Research on Construction and Application of 3D Printing Technology in University Art Design Laboratory

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Abstract—Based on the analysis and summary of the basic situation of 3D printing technology, according to the practical experience in the teaching and management of university art design professional laboratory, this paper carries out an in-depth discussion on the five aspects of the attribute positioning, construction principle, service object, management mode and experimental content of art design professional 3D printing laboratory and some thinking are suggestions are put forward.

Keywords: 3D printing; art design; laboratory construction

I. INTRODUCTION

3D (3D Printing Technology) was originated from America in the 19th Century and was developed and popularized in the mold processing industry in 1980s. It is called Rapid Prototyping (RP) technology in China. 3D printing technology can be applied to modeling

verification scientific hypothesis, different subject experiment and teaching. It can play an auxiliary role in many subjects and have achievement in education field [1].

II. OVERVIEW OF 3D PRINTING TECHNOLOGY

A. Technical Principle.

According to 3D design and 3D calculation, the special materials are stacked and solidified are stacked and solidified layer by layer through software and numerical control system, thus generating 3D entity. 3D printing is widely used in daily consumer goods, transportation, medical treatment, industrial equipment, architecture, food, scientific research, aerospace, education, entertainment and other industries. The commonly used 3D technologies are as follows.

TABLE 1: TECHNICAL PRINCIPLE AND CLASSIFICATION OF 3D PRINTER

Form type	Form technology	Material used
Extrusion molding	Fused Deposition Molding (FDM)	Thermoplastic plastics, fused metals, edible materials
Shot-like particle molding	Direct Metal Laser Sintering (DLMS)	Metal alloy
	Selective thermally sintered (SHS)	Thermoplastic powder, metal powder, ceramic powder
	Electron beam melting (EBM)	Titanium alloy
	three dimensional printing of powder layer nozzle (PP)	Gesso
Photopolymerization molding	Digital Light Processing (DLP)	Liquid resin
	Stereo lithography apparatus (SLA)	Photosensitive polymer
	Polymer injection (PI)	Photosensitive polymer
Laminating	Laminated Object Manufacturing (LOM)	Paper, metal film, plastic film

B. Classification of 3D Printer

It can be divided into two categories, industrial level and desktop level according to application level. The processing size of industrial 3D printer can reach more than 300mm, and the minimum processing precision can reach 0.016mm, but its price is expensive and its volume is huge. It is mainly used for research and development of products and enterprise production.

The processing size of desktop 3D printer is about 300mm and the processing precision is about 0.1-0.2mm. Its price is low, the volume is small and the operation is simple. It is used for education, entertainment and so on.

C. Introduction of 3D Printing Materials

At present, in the field of 3D printing, the materials used mainly include five kinds of materials, such as polymeric material, metallic material, ceramic material, composite material and gesso. According to different printing requirements, considering the cost, appearance, details, mechanical properties, mechanical properties, chemical stability, and special application environment, the most suitable materials are selected. The commonly-used materials are as follows.

TABLE 2: INTRODUCTION OF 3D PRINTING MATERIALS

Commonly used 3D printing materials			Characteristic Material
Polymeric material	Engineering plastic	ABS material	Engineering plastics refer to plastics used industry for industrial parts or sheathing material. They are excellent plastics with excellent strength, impact resistance, heat resistance, hardness and aging resistance. Engineering plastics is the most widely used 3D printing material nowadays. The most commonly used materials are ABS class materials, PC materials and nylon materials. ABS materials are (FDM) thermoplastic engineering plastics commonly used in the rapid prototyping process of fused deposition modeling. It has the advantages of high strength, good toughness and impact resistance. The normal deformation temperature is more than 90 degrees. It can have mechanical treatment, (drilling, tapping screw), spray paint and electroplating.
		PA material	
		PC material	
		PPFS material	
		PEEK material	
		EP material	
		Endur material	
	Bioplastics	PLA material	Biodegradable plastic is non-toxic and harmless with low shrinkage, good toughness, high strength and easy degradation. The disadvantage is that it is not heat-resistant, and the chemical stability is poor. Printing temperature: 190-210°C. The diameter of the wire is 1.75mm, and the diameter is 3mm.
		PETG material	
		PCL material	
	Thermosetting plastics		For example, epoxy resin, unsaturated polyester, phenolic resin, amino resin, polyurethane resin, organic silicon resin, aromatic heterocyclic resin are characterized by high strength and fire resistance. It is suitable for powder laser sintering process which uses 3D printing.
	Photosensitive resin		Generally liquid, it can be used for making high strength, high temperature resistant and waterproof materials. It has excellent toughness, good accuracy and good surface quality.
Metallic materials	Ferrous metal	Stainless steel	It can be used in the manufacturing of actual products. For example, high strength titanium alloy has accurate size and the minimum size can be made up to 1mm. The mechanical properties of its parts are better than the forging process. The stainless steel model printed by 3D has high strength and is suitable for printing large size articles. The metal powder used for 3D printing generally has requirement for high purity, good sphericity, narrow particle size distribution and low oxygen content.
		High-temperature alloy	
	Nonferrous metal	Titanium material	
		Magnesium-aluminum alloy	
		Gallium indium alloy	
		Rare and precious metals	
Ceramic material			The ceramic powder for 3D printing is a mixture of ceramic powder and a certain kind of binder powder. It has the advantages of high strength, high hardness, high temperature resistance, low density, good chemical stability, corrosion resistance and so on. The disadvantage is that high temperature reburning is needed in the later period. At present, the technology of ceramic direct rapid prototyping is not yet mature. It is still in the research period both at home and abroad and it has not realized commercialization.
Gesso and other materials			It includes colored gesso material, artificial bone dust, cell biological material and granulated sugar. The colored gesso is a full color 3D printing material based on gypsum and material that is fragile, strong and clear in color. Based on the forming principle of layer by layer printing on the powder medium, there may be fine particle effect on the surface after processing of 3D printing of finished products. The appearance is very similar to rock. There may be subtle ring like texture on the surface of the curved surface. It should be applied to the fields of anime dolls and so on.

D. 3D Printing Process

The process of 3D printing includes four parts, 3D modeling design, slice processing, model printing and subsequent processing. First, standard file format (suffix STL) is derived through three dimensional software (3dsmax, Maya, Autocad, etc.) or 3D scanner scanning model. Second, STL files are derived into 3D printing software (Cura, etc.) for print setup. Third, print model. Due to different machines and printing time, patience is needed. Fourth, follow-up treatment includes polishing, adhesion, coloring and so on.

III. RESEARCH ON CONSTRUCTION AND APPLICATION OF 3D PRINTING TECHNOLOGY IN UNIVERSITY ART DESIGN LABORATORY

The professional laboratory of art and design is different from the laboratory of engineering specialty. Its laboratory construction management should be carried out around the 4 aspects "practice, practical training, practical operation, experiment. It emphasizes the cultivation of students' creative ability, cognitive ability, thinking ability, design ability, hand ability, application ability and display ability so as to activate the students to try and complete the "invisible" construction and "tangible" molding of the curriculum plan. [2]The construction of 3D professional

laboratory, 3D printing related experimental projects are set up, which can strengthen students' cognitive ability and practice ability, expand students' creative ability in thinking, enhance students' creative ability in design, increase students' opportunity for employment and promote the development of scientific research in colleges and universities. [3] It is believed that the construction of 3D Laboratory for art design in colleges and universities can be carried out in the following aspects.

A. Attribute Orientation: Service Teaching and Strengthening Innovation Application

The laboratory is the main position of teaching and studying the creative practice activities and the implementation of the technology manufacturing and modeling art. The regular results and demonstration of college students' innovative experiment practice teaching will also enhance the students' interest in the training of creative practice ability, and then promote the professional quality education of college students. [4] Service teaching and innovative application are typical attributes of 3D printing Laboratory of art and design major in colleges and universities. With the purpose to serve the innovative teaching activities, the laboratory is oriented to innovation activities, innovation courses, graduation design, discipline competition and other innovative teaching activities. It is open to students and provides a platform for the students' innovation and innovation practice competition.

B. Construction Principle: Substep Construction and Rational Purchasing of Equipment

3D printing technology is changing rapidly and the speed of updating is fast. As an innovative application party of 3D printing, colleges and universities should purchase software and hardware rationally according to the actual requirements of the college (number for experiments, teachers, budget, maintenance cost, printing precision, frequency [2] rate, etc.). After considering the factors of purchase and other factors, our school finally chose to build step by step, and rationally purchase the laboratory construction principles of equipment. That is to say, first we should solve the problem of "yes or no", and choose the more advanced equipment if condition permits. Specifically speaking, the desktop printer (Seefun 3D) and the scanner (PowerScan-Std) are purchased and maintained at low cost with simple operation and high cost performance while satisfying the requirements of daily

teaching and innovation experiments. If students need higher precision printing, they can solve the problems through other ways, such as contacting outside laboratories or business printing.

C. Service Object: Cover whole School, mainly for Art Design

The service object of 3D printing laboratory is mainly for students in art and design major and covers teachers and students in the whole school. All kinds of ideas in the mind are transformed quickly and accurately into visible entity objects through the students' independent design model for better test and completion of design activity.

D. Management Model: Reservation Application, full Open Management

Open laboratory is an important measure for the reform of experimental teaching in colleges and universities, an effective platform to improve the teaching and scientific research level of teachers and to cultivate the ability of independent innovation of college students. [1] Open laboratory should not only be the opening of resources, time, space and personnel, but also the all round opening of experimental contents and teaching means [4]. Curriculum teaching, discipline competition, graduation design and so on need to use the 3D printing experiment creative project and the project team leader is responsible for writing and network reservation application. In the whole process of the experiment, the professional experiment teachers guide and supervise the students to carry out the experiment according to the regulations and to ensure the safety of students and instrument. After the experiment, the project group completes the project report.

E. Experiment Content: Independent Design and Integration of Theory and Practice

In order to make the students master the content of the module fully, the experiment course adopts the gradual setting, from the introduction of theory to familiarity of equipment and software, practical operation and completion of experiment [3], including the basic training module and the special practice module. The basic training modules include the overview of 3D printing technology and the independent design of 3D model printing practice. Professional practice is based on the needs of curriculum teaching, discipline competition and graduation design, and is proficient in completing 3D printing projects.

TABLE 3: INTRODUCTION OF EXPERIMENT CONTENT

Sequence No.		Experimental content	Requirement
1	Basic training	Overview of 3D printing technology	Master the basic theory of 3D scanning and 3D printing
2		Independent design of 3D model printing practice	Proficient in using 3D printer to print the self design model.
3	Professional practice	Course teaching, discipline competition, graduation design and other 3D printing practice	Skilled with 3D printing to complete thematic practice

IV. SUMMARY

It also needs to be groped in continuous teaching practice on how to integrate 3D printing with the existing

teaching system, to give a full play of 3D printing to a greater extent and to better cultivate students' creativity. The art design specialty laboratory teaching in colleges and universities should apply 3D printing technology

rationally, and actively cooperate with social enterprises in many fields of "production, learning and research", so as to promote the sustainable development of "production, learning and research" of the art design specialty.

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