.

This study develops 3D-animated stories about mathematicians and adds them into the teaching concept of a flipped classroom, so as to enhance the effect of mathematical learning and to extend the application of a flipped classroom in courses on mathematics or general education. Moreover, it motivates students to know the meaning and application of mathematics and to enrich their basic knowledge of science.

Research Approach

The animated teaching materials were developed with the software named 3D MAX and can be installed in a website system. Figure 1 presents the teaching material development procedure.

This study takes the example of the historical mathematician Leibniz, whose achievements in the binary system, calculator, and calculus great contributed to human beings’ advancement and have become important teaching materials in mathematical education and general education.

The scripts of the stories about Leibniz for the development of the animated stories are divided into the following step-wise parts: (1) the self-learning of Leibniz in a picture book of his childhood; (2) the mathematical inspiration from his friend Huygens; (3) Leibniz noticed the paper about “adder” by Pascal, which stimulated his strong desire to make an invention - developing the machine into a calculator capable of addition, subtraction, multiplication, and division; (4) the development of calculus algorithms and signs.

Figure 1. Teaching material development procedure.
One of Leibniz’s contributions is that he sorted out the skills of differentiation and integration, including the four theorems of differentiation (the four algorithms of function and the commutation rule of differentiation algorithm), as well as the skill of the integration by parts, which is derived from the basic theorem of calculus [4]. The significance of Leibniz’s calculus signs is more far-reaching, so much so that they are very popular even now. For example, \( \frac{dy}{dx} \), one of Leibniz’s calculus signs, is as direct as infinitesimal; the chain rule \( \frac{dz}{dx} = \frac{dz}{dy} \frac{dy}{dx} \) looks like a natural result, though it is a theorem that requires a strict demonstration, is easy to remember, and can facilitate computation. One of his integration signs, \( \int_{a}^{b} f(x) \, dx \), is also as direct as infinitesimal. In many integration formulae in physics, physical meaning and integration formula alone can lead to variable substitution. Under such a sign, integration by parts changes into the formative operation of the sign.

Leibniz occupies a vital position in the history of mathematics and philosophy. In mathematics, he and Newton separately invented calculus. Some believe that the greatest attainment of Leibniz is not the creation of calculus, but the development of mathematical signs applied in calculus, for the signs used by Newton are widely regarded as less effective than that by Leibniz. Moreover, Leibniz contributed to the development of the binary system.

Leibniz improved Pascaline and transformed it into a calculator with such functions as addition, subtraction, multiplication, and division, yet his contribution to the calculator is not confined to the multiplier. Despite the fact that the decimal system still operates in Leibniz’s calculator, he took the initiative to propose the binary system for the design system of the calculator. He pointed out that the binary system might be more suitable for the mathematical algorithm in the machine, which laid out the theoretical foundation for modern computer science.

The specifications of the animation application of this study are as follows.
(1) Computer-based animation film: resolution is at least 1920X1080.
(2) The animation frame is at least 24 frames per second: 24fbs built in Blender.

Figures 2 to 5 illustrate the different images of the animation created with 3D MAX in this study. Figure 2 is the section for Figure setting. Figure 3 is the page-turning image in the animation. Figure 4 shows the mathematical stories about the binary system and calculator of Leibniz and Pascal. Figure 5 is the image where Leibniz thinks about calculus signs.
In the curriculum, the importance of the binary system is illustrated in the teaching materials. Nowadays, most computer-based calculations and computations are not done with the decimal system, but the binary system that consists of “0” and “1”. Although the number of the binary system is longer, it is very convenient when it comes to the multiplication algorithm, as “1×1=1” and “0×0=1×0=0×1=0” are adequate for the task [5]. This can increase the effectiveness of the computer.

The calculator and computer, which are widely used by modern people, are actually the extension of the application of Leibniz’s binary system in the calculator. Their historical stories are worth raising the digital animation-based popularization of the practical value of mathematics.

**Conclusion**

Information technology has provided scientists with an excellent communication method and greatly accelerated the development of other subjects. A connection between subjects and information technology has led to a significant integration of information technology and subject [6-8]. Information technology has brought about information exchange in teaching and learning and contributed to the revolutionary change of thinking.

The students on the research team come from different education departments, and so the source of students is diversified. According to the difference among the students, we have employed appropriate information technologies to combine digital image, information and education technology, and the cultural stories about mathematics, enhancing the stories about Leibniz into 3D-animated teaching materials. Moreover, this study uses information and education technology in the multimedia teaching, education, and communication of various subjects, so as to meet the different needs of students and to enhance their understanding of concepts, conceptual presentation, and communication. This is consistent with the technological pedagogical content knowledge proposed by literature [6].

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