Reform of teaching and the introduction of an autonomous learning centre in a mechanical drawing course

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ABSTRACT: In order to resolve existing teaching problems in a mechanical drawing course, a practical teaching mode is proposed, which includes three parts: teachers' practical demonstrations with multimedia courseware; integration of CAD software into the curriculum; and mapping the course against the professional and product digital design process. The teaching aims to improve students' practical capability in drawing by reform of the teaching methods and means, class content and teaching system. The engineering graphics autonomous learning centre is built to assist classroom teaching and also assist students' mastery of the drawing course. The engineering graphics autonomous learning centre is composed of six units: drawing base module; standards and specifications module; parts representation module; assembly and craft module; architectural drawing module; and the 3D modelling and 3D printing module. It is seen that the teaching mode and the autonomous learning centre can effectively stimulate students' learning interest, promote engineering practice, as well as cultivating students' practical and innovative ability.

INTRODUCTION

The *Mechanical Drawing* course is an important basic course for the mechanical engineering specialty in national engineering colleges. The course has a strong theoretical basis, but it also is very practical. The course aims to cultivate students' abilities, including the understanding of spatial forms, creative configuration design, freehand drawing and professional drawing. The course emphasises raising the engineering consciousness of students and engineering standards [1].

The teaching needs to consider both the teaching content and schedule arrangements. Traditional teaching involves understanding and digesting classroom teaching, with revision and review after class; there is little opportunity for independent analysis and investigation [2].

Deepening of teaching reforms leads to innovation in teaching, with autonomous learning widely recognised as important. This is a way of creative learning by analysis, exploration, practice and questioning. In this article, a practical teaching mode is proposed, which reforms teaching methods and means, class content and the curriculum. An engineering graphics autonomous learning centre was built for on-line learning and demonstrations, as a means of integrating teaching, learning and practice.

EXPLORATION OF TEACHING MODE

In recent years, reform in education has improved the integration of teaching content and the optimisation of teaching methods. However, students' practical ability remains relatively low, which is reflected in superficial multimedia teaching, poor use of CAD (computer-aided design) software by students, and unchanged content and form of the surveying and mapping components of the course [3]. Therefore, a practical teaching mode is proposed to strengthen the students' drawing and drawing comprehension.

Co-ordination of Teachers' Practical Demonstration with Multimedia Courseware

For a long time, the lack of spatial ability and machining experience has restricted students' understanding of the projection graphics of mechanical products, which is important since it makes it difficult to teach mechanical drawing.

Multimedia courseware can effectively solve these problems. For example, complicated components of 3D models can be shown in multiple perspectives, which improve students' spatial awareness and ability to understand drawings. When teaching the parts of a structure, a mechanical processing video not only enriches the teaching content, but also broadens students' horizons and cultivates engineering analysis [4].

In teaching CAD drawing, teachers demonstrate each operation, step-by-step, from beginning to end. Students can view the full demonstration before doing their homework exercises.

Integration of CAD Software into the Curriculum

The CAD tool is goal-driven and integrated into traditional teaching. In the *standard parts* and *common parts* of the course, teachers teach the use of AutoCAD, so as to draw a threaded fastener and gear. In *parts drawing*, teachers teach modelling functions and engineering drawings generated by Autodesk Inventor (an application for creating 3D digital prototypes). In *assembly drawing*, teachers teach the assembling functions of Inventor. The teaching mode of study with practice at the same time, improves students' interest and practical ability.

Combination of *Mapping* with Product Digital Design

When designing content and form for *surveying and mapping*, the students' specialty and the practice digital product design should be considered. The drawing content and subsequent learning should be cohesive and improve the design ability using CAD software enhanced [5].

The specific content and tasks of *surveying and mapping* after reform is as follows: six to eight students will be in a group. Products related to the major are chosen, e.g. oil pump of a car or motorcycle for the vehicles major. Students are required to disassemble the parts, select representation methods, draw freehand sketches and, then, design a new product according to changes to the specifications, performance, etc. This requires a computer to design parts, a *3D solid modelling and products* assembly model, and simulation of a virtual prototype.

ENGINEERING GRAPHICS AUTONOMOUS LEARNING CENTRE

Module Design of the Autonomous Learning Centre

The goal of building an autonomous learning centre is to provide students with an independent learning environment through networking and practical demonstrations, so as to improve learning and teaching [6].

Therefore, combined with the teaching content and experience in the Mechanical Drawing course, the engineering graphics autonomous learning centre has six units, viz. drawing base module, standards and specifications module, parts representation module, assembly and craft module, architectural drawing module, as well as a 3D modelling and 3D printing module, as shown in Figure 1.

At the same time, the mapping classrooms, measurement classrooms, modelling and 3D printing classrooms are available for training.

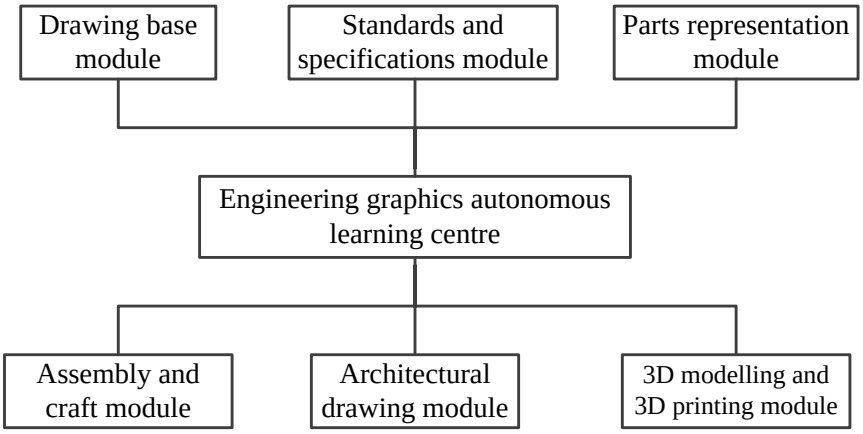

Figure 1: Engineering graphics autonomous learning centre.

Drawing Base Module

The contents of this module are shown in Figure 2. Basic drawing skills require the use of common drawing tools, size analysis and mastery of the drawing steps. In order to master the drawing method of orthographic views, projection rules are demonstrated by animation.

Projection rules of point, line and plane include line-line-point → perpendicular line of projective plane, plane-plane-line → vertical plane of projective plane, and so on. Projection characteristics of basic solid include circle-circle → sphere, circle-cuboid → cylinder, circle-triangle → cone, triangle-rectangle → triangular prism, and so on.

Projection characteristics of intersecting line and line sections are difficult. For example, if two different-diameter cylinders intersect, the intersecting line is concave toward the axis of the larger-diameter cylinder; if two same-diameter cylinders intersect, the intersecting line is two intersecting lines. The module also provides methods for freehand drawing and visual object ratios, with demonstrations through video examples.

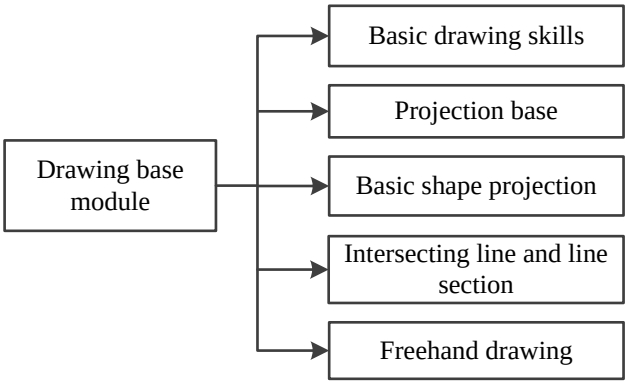

Figure 2: Drawing base module.

Standards and Specifications Module

In order to ensure normalised engineering drawings that meet the needs of modern production and management, and facilitate technical exchanges, a series of Chinese national standards have been developed. The module excerpts basic provisions concerning the drawing format, proportions, font, line and dimensioning.

In order to draw mechanical drawings according to the national standard, drawing software needs standardised settings, such as layers, text style and size. This enables students to understand the national standards in the learning process and develop good plotting habits.

It is easy to ignore *standard parts* and *common parts* for students. Standard parts will be provided and can be included in the parts diagram, while common parts need to be drawn. Hence, the module contains support for drawing standard parts, common parts and connection drawings for the assembly diagram. It also provides three-dimensional diagrams and entities. Limit and tolerance is an important standard for mechanical interchangeability, which directly affects the products' accuracy, performance and service life. This module describes concepts of the limit and tolerances, such as size, offset, and so on, as well as providing the basic deviation series graph, hole and axis limit deviation table, etc. The standards and specifications module is shown in Figure 3.

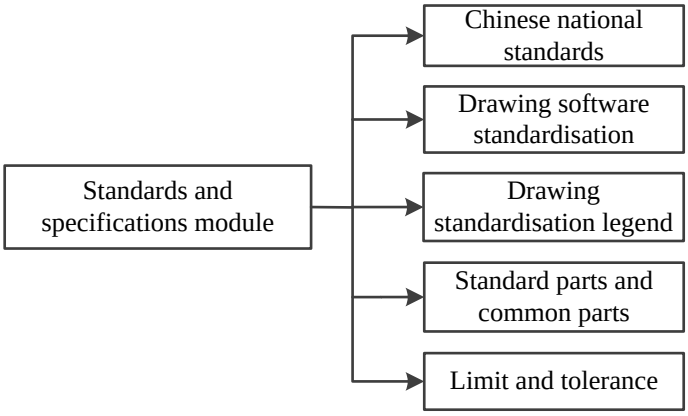

Figure 3: Standards and specifications module.

Parts Representation Module

This module teaches how to represent internal and external structural shapes and determine reasonably the size of mechanical configuration. The parts representation module is shown in Figure 4.

The *View* representation method introduces views of a mechanical external structure, cutaway views of internal structure and cross-section diagrams of a truncated surface shape. Configuration design of an assembly only considers geometry, but the configuration design of parts also needs to understand the relationship between structure and manufacturing, assembly, use and aesthetics. The dimension considers baseline, dimensioning and design process requirements.

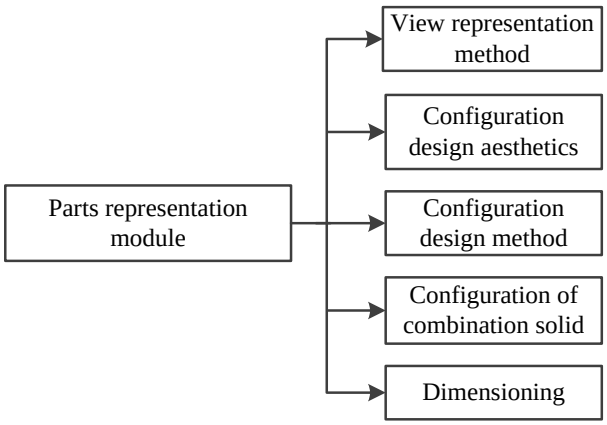

Figure 4: Parts representation module.

Assembly and Craft Module

When designing a machine, the assembly drawing should be drawn first and, then, the part drawings. Assembly drawings should reflect the design intent and express the working principles, performance requirements, assembly relationship, structural shape, dimensions and technical requirements. The module mainly relates to assembly drawings, as shown in Figure 5.

According to the specific machine, students can produce an assembly process specification and through video animation demonstrate assembling and dismantling. After this module, students can understand assembly intuitively, as well as the relationship between the component parts.

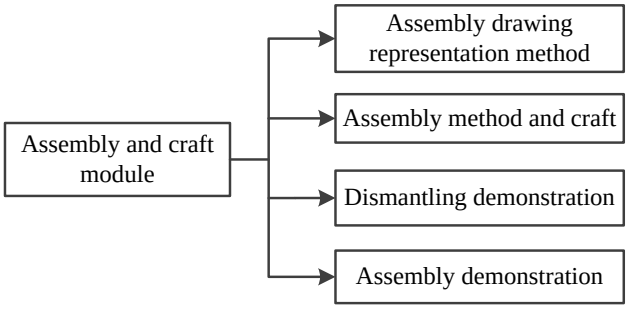

Figure 5: Assembly and craft module.

Architectural Drawing Module

Architectural drawing is used for architectural designs. The design drawings can be for different content and different stages. The architectural drawing module provides students with cartography methods and skills in the various aspects of a building, as shown in Figure 6.

The buildings are classified into many types, and different types have different drawings. The module also provides water supply and drainage standards, as well as an analysis of the construction plans. The building construction plans need to be designed based on the load-bearing member in the building. The HVAC (heating, ventilation, air conditioning) is an integral part of the building; HVAC legends are explained to enhance students' ability to read HVAC drawings.

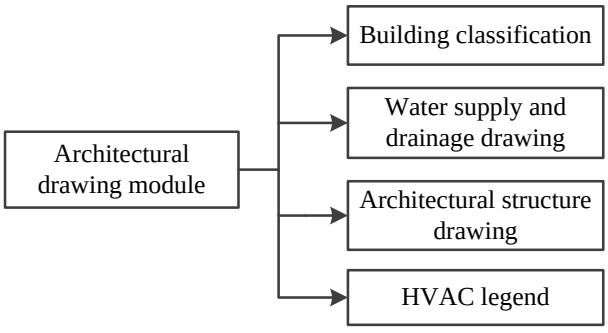

Figure 6: Architectural drawing module.

3D Modelling and 3D Printing Module

With the rapid development of computer technology and the extensive application of three-dimensional software, the modern enterprise is gradually being transformed, from using two-dimensional to three-dimensional design, and the three-dimensional solid model is becoming the medium of communication [7].

The 3D modelling and 3D printing module is shown in Figure 7. It aims to improve students' spatial awareness in product design. This module introduces the development of 3D technology, explains currently used 3D software and provides instructional videos. The module has a 3D model library and common mechanical system simulation library, including 3D models and motion simulations of common mechanisms.

With the wide application of sheet metal in the industry, sheet metal mould design is particularly important. The module introduces the design specifications and procedures of sheet metal moulds.

Due to 3D printing technology becoming more popular, students are provided with information about 3D printing, including the structure of a 3D printer, the principle of 3D printing and a demonstration of the printing process.

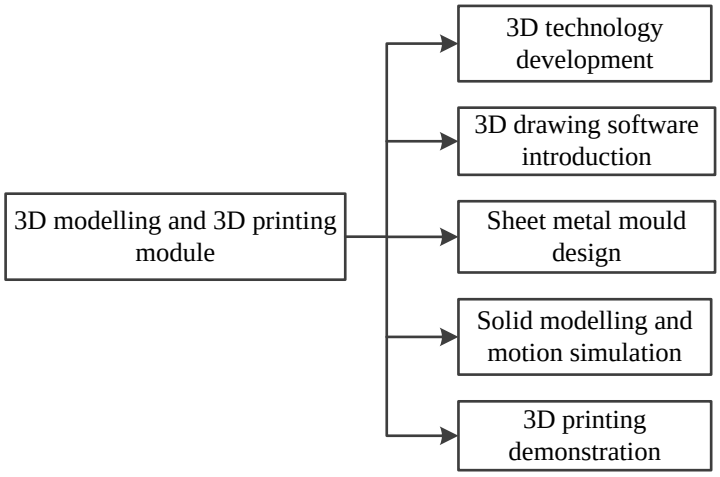

Figure 7: 3D modelling and 3D printing module.

Characteristics of the Autonomous Learning Centre

- Autonomy

  The engineering graphics autonomous learning centre provides a completely autonomous learning environment for learners. Learners arrange their own learning content and learning time according to their interests, hobbies and work. Learning centres were established to improve students' interest in learning, enrich the learning content, take advantage of networks and display systems, and to develop students' self-learning ability.

- Subsidiarity

  The engineering graphics autonomous learning centre is not only used for learners' autonomous learning, but also as an extension of conventional classroom teaching. Each module has classroom content as core, which is expanded through examples and animations. Students can learn based on their interest and to choose material to address their weak points.

- Repeatability

  The engineering graphics autonomous learning centre provides support for repetitive learning. Learners can get secondary and even multiple learning opportunities through hearing lesson-plan dubbing or watching video lectures and the actual operation.

- Openness

  Traditional teaching centres on teaching material and is constrained by classroom time, and so teaching content is limited. The autonomous learning centre provides an open learning environment, which can expand curriculum content under the guidance of teachers. Hence, content is no longer abstract and students better appreciate the usefulness of the course.

- Interactivity

  Exchanges and communication in traditional teaching are very limited, while the autonomous learning centre can take advantage of a variety of communication tools to enhance exchanges and communication in time and space. This allows teachers to grasp fully the status and effectiveness of student learning, understand how to improve the teaching and play a catalytic role in promoting students' self-learning ability.

RESULTS OF THE REFORM

The practical teaching mode and the autonomous learning centre have a multiplier effect in improving teaching quality, so that the Mechanical Drawing course is popular with the majority of students. In the drawing course, the students' interest and the overall learning environment have much improved. After focusing on teaching practice, the teamwork learning mode was introduced to complete group projects under supervision. After class, students exercise together at the autonomous learning center, which greatly improves their cartographic learning.

Students have participated in many competitions and received more than 30 awards, such as second prize in the 2013 National 3D Digital Innovation Design competition; first prize in the 2014 National Contest of Digital Design of Mechanical Product for College Students; first prize in the 2014 Mechanical Innovative Design Competition; second prize in the 2015 National 3D Digital Innovation Design competition; and third prize in the 2015 Mechanical Innovative Design Competition. Students also have applied for more than 10 patents and have published more than 10 papers. It can be seen from these achievements that students' knowledge of mechanical drawing is comprehensive, practical and of high quality.

CONCLUSIONS

Guided by the teaching concept of *taking students as the main body and teachers as leading*, a practical teaching mode is proposed for the Mechanical Drawing course. This involves careful planning of the classroom teaching and integration of CAD software into the curriculum to stimulate students' learning interest and to cultivate their innovative ability.

The engineering graphics autonomous learning centre breaks through the limitations of traditional teaching by offering students a platform for autonomous learning, to improve the learning efficiency and teaching effect. These two aspects of reform solve problems of teaching and learning for engineering students by allowing practical autonomous engineering training to augment the teaching and lay a good foundation for students' future professional careers.

The intent is to constantly improve the teaching mode and content of the learning centre to achieve an even better teaching effect.

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