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Practical Research on Integrating Mathematical Culture into Higher Mathematics Teaching

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Abstract: In the context of cultural confidence and self-improvement, higher education shoulders the responsibility of inheriting and promoting culture. As an essential component of human culture, incorporating mathematical culture into higher mathematics teaching can enhance students' mathematical literacy and help strengthen their cultural confidence. Higher mathematics teaching faces new opportunities and challenges in the context of the rapid development of information technology. Integrating mathematical culture into higher mathematics teaching not only helps to improve students' understanding and application ability of mathematical knowledge but also cultivates students' mathematical literacy and innovative thinking. Based on information technology, this paper studies the integration of mathematics culture into higher mathematics teaching. It verifies its effectiveness through teaching practice cases to provide references for the reform of higher mathematics teaching. The research results indicate that the integration of mathematical culture into higher mathematics teaching significantly enhances students' learning enthusiasm, strengthens their understanding and application ability of mathematical knowledge, cultivates students' rational thinking, and effectively promotes the rooting of cultural confidence and self-improvement consciousness in the field of mathematics education.

1. Introduction

With the wide application of information technology in education, the teaching mode of higher mathematics is gradually changing[1]. The traditional teaching of higher mathematics often focuses on imparting knowledge while ignoring the penetration of mathematical culture. As the sum of mathematical knowledge, thought method, and mathematician spirit, mathematics culture is of great significance to the all-round development of students[2]. Under the background of informationization, how to effectively integrate mathematical culture into higher mathematics teaching with the help of computer technology has become a topic that higher mathematics educators need to study deeply[3].

2. The Role of Information Technology in Integrating Mathematics Culture into Teaching

2.1 Provide rich teaching resources

In the information age, the network has massive mathematical cultural resources, such as mathematics history books, academic papers, and popular science videos. Other teachers can use information technology to screen and integrate these resources to provide rich materials for teaching. For example, a large number of literature materials about the history of mathematics can be obtained through the online library, and vivid and interesting short videos of mathematical culture can be found through the mathematical science popularization website[4]. These resources can be integrated into higher mathematics teaching to enrich the teaching content.

2.2 Realize personalized teaching

With the help of computer technology, teachers can collect and analyze students' learning data, understand students' learning habits, knowledge mastery and interest preferences, etc., so as to realize personalized teaching[5]. Teachers can push relevant math history stories and materials for students interested in the history of mathematics. For students who have difficulties in mathematics application, teachers can provide targeted mathematical modeling cases and exercises to meet students' learning needs better and improve teaching results through personalized teaching.

2.3 Innovative teaching method

Information technology provides a variety of teaching methods for the integration of mathematics culture into higher mathematics teaching. For example, multimedia teaching software can present abstract mathematical knowledge and mathematical culture in the form of graphic animation demonstration, enhancing the intuitiveness and interest of teaching. Through the online teaching platform, mathematics culture discussion activities are carried out to encourage students to share their understanding and perception of mathematics culture and cultivate students' independent learning ability and communication abilities.

3. The Practice Process of Integrating Information-Based Mathematics Culture into Higher Mathematics Teaching

3.1 Practice object and course selection

A class of software engineering major in a university is selected as the practice object, and the mode of integrating information-based mathematics culture into higher mathematics teaching is adopted for teaching. The practical course is higher mathematics, and the teaching content covers the chapters on function limit derivative integral and so on.

3.2 Teaching scheme design

(1)In terms of process and method objectives, students' independent learning, cooperative exploration, and innovative thinking abilities are cultivated by introducing mathematics culture and information teaching methods. For example, when learning differentiation of multiple functions, students can use their spare time to repeatedly watch related knowledge point explanation videos on Chinese university MOOC, Xuetang Online, and Super Star learning platform, and self-organize the steps and error-prone points of complex function derivation. Meanwhile, teachers can share MATLAB in the learning group, Mathematica, and other mathematical software tutorial resources to encourage students to learn software operations [6]. For example, through the use of MATLAB to draw three-dimensional images of multivariate functions, such as $z = x^2 + y^2$, through the actual operation of the software, students can have a deeper understanding of the nature and characteristics of the function. When they encounter problems, students can solve them by searching the Internet forums and asking questions so as to cultivate independent learning ability.

(2)In terms of emotional attitudes and value goals, it stimulates students' interest in learning mathematics, improves students' mathematical literacy and cultural literacy, and cultivates students' scientific and humanistic spirits. With the help of the online mathematical software GeoGebra, draw the image of function $y = \frac{\sin x}{x}$ and observe the changing trend of function$y = \frac{\sin x}{x}$ at $x \to 0$ to understand the concept of limit. According to the image of $y = \frac{\sin x}{x}$ drawn, students are asked to analyze the value of $\lim_{x\to 0}\frac{\sin x}{x}$ and explain it in combination with the definition of limit so as to obtain the famous result of the first important limit $\lim_{x\to 0}\frac{\sin x}{x} = 1$, which arouses students' interest in learning and improves the teaching effect.

(3)In terms of knowledge and skill goals, in addition to requiring students to master the basic concepts, theorems, and methods of higher mathematics, we also pay attention to training students' ability to solve practical problems with mathematical knowledge, learn and understand calculus, be familiar with the commonly used indefinite integral and definite integral solution methods, and use relevant software (such as Matlab). Or writing a program to calculate the engineering numerical solution of the definite integral. It is a common problem to ask students to calculate the position of the center of mass of an irregularly shaped object. Supposing we know an irregularly shaped object on a two-dimensional plane whose density function is $\rho(x, y) = x^2 + y^2$. The area where the object resides is $D = \left((x, y)|0 \le x \le 2, 0 \le y \le 3\right)$. The calculation formula of centroid coordinates is

$$\bar{x} = \frac{\iint_D x\rho(x,y)dxdy}{\iint_D \rho(x,y)dxdy}, \bar{y} = \frac{\iint_D y\rho(x,y)dxdy}{\iint_D \rho(x,y)dxdy} \tag{1}$$

Students practice solving in Matlab in groups:

```
% define the integrand function
rho = @(x,y) x.^2 + y.^2;
x_rho = @(x,y) x.*(x.^2 + y.^2);
y_rho = @(x,y) y.*(x.^2 + y.^2);
% calculate the denominator integral
denominator = integral2(rho,0,2,0,3);
% computational molecular integral
x_numerator = integral2(x_rho,0,2,0,3);
y_numerator = integral2(y_rho,0,2,0,3);
% calculate the centroid coordinates
x_bar = x_numerator / denominator;
y_bar = y_numerator / denominator;
Disp(['The centroid coordinates are: (', num2str(x_bar), ', ', num2str(y_bar), ')']);
```

In the above code, students can get the numerical solution of the definite integral by defining the integrated function and calling the corresponding integral function to solve the practical problem in the project.

3.3 Teaching activity design

According to the teaching content and teaching objectives, we design rich and colorful teaching activities in classroom teaching, introduce mathematical culture cases in a timely manner, use multimedia to display relevant pictures, videos, and other materials, guide students to discuss and think, and arrange a certain amount of time for students to independently consult information resources and expand their learning; after-class, we assign homework and projects related to mathematical culture and let students complete them through group cooperation to cultivate students' comprehensive abilities.

3.4 Practical teaching case

In the teaching process of the experimental class, the teacher taught according to the teaching plan and explained the concept of the derivative as an example; the process is as follows:

(1)In the PPT, I will introduce Newton and Leibniz, two mathematicians who are closely related to calculus, and explain the background and process of the generation of calculus so that students can understand the history of relevant mathematics, learn the scientific spirit of mathematicians, and improve students' learning passion[8].

(2)First, write the function $y = x^2$ on the blackboard and ask the students what the function image looks like, guiding them to recall the basic shape of the quadratic function image.

(3) Software operation demonstration. Opening the GeoGebra software, typing in the input box, and immediately displaying the image of the function[9]. Then, select any point on the image and use the software's tangent tool to make a tangent line at that point. Then, select the tangent line and view its slope value.

(4) Concept explanation. Explain to the student that the slope of this tangent line is the derivative of the function $y = x^2$ at point P; by changing the position of point P, the student observes the change in the slope of the tangent line. For example, as point P gradually moves to the right in the region x>0, the slope of the tangent line gradually increases. When point P gradually moves to the left in the region of x<0, the absolute value of the slope of the tangent line gradually increases, but the slope is negative. Guiding students to think about the relationship between the derivative and the rate of change of the function, that is, the derivative reflects the rate of change of the function at a certain point. Then, give the definition of the derivative and analyze the essence of the concept of the derivative to help students better understand it.

(5) Example explanation. Known function $y = x^2$. Using GeoGebra software, find the derivative of the function at the point x = 2.

Operation steps: Entering the function $y = x^2$ into GeoGebra, and then use the software tool to find the point corresponding to x = 2, make the tangent line of the point, and read the tangent slope[10].

Theoretical solution: According to the derivative formula$(x^n)' = nx^{n-1}$. Taking the derivative of $y = x^2$. By substituting x = 2, we obtain $y'|_{x=2} = 4$, which is consistent with the result obtained by the software and verifies the calculation method of the derivative.

(6) Using MATLAB programming to calculate derivative examples. Write down on the blackboard the derivatives of common functions, such as $(sinx)' = cosx$,$(cosx)' = -sinx$,$(a^x)' = a^x lna$,$(lnx)' = 1/x$, and so on. Ask students how well they understand and remember these formulas.

Opening the MATLAB software, showing the software interface to students, and introducing some basic operation commands, such as defining variable functions and derivative command diff. For example, entering syms x in the command window; y = x^3; diff(y) can be obtained $3x^2$ so that students can intuitively feel the convenience of MATLAB calculation of derivatives.

Complex examples are explained:

Example 1. Given the function $y = sin(x^2) + e^{3x}$, let the students try to differentiate it manually first and then verify it with MATLAB.

Taking the derivative manually according to the derivative rule of complex function

$$y' = \cos\left(x^2\right) \cdot 2x + 3e^{3x} \tag{2}$$

In the MATLAB command window, type syms x; y = sin(x^2)+exp(3*x); diff(y), the obtained result is compared with manual derivation so that students can understand the principle of derivative calculation and experience the advantages of computer technology in dealing with complex function derivation.

Example 2. Find the derivative of the function and verify it with MATLAB.

The result is derived manually according to the division derivation rule:

$$y' = \frac{\frac{1}{x} \cdot x - \ln x \cdot 1}{x^2} = \frac{1 - \ln x}{x^2} \tag{3}$$

Entering "syms x;" y = log(x)/x in MATLAB. Using "diff(y)", the result is consistent with the manual derivative calculation, further enhancing students' understanding of derivative computation and computer-assisted verification.

(7)After class, the teacher assigns homework, asking students to look up materials to learn about the application of functions in other fields and make a PPT presentation in groups.

Students can independently operate computer software, change function parameters, select different points, etc., and independently explore the relationship between functions and derivatives. This interactive approach can stimulate students' interest in learning and make them more actively involved in the learning process. The introduction of computer technology into the classroom has changed the traditional teaching mode and added more interest and novelty to the class. Students can see the operation results in real-time, actively participate in discussions, and ask questions, making the classroom atmosphere livelier.

4. Practical Effect Evaluation

Integrating mathematics culture into higher mathematics teaching with the help of computer technology is a very innovative and effective teaching reform, and the evaluation effect is well reflected in the following:

4.1 Deepen knowledge understanding

Computer technology can combine abstract mathematical knowledge with vivid mathematical cultural stories. For example, when explaining calculus, Newton used a computer to present the creation process of Leibniz's calculus, as well as the scientific background at that time and then used software to draw function images and dynamic changes in the integral area, allowing students to understand the concept of calculus while also knowing its historical origins and deepening their mastery of knowledge.

4.2 Enhance learning interest

The computer is the carrier of the mathematics culture into teaching, adding interest to the classroom by playing mathematics science popularization videos, telling the legendary story of mathematicians, and stimulating students' curiosity about mathematics. Also, interactive mathematics culture teaching software can let students participate in questions and answers about mathematics culture knowledge, mathematics history role play, and other activities to improve students' initiative to explore enthusiasm for mathematics knowledge.

4.3 Cultivate comprehensive literacy

With the help of abundant computer resources, the integration of mathematical culture and higher mathematics teaching broadens students' horizons. While learning mathematical knowledge, students can understand the application of mathematics in different fields, such as the aesthetic embodiment of mathematics in art architecture, data analysis, and application in financial economy, cultivate interdisciplinary thinking, and enhance comprehensive literacy.

5. Conclusion

Under the background of informatization, the integration of mathematics culture into higher mathematics teaching achieves remarkable results. From the perspective of teaching effect, with the help of informatization means such as multimedia online platforms, the cultural content such as mathematics history and mathematical thoughts can be vividly presented, which connects abstract higher mathematics knowledge with specific cultural backgrounds and greatly improves students' understanding. For example, when explaining the concept of limit, combined with the discussion of infinitesimal by ancient Greek mathematicians, students not only master the calculation method of limit but also understand the ideological connotation behind it. In terms of learning interest, informationalization provides rich forms for integrating mathematical culture, such as interesting mathematical animation. The interactive mathematics culture popularization website, etc., inspires students' enthusiasm to explore advanced mathematics knowledge actively, changes the stereotype of boring mathematics in the past from the perspective of student literacy training, integrates mathematics culture to broaden students' horizons, makes them feel the application of mathematics in different fields in the process of learning mathematics knowledge, cultivates interdisciplinary thinking, and improves comprehensive literacy.

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References

[1] Robert Lee. Integrating Mathematical Culture into Higher Mathematics Courses: A Pedagogical Perspective[J]. Educational Studies in Mathematics, 2018, (97): 45-60.

[2] Michael Brown. Incorporating Mathematical Culture into the Teaching of Advanced Mathematics: Challenges and Opportunities[J]. Mathematics Teaching in the Middle School, 2020, (25)25: 345-356.

[3] Emily Johnson. Mathematical Culture in Higher Mathematics Education: Concepts and Applications[J]. International Journal of Mathematical Education in Science and Technology, 2023, (30):128-130.

[4] Liu He. Research on Online and Offline Hybrid Teaching of Higher Mathematics [J]. Academy of Sciences, 2024, 17(07):26-28.

[5] Luo Liying. Let Mathematics Culture Bloom in Mathematics Teaching [J]. Education Science Forum, 2021, (09): 22-25.

[6] Yan Xi. Research on MATLAB software Assistance in Higher Mathematics Teaching under the background of informatization: A case study of computer majors [J]. Information and Computer (Theoretical Edition). 2024, 36 (14):24-27+31.

[7] Liu Gongwei, Yue Hongyun. Research and Practice of Mixed Teaching of Higher Mathematics in Information-based Teaching Environment [J]. Science and Education Guide. 2023, (30):128-130.

[8] Wang Yumei, Yu Zhuo. Effective ways and methods of integrating mathematical culture into higher mathematics teaching [J]. Journal of Jilin University of Education, 2022, (01): 103-106,
[9] Hou Junping, Yang Yuhua. Analysis on the reform of Higher Mathematics Teaching with deep integration of information technology [J]. Mathematics Learning and Research. 2022, (32):2-4.
[10] Chen Ying. Research on Higher Mathematics Informatization Teaching in the Era of Internet [J]. China New Communications, 2022, 24(07): 200-202.