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Curriculum for additive manufacturing competition

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Contents

Foreword

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Curriculum for additive manufacturing competition

1 Scope

This document specifies the basic requirements, safety regulations, assessment proportion, competition result evaluation and award setting of additive manufacturing skill contest, including but not limited to the resource requirements for personnel, site and equipment of additive manufacturing skill contest.
This document is applicable to the holding and organization of additive manufacturing skill contest.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
skilled talents
individuals who possess specialized knowledge and skills, have corresponding practical (internship) work experience, and are able to independently (or collaboratively) complete practical work tasks in production, service, and management frontline work

3.2
vocational ability
ability to solve comprehensive professional problems as a whole in real work situations is a necessary skill for people to engage in one or several similar professions, and is a combination of general and professional abilities

3.3
general ability
social and methodological abilities required for engaging in the corresponding profession include professional ethics, communication with others, cooperation with others, self-learning, problem-solving, information processing, digital application, foreign language application, innovation ability, management ability, etc

3.4
professional competence
ability of people to apply knowledge and skills to solve practical problems in a specific profession, including the grasp of work standards, the application of work methods, the use of labor tools, and the selection of labor materials

3.5
typical work tasks
comprehensive tasks with complete work processes and elements determined through expert interviews are of typical significance for engaging in a profession (job group) and serve as the basis for curriculum development in vocational colleges

3.6
representative work tasks
specific tasks of challenging positions that practical experts engage in during their career growth process, which can promote the development of their professional abilities

4 Curriculum overview

4.1 Typical work task description

There are three core areas in the additive manufacturing competition course: product 3D design and modeling, 3D scanning and reverse modeling, and 3D printing and post-processing. Typical work tasks are detailed in table 1-3.

Table 1 Typical tasks for product 3D design and modeling

<table>
<tr><td colspan="2">Typical work task name</td><td colspan="2">Product 3D design and modeling</td></tr>
<tr><td colspan="4">Typical work task description</td></tr>
<tr><td colspan="4">3D design and modeling is a technique for creating models with 3D data in virtual 3D space. It is a systematic process that integrates technological innovation and engineering implementation, with the core of building a data loop from concept to manufacturing. The process begins with precise analysis of customer requirements and the formation of guiding design specifications through technical feasibility analysis; Subsequently, based on the principles of ergonomics and aesthetics, multiple sketch simulations were completed to select the optimal design direction. In the modeling phase, a parameterized driving strategy is adopted to construct a three-dimensional digital twin with complete features, and finite element analysis is synchronously integrated for structural strength and motion simulation, balancing functional implementation and cost control. After iterative optimization, the model will be transformed into engineering drawings that strictly comply with ISO/GB standards, accurately define manufacturing tolerances and surface process requirements, and generate high simulation renderings and dynamic demonstrations through tools such as keyshot, providing visual support for decision review and market preheating. The entire process relies on the PLM system to achieve cross departmental collaboration and version traceability, ultimately achieving an organic unity of design data, process validation, and production practice, ensuring a multidimensional balance of product innovation, manufacturability, and commercial value.</td></tr>
<tr><td rowspan="5">1</td><td rowspan="5">Work object</td><td>Obtain task</td><td>Receive the task book
Obtain workflow
Communication with business departments</td></tr>
<tr><td>Prepare the plan</td><td>Determine work objectives
Content of analysis
Develop work steps
Prepare work plan
Submit to the business department for review and confirmation</td></tr>
<tr><td>Product Reverse Modeling</td><td>Receiving products
Prepare tools
Scan the product
Product model reconstruction and optimization</td></tr>
<tr><td>Model Quality Assessment</td><td>Check the integrity of the model
Detection model accuracy
Generate test report</td></tr>
<tr><td>Delivery and acceptance</td><td>Check model integrity and accuracy
Delivery by signature</td></tr>
<tr><td rowspan="5">2</td><td rowspan="5">Tools, materials, equipment and data</td><td>Obtain task links</td><td>Work task list, computer, 3D design modeling software user manual</td></tr>
<tr><td>Planning link</td><td>Work task list, office software</td></tr>
<tr><td>Product 3D design and modeling</td><td>Modeling software CAD, CAM, CAE, etc. and operation manuals</td></tr>
<tr><td>Model quality evaluation</td><td>Work task list, 3D design modeling software</td></tr>
<tr><td>Delivery and acceptance link</td><td>Work task list and acceptance list</td></tr>
</table>

Table 1 *(continued)*

Typical work task description			
3	Method of working	Obtaining task links	On-site communication method and literature search method
		Planning link	Gantt chart display method
		Product 3D design modeling link	Product design planning method, data collection, product concept design, modeling software setup and calibration, geometric modeling, product rendering and optimization
		Model quality evaluation	Point cloud comparison method, surface comparison method, etc
		Delivery acceptance link	Methods for delivery tasks such as standard filling of work records and sorting and filing of data documents
4	Work Requirements	Obtain the task link	Obtain the task according to the project process, read the reverse modeling task list, communicate with the department head, obtain the product 3D design processing software and model accuracy requirements and other information, and define the 3D design modeling contents and standards.
		Formulation of plan link	Retrieve and analyze similar 3D modeling cases of similar products, observe the product, analyze the product characteristics, determine the concept design and geometric design ideas, and formulate a reverse modeling work plan in combination with the task duration, and submit it to the department director for review and approval.
		Product 3D design modeling link	Determine the product design method and software according to the collected product characteristics; Set and express the software entry, use the software to create 3D modeling of the product, and optimize the 3D model according to the product requirements.
		Model quality evaluation	Check the completeness of the model by comparing the actual product; Compare the deviation between the detection model of the detection function and the real object by point cloud comparison method and curve surface comparison method, and issue the detection report; Modification andimprovement shall be carried out according to the inspection report to ensure that the model features are complete, and the dimensional deviation, roughness, form and position tolerance, etc. shall be controlled within the allowable range and meet the requirements of the work task list.
		Delivery and acceptance link	The delivered project data shall be complete, the model format shall meet the requirements, the test report data shall be accurate and the text shall be clear; Fill in satisfactory work records and summarize experience in reverse modeling.
		Professional quality requirements	Have general abilities such as communication with people, cooperation with people, information processing, autonomous learning and digital application; Have professional quality such as time consciousness, norm consciousness, efficiency consciousness, quality consciousness, discipline consciousness and confidentiality consciousness; With core values of dedication and hard-working spirit.

Table 1 *(continued)*

<table>
<tr><td colspan="3">Typical work task description</td></tr>
<tr><td>5</td><td>Labor organization mode</td><td>Three-dimensional design engineering personnel shall obtain the modeling task book from the department director, clarify the work content and relevant requirements after communicating with the department director, prepare the three-dimensional design modeling work plan, and submit it to the department director for review; Independently complete the 3D modeling of work piece according to the work schedule; Upon completion of the model quality evaluation, submit the model to the department head for review and improve the model according to his/her opinions; Promptly and normatively fill in relevant work records and submit project documents in specified manner.</td></tr>
</table>

<table>
<tr><td colspan="3">Representative work task</td></tr>
<tr><td>Task name</td><td>Task description</td><td>Time (hour)</td></tr>
<tr><td>Electrical enclosure modeling design</td><td>The design department of an electrical appliance enterprise has been tasked with the design of the electrical enclosure, which needs to optimize the design based on the similar electrical enclosure. Students shall communicate with teachers, analyze product data and structural characteristics, prepare equipment modeling tools and define product accuracy requirements after receiving work task list and similar products; Initially determine the modeling idea, formulate the product 3D modeling work plan based on the task duration, and submit it to the instructor for approval; The basic modeling methods such as stretching, array, fillet and shell extraction are used to design the product. The basic view, full sectional view, partial enlarged view, notes and notes of the product are drawn according to the specification requirements. After modeling, the integrity of the model is checked. The point cloud method, surface analysis method and other detection functions are used to detect the deviation between the model and the entity, and a detection report is issued. The dimensional parameters of the optimized features are trimmed according to the detection report to achieve the best design effect; Upon review by the trainer, the point engineering drawing, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. During the whole design process, aesthetics, functionality and practicality shall be comprehensively considered to ensure that the final product can meet the market demands and user expectations.
In the working process, the operator shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer data; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.</td><td>4</td></tr>
<tr><td>Bottom plate modeling design</td><td>The design department of an enterprise receives the design task of baseboard modeling, and needs to optimize the design based on the actual baseboard products. Students shall communicate with teachers, analyze product data and structural characteristics, prepare equipment modeling tools and define product accuracy requirements after receiving work task list and similar products; Comprehensively consider the engineering, aesthetic and functionality of the product, preliminarily determine the modeling idea, formulate the product 3D modeling work plan in combination with the task duration, and submit it to the instructor for review and approval; Draw the base plate foundation structure, on this basis, design the product with basic modeling methods such as stretching, array, fillet, shell extraction, etc. After the design is completed, it is also required to export and save the model according to the file format requirements, use the point cloud method,</td><td>4</td></tr>
</table>

Table 1 *(continued)*

Representative work task		
Task name	Task description	Time（hour）
Bottom plate modeling design	surface analysis method and other detection functions to check the deviation between the model and the entity, issue the detection report, and trim the optimized dimensional parameters according to the detection report to achieve the best design effect; Upon review by the trainer, the point engineering drawing, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. During the whole design process, aesthetics, functionality and practicality shall be comprehensively considered to ensure that the final product can meet the market demands and user expectations. In the working process, the operator shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer data; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	4
Plastic water cup modeling design	The design department of an enterprise receives the task of water cup design, which needs to optimize the design based on the actual water cup products. The students shall communicate with the teachers after receiving the task list and similar products, analyze the structural characteristics (curved surface) of the plastic water cup, prepare the equipment modeling tools, and define the accuracy requirements of the design water cup; Comprehensively consider the practicality and aesthetic characteristics of the product and carry out the conceptual design (taking into account the shape, size, decoration and other elements of the cup. The shape can be classic round, elegant square or individualized shapes. The size shall be determined according to the actual needs. Both the capacity of the cup and the comfort of holding shall be ensured. For decoration, such techniques as carving, painting and decal can be used to add unique artistic charm to the cup). The modeling idea shall be preliminarily determined, and the three-dimensional modeling work plan of the product shall be formulated in combination with the task duration. The product shall be designed with basic modeling technologies such as rotation, sweeping, rendering, mapping and sketch closure inspection. After the design is completed, the model shall be exported and saved according to the document format requirements. Point Cloud Method shall be used Surface analysis method and other detection functions detect the deviation between the model and the entity, issue a detection report, and trim and optimize the dimensional parameters of the feature according to the detection report to achieve the best design effect; Upon review by the trainer, the point engineering drawing, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. During the whole design process, aesthetics, functionality and practicality shall be comprehensively considered to ensure that the final product can meet the market demands and user expectations. In the working process, the operator shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer data; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	4
Pipe body modeling design	The design department of an enterprise receives the design task of pipe body, and needs to optimize the design on the basis of pipe products. Students shall communicate with teachers, analyze product data and structural characteristics, prepare equipment modeling tools, select appropriate 3D design software and define product accuracy requirements after receiving work task list and similar products; Initially determine the modeling idea, formulate the product 3D modeling work plan based on the task duration, and submit it to the instructor for approval; Design the product with basic operation model methods such as pipe, stretching,	4

Table 1 *(continued)*

Representative work task		
Task name	Task description	Time （hour）
Pipe body modeling design	hole, etc. Draw notes and notes on the full sectional view of the product according to the requirements of the specification. Check the completeness of the model after modeling. Detect the deviation between the model and the real body with point cloud method, surface analysis method, etc. and issue a test report. Trim and optimize the dimensional parameters of the characteristics according to the test report. Keep improving and adjust and optimize the details to ensure that the appearance and performance of the pipe body meet the design requirements. Upon review by the trainer, the point engineering drawing, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. During the whole design process, aesthetics, functionality and practicality shall be comprehensively considered to ensure that the final product can meet the market demands and user expectations. In the working process, the operator shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer data; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	4
Shape design of spiral shaft	The design department of an enterprise receives the design task of spiral shaft shape, and needs to optimize the design on the basis of spiral shaft products. Students shall communicate with teachers, analyze product data and structural characteristics, prepare equipment modeling tools, select appropriate 3D design software and define product accuracy requirements after receiving work task list and similar products; Initially determine the modeling idea, formulate the product 3D modeling work plan based on the task duration, and submit it to the instructor for approval; The product is designed by basic operation mode methods such as slewing, spiral, sweeping (pipe), hole and array. The annotation and annotation of the full sectional view of the product are drawn according to the specification requirements. The integrity of the model is checked after modeling. The deviation between the model and the entity is detected by point cloud method, surface analysis method and other detection functions. The detection report is issued. The dimensional parameters of the optimized features are trimmed according to the detection report. The details are adjusted and optimized to ensure that the appearance and performance of the pipe body meet the design requirements. The project data such as engineering drawings, 3D models and inspection reports shall be packaged and stored as required after being reviewed by the teachers, and the work log shall be filled as required. During the whole design process, aesthetics, functionality and practicality shall be comprehensively considered to ensure that the final product can meet the market demands and user expectations. In the working process, the operator shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer data; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	4
Bottle Styling	The design department of an enterprise receives the design task of bottle (blow molding parts) modeling, and needs to optimize the design on the basis of bottle products. Students shall communicate with teachers, analyze product data and structural characteristics, prepare equipment modeling tools, select appropriate 3D design software and define product accuracy requirements after receiving work task list and similar products; Initially determine the modeling idea, formulate the product 3D modeling work plan based on the task duration, and submit it to the instructor for approval; The product shall be designed by the basic operation methods such as curve, curve grid, bounded plane, sewing, etc., and the engineering drawing notes and notes such as full sectional view of the product shall be drawn according to the specification requirements.	

Table 1 *(continued)*

Representative work task		
Task name	Task description	Time (hour)
Bottle Styling	After the independent modeling, the integrity of the model shall be checked, the deviation between the model and the entity shall be detected by the point cloud method, curve analysis method, etc., and the test report shall be issued. The dimensional parameters of the optimized features shall be trimmed according to the test report, and the details shall be adjusted and optimized to ensure that the appearance and performance of the pipe body meet the design requirements. The project data such as engineering drawings, 3D models and inspection reports shall be packaged and stored as required after being reviewed by the teachers, and the work log shall be filled as required. During the whole design process, aesthetics, functionality and practicality shall be comprehensively considered to ensure that the final product can meet the market demands and user expectations. In the working process, the operator shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer data; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	4
Toy airplane shape	A toy manufacturing and design department was tasked with the design of airplane shape of toy, which needed to optimize the design on the basis of spiral shaft products. Students shall communicate with teachers, analyze product data and structural characteristics, prepare equipment modeling tools, select appropriate 3D design software and define product accuracy requirements after receiving work task list and similar products; Initially determine the modeling idea, formulate the product 3D modeling work plan based on the task duration, and submit it to the instructor for approval; The product is designed by using the basic operation methods such as N-side surface, sweeping surface along the guide line, surface rounding, fillet, shell extraction, etc., and the product annotation and annotation of engineering drawings such as full sectional view are drawn according to the specification requirements. After modeling, the integrity of the model is checked, and the deviation between the model and the entity is detected by point cloud method, surface analysis method and other detection functions, and a detection report is issued. The dimensional parameters of the optimized features are trimmed according to the detection report, and the details are adjusted and optimized to ensure that the appearance and performance of the pipe body meet the design requirements. Upon review by the trainer, the point engineering drawing, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. During the whole design process, aesthetics, functionality and practicality shall be comprehensively considered to ensure that the final product can meet the market demands and user expectations. In the working process, the operator shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer data; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	4
Outer cover shape (metal plate)	The design department of an enterprise receives the design task of the outer lid shape (metal plate), and needs to optimize the design on the basis of the metal plate outer lid shape products. Students shall communicate with teachers, analyze product data and structural characteristics, prepare equipment modeling tools, select appropriate 3D design software and define product accuracy requirements after receiving work task list and similar products; Initially determine the modeling idea, formulate the product 3D modeling work plan based on the task duration, and submit it to the instructor for approval; The basic drawing method of metal plate, especially the basic operation methods such as protruding block, bending	4

Table 1 *(continued)*

Representative work task		
Task name	Task description	Time (hour)
	edge, normal material removal, stretching and mirroring, shall be used to design the product. According to the specification requirements, the product shall be plotted with engineering drawing notes and notes such as full sectional view. After modeling, the integrity of the model shall be checked. The point cloud method, surface analysis method and other detection functions shall be used to detect the deviation between the model and the entity.The inspection report shall be issued. The dimensional parameters of the optimized features shall be trimmed according to the inspection report. The details shall be adjusted and optimized to ensure that the appearance and performance of the pipe body meet the design requirements. Upon review by the trainer, the point engineering drawing, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. During the whole design process, aesthetics, functionality and practicality shall be comprehensively considered to ensure that the final product can meet the market demands and user expectations. In the working process, the operator shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer data; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	
Modeling of chassis shell	The design department of a machinery manufacturing enterprise receives the design task of the chassis shell (metal plate), which needs to optimize the design on the basis of the metal plate outer cover molding products. Students shall communicate with teachers, analyze product data and structural characteristics, prepare equipment modeling tools, select appropriate 3D design software and define product accuracy requirements after receiving work task list and similar products; Initially determine the modeling idea, formulate the product 3D modeling work plan based on the task duration, and submit it to the instructor for approval; The basic drawing methods of sheet metal, especially the basic operation methods such as protruding block, bending edge, contour bending edge, bending, normal material removal, pit, solid punching, straightening, re-bending and mirroring, are used to design the product. According to the specification requirements, the engineering drawing notes and annotations such as full section view of the product are drawn. After modeling, the integrity of the model is checked. The point cloud method, curved surface analysis method and other detection functions are used to detect the deviation between the model and the entity. The detection report is issued. The dimensional parameters of the optimized features are trimmed according to the detection report. The fine sections are adjusted and optimized to ensure that the appearance and performance of the pipe body meet the design requirements. Upon review by the trainer, the point engineering drawing, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. During the whole design process, aesthetics, functionality and practicality shall be comprehensively considered to ensure that the final product can meet the market demands and user expectations. In the working process, the operator shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer data; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	4

Table 1 *(continued)*

Representative work task		
Task name	Task description	Time（hour）
Bottle opener mechanism design	The design department of a machinery manufacturing enterprise has been assigned the task of structural design of the bottle opener. It is necessary to optimize the design on the basis of getting familiar with the basic curriculum knowledge of mechanical design. Students shall communicate with teachers, analyze product data and structural characteristics, prepare equipment modeling tools, select appropriate 3D design software and define product accuracy requirements after receiving work task list and similar products; Initially determine the modeling idea, formulate the product 3D modeling work plan based on the task duration, and submit it to the instructor for approval; The basic drawing method of sheet metal, especially the basic operation methods of sudden stretching, stiffener, draft, hole, array, summation and difference, is used to design the product. According to the specification requirements, the engineering drawing notes and notes on the full sectional view of the product are drawn. After modeling, the integrity of the model is checked. The point cloud method, curved surface analysis method and other detection functions are used to detect the deviation between the model and the entity. The inspection report is issued. According to the inspection report, the dimensional parameters of the optimized features are trimmed, refined, and the details are adjusted and optimized to ensure that the appearance and performance of the pipe body meet the design requirements. Upon review by the trainer, the point engineering drawing, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. During the whole design process, aesthetics, functionality and practicality shall be comprehensively considered to ensure that the final product can meet the market demands and user expectations. In the working process, the operator shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer data; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	4
Lifting jack assembly design	The design department of a certain equipment manufacturing enterprise receives the task of jack assembly design, and needs to optimize the design of jack modeling products. Students shall communicate with teachers, analyze product data and structural characteristics, prepare equipment modeling tools, select appropriate 3D design software and define product accuracy requirements after receiving work task list and similar products; Initially determine the modeling idea, formulate the product 3D modeling work plan based on the task duration, and submit it to the instructor for approval; The product shall be designed by using the methods of component positioning, constraint tools and component array, and the engineering drawing annotation and annotation of the product such as full sectional view shall be drawn according to the specification requirements. After modeling, the integrity of the model shall be checked, and the deviation between the model and the entity shall be detected by using the point cloud method, curved surface analysis method and other detection functions, and the inspection report shall be issued. The dimensional parameters of the optimized characteristics shall be trimmed according to the inspection report, and the details shall be adjusted and optimized to ensure that the appearance and performance of the pipe body meet the design requirements. Upon review by the trainer, the point engineering drawing, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. During the whole design process, aesthetics, functionality and practicality shall be comprehensively considered to ensure that the final product can meet the market demands and user expectations. In the working process, the operator shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer data; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and	4

Table 1 *(continued)*

Representative work task		
Task name	Task description	Time (hour)
	comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	
Appearance design of intelligent home remote controller	The design department of a home manufacturing enterprise receives the design task of appearance and modeling of intelligent home remote controller, and needs to optimize the design of intelligent home remote controller products. Students shall communicate with teachers, analyze product data and structural characteristics, prepare equipment modeling tools, select appropriate 3D design software and define product accuracy requirements after receiving work task list and similar products; Initially determine the modeling idea, formulate the product 3D modeling work plan based on the task duration, and submit it to the instructor for approval; The basic drawing methods for 3D design of the product, especially the motion diagram of the mechanism, the determination of relative motion of the mechanism, the structural design according to the principle scheme of the mechanism, the integration structure design after the combination of several parts according to the characteristics of 3D printing and manufacturing process, the determination of the overall scheme according to the functional requirements of the product, the annotation and annotation of engineering drawings such as full sectional view of the product according to the requirements of the specification, the completeness of the model after the modeling is completed, the deviation between the model and the entity is detected by the point cloud method, the surface analysis method and other detection functions, the detection report is issued, the dimensional parameters of the optimized characteristics are trimmed according to the detection report, the details are adjusted and optimized to ensure that the appearance and performance of the pipe body meet the design requirements. Upon review by the trainer, the point engineering drawing, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. The whole design process needs to consider aesthetics, ergonomics and practicality comprehensively to ensure that the final product can meet the market needs and user expectations. In the working process, the operator shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer data; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	4
Remarks		48

Table 2 Typical tasks for 3D scanning and reverse modeling

Typical work task name	3D scan and reverse modeling
Typical work task description	
Three-dimensional scanning and reverse modeling are the process of acquiring the data of mechanical products with the help of three-dimensional scanners, processing the data with data processing software, and reconstruction of three-dimensional models of products with reverse modeling software. In case of absence of original product drawings, 3D scanning and reverse modeling technology can be used to transform the real product into 3D digital model for innovative design and 3D printing of the product, which is usually completed by the additive manufacturing equipment operator. The operator of additive manufacturing equipment shall communicate with the department director after receiving the work task list and product physical objects, obtain the data acquisition equipment, data processing	

Table 2 *(continued)*

<table>
<tr><td colspan="2">Typical work task name</td><td colspan="2">3D scan and reverse modeling</td></tr>
<tr><td colspan="4">Typical work task description</td></tr>
<tr><td colspan="4">software, reverse modeling software, model accuracy requirements and other information, and define the contents, tools and standards of reverse modeling; Retrieve and analyze reverse modeling cases of similar products, observe product objects, analyze product characteristics, determine data acquisition strategies and model reconstruction ideas, prepare reverse modeling work plans in combination with task duration, and submit to department heads for review and approval; Pretreatment shall be carried out for the product, the product surface shall be cleaned, and developer shall be applied if necessary; Calibrate and calibrate the 3D scanner, scan the real product and obtain point cloud data of the product; Use data processing software to process point cloud data such as noise filtering, smoothing, alignment, stitching, interpolation and point filling, and encapsulation; Using the processed scan data, use the reverse modeling software to reconstruct the three-dimensional model of the product; Check the completeness of the model, test the accuracy of the model, generate a test report, and perfect the model according to the test results; The project documents, such as point cloud data, reverse 3D model and inspection report, shall be packaged and stored according to the requirements after being reviewed by the department head and submitted in the specified way.
In the working process, the operator of additive manufacturing equipment shall conduct the data acquisition, data processing and model reconstruction of the product according to the relevant technical specifications and requirements. The established model shall have complete characteristics and the accuracy shall meet the customer's requirements: the data security and confidentiality system shall be observed to prevent the disclosure of customer data. The working process shall comply with the "6S" management specification, and the safety operation specification and the enterprise project data arrangement specification shall be strictly observed.</td></tr>
<tr><td rowspan="8">1</td><td rowspan="8">Work object</td><td>Obtain task</td><td>Receive the task book
Obtain workflow
Communication with business departments</td></tr>
<tr><td>Prepare the plan</td><td>Determine work objectives
Content of analysis
Develop work steps
Prepare work plan
Submit to the business department for review and confirmation</td></tr>
<tr><td>Product Reverse Modeling</td><td>Receiving products
Prepare tools
Scan Products
Product model restructuring</td></tr>
<tr><td rowspan="3">Type quality evaluation</td><td>Check the integrity of the model</td></tr>
<tr><td>Detection model accuracy</td></tr>
<tr><td>Generate test report</td></tr>
<tr><td rowspan="2">Delivery and acceptance</td><td>Check model integrity and accuracy</td></tr>
<tr><td>Delivery by signature</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Tools, materials, equipment, and materials</td><td>Task acquisition process</td><td>Work task list,3D scanner operation manual, reverse modeling software user manual</td></tr>
<tr><td>Planning process</td><td>Work task list, office software</td></tr>
<tr><td>Product reverse modeling</td><td>Physical product, 3D scanner, graphics workstation, marker points, developer,</td></tr>
</table>

Table 2 *(continued)*

Typical work task description			
2	Tools, materials, equipment, and materials		reverse modeling software, 3D scanner operation manual, reverse modeling software user manual
		Model quality assessment	Work task list, reverse modeling software
		Delivery and acceptance process	Work task list, acceptance form
3	Working methods	Task acquisition process	On-site communication method, literature search method
		Planning process	Gantt chart display method
		Product reverse modeling process	Scanning preprocessing methods such as cleaning and pasting, product scanning methods such as overall scanning and local scanning, scanning data processing methods such as noise filtering and packaging, optimization and repair methods for patch models such as filling holes and removing features, model alignment methods such as 3-2-1 alignment and X-Y-Z alignment, feature and constraint based model reconstruction methods
		Model quality assessment process	Methods for checking model quality, such as 2D dimension comparison and body deviation inspection
		Delivery and acceptance process	Methods for completing work record specifications and organizing and archiving data files for delivery tasks
4	Job requirements	Task acquisition process	Obtain tasks according to the project process, read the reverse modeling task sheet, communicate with department supervisors, obtain information on data collection equipment, data processing software, reverse modeling software, and model accuracy requirements, and clarify the content and standards of reverse modeling.
		Planning process	Retrieve and analyze reverse modeling cases of similar products, observe the physical product, analyze product features, determine data collection strategies and model reconstruction ideas, develop a reverse modeling work plan based on the task schedule, and submit it to the department head for review and approval.
		Product reverse modeling stage	Based on the surface characteristics of the product, the surface of the product is cleaned and pre treated with stickers; According to the operating specifications of the 3D scanner, after calibrating and calibrating the 3D scanner, the actual product is scanned to obtain point cloud data of the product; Perform data processing such as noise filtering, smoothing, alignment, stitching, interpolation, and encapsulation on point cloud data to ensure the accuracy and smoothness of scanned data; Using product scanning data, a feature and constraint based reconstruction method is adopted to reconstruct the 3D model of the product. The model features are complete and the parameters can be edited to meet the requirements of secondary design.
		Model quality assessment stage	Compare the physical product and check the integrity of the model; Use the comparative detection function to detect the deviation between the model and the scanned data, and issue a detection report; According to the testing report, make modifications and improvements to ensure the completeness of model features,

Table 2 *(continued)*

<table>
<tr><td colspan="4">Typical work task description</td></tr>
<tr><td rowspan="3">4</td><td rowspan="3">Job requirements</td><td></td><td>control deviations within the allowable range, and meet the requirements of the work task order.</td></tr>
<tr><td>Delivery acceptance stage</td><td>The delivered project materials are complete in content, the model format meets the requirements, the testing report data is accurate, and the text expression is clear; Standardize the filling of work records that meet the requirements, and summarize the experience of reverse modeling work.</td></tr>
<tr><td>Professional ethics requirements</td><td>possess general abilities such as communication, collaboration, information processing, self-learning, and digital applications; Having professional qualities such as time awareness, standardization awareness, efficiency awareness, quality awareness, discipline awareness, and confidentiality awareness; Having the core values of love for work and dedication, as well as the spirit of hard work and perseverance.</td></tr>
<tr><td>5</td><td colspan="2">Labor organization mode</td><td>The operator of additive manufacturing equipmentreceives a modeling task book from the department head, communicates with the department head to clarify the work content and relevant requirements, develops a reverse modeling work plan, and submits it to the department head for review; Independently complete the scanning and reverse modeling of workpieces according to the work plan schedule; After completing the model quality assessment, submit it to the department head for review and improve the model based on their opinions; Timely and standardized completion of relevant work records, and submission of project documents in the designated manner.</td></tr>
</table>

<table>
<tr><td colspan="3">Representative work task</td></tr>
<tr><td>Task name</td><td>Task description</td><td>Time（hour）</td></tr>
<tr><td>Reverse design of rotary products</td><td>The design department of an enterprise receives the design task of a shaft sleeve and needs to carry out the secondary design on the basis of a certain shaft sleeve. It is required to complete the reverse modeling of the shaft sleeve within 4 class hours for the secondary design of the product. The main body of the shaft sleeve is a cylinder with a center hole and other structures. The students shall communicate with the teachers after receiving the work task list and product objects, and define the modeling tools and accuracy requirements of the data acquisition equipment; Analyze the structure of shaft sleeve, determine the strategy of data acquisition and the idea of model reconstruction, formulate the work plan of reverse modeling based on the task duration, and submit it to the instructor for approval; Pre-treatment of the surface of the shaft sleeve, scanning with a 3D scanner, acquiring point cloud data of the shaft sleeve, and optimizing and packaging the data; Create a cylindrical section using the rotating solids function of Reverse Modeling software; Use the stretching feature command to complete the construction of the shaft sleeve; Check the completeness of the model, detect the deviation between the model and the scanning data with the contrastive detection function, issue the detection report, and trim the dimensional parameters of the feature according to the detection report; Upon the review by the teacher, the point cloud data, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required.
In the working process, students shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer information; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations,</td><td>4</td></tr>
</table>

Table 2 *(continued)*

Representative work task		
Task name	Task description	Time (hour)
	and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	
Reverse design of disk and jacket products	The design department of an enterprise receives the design task of a product cup bottom and needs to carry out secondary design on the basis of a product cup bottom. It is required to complete the reverse modeling of the product cup bottom within 6 class hours for the secondary design of the product. The main body of the product cup bottom is a hemisphere with a center hole and other structures. The students shall communicate with the teachers after receiving the work task list and product objects, and define the modeling tools and accuracy requirements of the data acquisition equipment; Analyze the structure of the product cup bottom, determine the data acquisition strategy and model reconstruction idea, formulate the reverse modeling work plan in combination with the task duration, and submit it to the instructor for approval; Scanning the product cup bottom surface with a three-dimensional scanner after pre-treatment, acquiring the product cup bottom point cloud data, and optimizing and packaging the data; Use the rotating entity function of Reverse Modeling Software to create a hemispherical part; Use the stretching feature command to complete the construction of the product cup bottom; Check the completeness of the model, detect the deviation between the model and the scanning data with the contrastive detection function, issue the detection report, and trim the dimensional parameters of the feature according to the detection report; Upon the review by the teacher, the point cloud data, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. In the working process, students shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer information; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	6
Reverse design of box and shell products	The design department of an enterprise receives the design task of a product headlight and needs to carry out the secondary design on the basis of a certain headlight. It is required to complete the reverse modeling of the headlight within 8 class hours for the secondary design of the product. The main body of the headlights is rectangular, with waist holes and other structures. The students shall communicate with the teachers after receiving the work task list and product objects, and define the modeling tools and accuracy requirements of the data acquisition equipment; Analyze the headlight structure, determine the data acquisition strategy and model reconstruction idea, formulate the reverse modeling work plan in combination with the task duration, and submit it to the instructor for review; Carrying out pre-treatment on the headlight surface, scanning the headlight surface with a three-dimensional scanner, acquiring headlight point cloud data, and optimizing and packaging the headlight surface; Use the reverse modeling software to complete the construction of headlights with stretch and other feature commands; Check the completeness of the model, detect the deviation between the model and the scanning data with the contrastive detection function, issue the detection report, and trim the dimensional parameters of the feature according to the detection report; Upon the review by the teacher, the point cloud data, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. In the working process, students shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer information; The working process	8

Table 2 *(continued)*

Representative work task		
Task name	task description	Time （hour）
	shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	
Reverse design of curved surface products	The design department of an enterprise receives the design task of a connecting base of a product, and needs to carry out secondary design on the basis of a certain connecting base. It is required to complete the reverse modeling of the connecting base within 8 class hours for the secondary design of the product. The main body of the connecting base is a cube, with structures such as ellipse and curved surface. The students shall communicate with the teachers after receiving the work task list and product objects, and define the modeling tools and accuracy requirements of the data acquisition equipment; Analyze the headlight structure, determine the data acquisition strategy and model reconstruction idea, formulate the reverse modeling work plan in combination with the task duration, and submit it to the instructor for review; Pre-processing the surface of the coupling base, scanning it with a three-dimensional scanner, acquiring point cloud data of the coupling base, and optimizing and packaging the data; Use the reverse modeling software to complete the construction of the connection base by using the commands such as stretching feature and face piece fitting;Check the completeness of the model, detect the deviation between the model and the scanning data with the contrastive detection function, issue the detection report, and trim the dimensional parameters of the feature according to the detection report; Upon the review by the teacher, the point cloud data, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. In the working process, students shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer information; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	8
Reverse design of blade products	The design department of an enterprise has been assigned the design task of turbine blades, and needs to carry out secondary design on the basis of a certain turbine blade. It is required to complete the reverse modeling of the turbine blade within 10 class hours for the secondary design of the product. The main body of turbine blade is composed of rotating shaft and blade. The main body of rotating shaft is a cylinder with hollow inside and central hole; Blades are of curved sheet structure and evenly distributed on the outer cylindrical surface of rotating shaft; Turbine blades are made of metal. The students shall communicate with the teachers after receiving the work task list and product objects, and define the modeling tools and accuracy requirements of the data acquisition equipment; Analyze the structure of the blade, determine the data acquisition strategy and the model reconstruction idea, formulate the reverse modeling work plan in combination with the task duration, and submit it to the instructor for review; A 3D scanner is used to scan the surface of a turbine blade after pre-treatment, obtain point cloud data of the turbine blade, and optimize and encapsulate the data; Create a rotating axis section using the Patch Sketch and rotating entity functions of reverse modeling software; Build the blade section using stretch feature, patch fit, circular array commands; Use the cutting function to cut the redundant part of the feature and complete the construction of the turbine blade; Check the completeness of the model, detect the deviation between the model and the scanning data with the contrastive detection function, issue the detection report, and trim the dimensional parameters of the feature according to the detection report; Upon the review by the teacher, the point cloud data, 3D model,	10

Table 2 *(continued)*

Representative work task		
Task name	task description	Time (hour)
	inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. In the working process, students shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer information; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	
Reverse design of comprehensive assembly product	The design department of an enterprise receives the design task of a fire gun and needs to carry out the secondary design on the basis of a fire gun. It is required to complete the reverse modeling of the fire gun within 12 class hours for the secondary design of the product. The main body of the firing gun consists of curved surfaces and is made of metal. The students shall communicate with the teachers after receiving the work task list and product objects, and define the modeling tools and accuracy requirements of the data acquisition equipment; Analyze the structure of the firing gun, determine the strategy of data acquisition and the idea of model reconstruction, formulate the work plan of reverse modeling in combination with the task duration, and submit it to the instructor for approval; Pretreatment of the surface of the firing gun, scanning the surface with a three-dimensional scanner, acquiring point cloud data of the firing gun, and optimizing andpackaging the data; Create a rotating axis section using the Patch Sketch and rotating entity functions of Reverse Modeling Software; Constructing a curved surface part by using stretching features, patch fitting and circular array commands; Use the cutting function to cut the redundant part of the feature and complete the construction of the firing gun; Check the completeness of the model, detect the deviation between the model and the scanning data with the contrastive detection function, issue the detection report, and trim the dimensional parameters of the feature according to the detection report; Upon the review by the teacher, the point cloud data, 3D model, inspection report and other project data shall be packaged and stored as required, and the work log shall be filled as required. In the working process, students shall strictly implement the relevant standards and abide by the data security and confidentiality system to prevent the disclosure of customer information; The working process shall comply with the "6S" management specification, strictly comply with the safety operation regulations, and comply with the project data arrangement specifications such as document preparation, document storage mode and data archiving.	12
Total		48

Table 3 Typical tasks for 3D printing and post-processing

Typical work task name	Product 3D design and modeling
Typical work task description	
Post 3D printing processing refers to a series of processing and improvement measures for the model after printing. These steps are intended to remove print marks, improve surface finish, enhance physical properties, or achieve specific visual effects. Proper post-processing allows the printout to move from prototype to finished product to meet final use or presentation requirements. Post-processing of 3D printing is not only a necessary link to improve model quality, but also an important part of creative expression. From simple cleaning and polishing to complex finishes and enhanced functionality, every step offers endless	

Table 3 *(continued)*

<table>
<tr><th colspan="4">Typical work task description</th></tr>
<tr><td colspan="4">possibilities. Even the most basic 3D printing models can shine like industrial products through meticulous post-processing. With these skills, the application boundary of 3D printing will be greatly expanded, and the path of exploring more creative and practical values will be opened.
Operators shall focus on printing and post-processing procedures, including model preparation, slice processing, printing, post-processing and other steps. The 3D printing process consists of exporting the model to a format suitable for the slicing software and adjusting various printing parameters in the slicing software and generating slice files for each layer (G code); When ready, the file is uploaded to a 3D printer, which heats the printed material melt from the heating coil and then deposits the material layer by layer through the nozzle along the specified path until the entire model is completed; Then take down the printed model for corresponding post-processing.
The operator receives the task book (including configuration sheet) from the business department, carries out modeling by himself or obtains modeling documents from various channels, formulates relevant work plans according to the requirements of the task book, receives relevant data and accessories, prepares 3D printers and tools, prints the specified products according to the work plan and work process, and conducts post-processing; Check and confirm the handling effect and then deliver it to the business department for acceptance.</td></tr>
<tr><td rowspan="11">1</td><td rowspan="11">Work object</td><td>Take out printed items</td><td>Ensure printing is completed
Remove the model</td></tr>
<tr><td>Simple post-processing</td><td>Remove the supporting structure
Cleaning and treatment</td></tr>
<tr><td>Fine post-treatment</td><td>Finishing and polishing;
Hole filling and repair;
Surface polishing
Painting</td></tr>
<tr><td>Obtain model file</td><td>-</td></tr>
<tr><td>Slice processing</td><td>Slicing software selection
Model import slice software
Select appropriate printing parameters
Export G code</td></tr>
<tr><td>Print out</td><td>Commissioning of printer and disposal of consumables
Import G code and start printing</td></tr>
<tr><td>Take out printed items</td><td>Ensure printing is completed
Remove the model</td></tr>
<tr><td>Simple post-processing</td><td>Remove the supporting structure
Cleaning and treatment</td></tr>
<tr><td>Fine post-treatment</td><td>Finishing and polishing
Hole filling and repair
Surface polishing
Painting</td></tr>
<tr><td>Delivery and acceptance</td><td>-</td></tr>
</table>

Table 3 *(continued)*

Typical work task description			
2	Tools, materials, equipment and data	Obtain model file	Model file, etc
		Slicing processing	Workstations, slicing software and other tools; Printing parameter settings, printing items, consumable types of supporting structures and other data and materials
		Printing	Tools such as 3D printer; D printing consumables, USB flash disk, solid adhesive and other materials; D printer instructions, consumable warpage rate and other data
		Post-treatment process	Scraper knife, scissors, small tool knife, cutter, sand paper (150-220 meshes), sand paper (400-600 meshes), sand paper (600-2000 meshes) and other tools; Protective equipment, 50-60 ℃ warm water, ethanol or isopropyl alcohol, filling glue or putty, polishing paste, polishing cloth, painting or painting materials; Polishing machine, spray gun or paint brush, grinding machine and other equipment
		Delivery acceptance	Assignment book, acceptance sheet, etc
3	Working method	Obtaining model documents	Data retrieval method, modeling
		Slice processing	Data retrieval method
		Printing	Observation method
		Post-treatment process	Observation method and cleaning method
		Delivery acceptance	Observation method
4	Work requirements	Obtain model file	Conduct modeling by yourself or obtain model file from various channels
		Slicing processing	Select the slicing software, set appropriate slicing parameters in the slicing software, and define the consumables used
		Printing	Determine whether to use solid adhesive according to the material warpage rate
		Post-treatment process	Skillfully remove the supporting structure, skillfully polish, fill, polishand paint the process
		Delivery acceptance	Confirm the handling effect and deliver for acceptance
5	Labor organization mode		It shall be carried out in an independent manner by cutting and printing the model documents, removing the supporting structure, cleaning, finishing and sanding, filling, surface polishing, painting and painting steps after taking out the printed items, and finally delivering for acceptance.

Table 3 *(continued)*

Representative work task		
Task name	Task description	Time (hours)
Preparation before printing and printing of articles	Self-modeling or obtaining modeling documents from online model library. Select slice software, import modeling file, adjust appropriate slice parameters and export slice as G code. Select 3D printer and consumables. After the consumables are smoothly loaded and unloaded, import the G code into the 3D printer via SD card, USB or wireless network. After the printer is leveled and preheated, start printing.	50
Take out the printed items and cleaned	Confirm that printing has been completed, and then remove the printed items from the printing platform after the printing items and the printing platform have cooled down. When removing the model, wear gloves, manually remove the support structure that is easy to remove, and then carefully remove the complex part with corresponding tools to avoid damaging the printing surface. If a water soluble support material is used, the printout can be immersed in water at a temperature of 50-60 ° C, waiting for the support structure to dissolve. For ethanol soluble materials, ethanol or isopropyl alcohol may be used for cleaning.	50
Printing surface treatment and delivery acceptance	Rough sanding: Use coarse abrasive paper (150-220 meshes) to initially polish the printing surface Fine grinding: Use fine sand paper (400-600 meshes) for further grinding to remove surface potholes. Grinding tools: The grinding machine can be used to speed up the grinding process, but it shall be operated carefully to avoid excessive wear. For surface imperfections or inter-layer gaps, large voids and small potholes may be filled with filler and the polished surface ground. Paint as required. Thoroughly inspect prints for surface and structure to ensure no omissions and defects. Deliver the printed copy to the receiver.	220
Remarks		320

4.2 Curriculum orientation

Product 3D design and modeling, 3D scanning and reverse modeling, 3D printing and post-processing are the core foundational courses in the talent development process of the additive manufacturing competition in the BRICS Skills Competition, aiming to cultivate the following abilities of students:

a) Professional ethics of loving and dedicating oneself to one's job, and daring to innovate;
b) Proficient in operating mainstream 3D scanning equipment and related software, proficient in calibration methods and parameter settings of common 3D scanning equipment, able to use professional software to process and optimize scanning data, and generate accurate digital models;
c) Master common reverse engineering software and be able to reconstruct CAD models from scanned data;
d) Ability to use 3D scanning technology and reverse modeling technology to solve practical engineering and design problems;
e) Learn commonly used modeling software, master its basic operations, especially the methods and skills of curve and surface modeling, and create realistic product renderings;
f) Understand the basic concepts of common 3D printing processes (FDM, photopolymerization, and metal printing), proficiently master the use of various process flows and typical equipment, and cultivate students' ability to combine theory and practice to solve practical problems.

Through this course, students will master the technical skills of modern intelligent devices, meet the requirements of the BRICS Skills Competition for additive manufacturing, and obtain the skills passport of BRICS countries.

They will also cultivate highly skilled talents in the international and comprehensive additive manufacturing industry.

5 Curriculum objectives

5.1 Knowledge objectives

5.1.1 Product 3D design and modeling

The knowledge objectives are as follows.

a) Master the basic 3D software modeling theory and common skills;
b) Master relevant modeling methods and commands;
c) Master modeling methods and skills of common products;
d) Master common assembly modeling methods and specifications;
e) Master the drawing method of engineering drawing;
f) Master the relevant knowledge of part structure design, 3D printing integrated structure design;
g) Master relevant knowledge of ergonomics;
h) Master relevant knowledge of product aesthetic design;
I) Understand optimization and post-processing techniques for digital models, including model repair, refinement and optimization, and conversion and export of geometric data;
j) Master the manufacturing process, materials, mechanics, electronics and other relevant knowledge involved in digital design and manufacturing process.

5.1.2 3D scan and reverse modeling

The knowledge objectives are as follows.

a) Understand the basic principles of different types of 3D scanning technologies and their application in industrial design, digital entertainment, cultural heritage protection, etc;
b) Master the key steps of 3D data acquisition, including setting of scanning equipment, scanning path planning and data processing technologies, such as point cloud processing, surface reconstruction and texture mapping;
c) Understand optimization and post-processing techniques for digital models, including model fixes, refinement and optimization, and conversion and export of geometric data;
d) Be familiar with the basic concept of reverse engineering, and be able to analyze and understand the ideas and methods of how to reconstruct CAD models by scanning data;
e) Get familiar with the cutting-edge application and future development trend of 3D scanning technology in digital art, virtual reality and medical field.

5.1.3 3D printing and post processing

The knowledge objectives are as follows.

a) Grasp the fundamental principles and workflow of fused deposition modeling (FDM) technology;
b) Master the process flow and operation methods of post-treatment of photocuring molding;
c) Master the process operation and post-treatment process of typical metal printer;
d) Master the post-treatment materials and tools: be familiar with the materials (such as sandpaper, painting, adhesive) and tools (such as grinding machine and hot air gun) commonly used in the post-treatment of various process printouts;
e) Skillfully master the post-processing of printed samples by using post-processing tools correctly;
f) Learn about various after-treatment processes (such as grinding, painting, bonding, filling, etc.) and their application and precautions;
g) Master how to check the post-treatment quality, including surface smoothness, color uniformity and strength.

5.2 Skill objectives

The skill objectives are as follows.

a) Skilled in basic knowledge and modeling methods of 3D modeling;
b) Be able to operate 3D software to complete solid modeling, surface modeling and assembly modeling;
c) Capable of operating 3D software processing engineering drawings and assembly drawings;
d) Capable of 3D modeling of general products, drawing engineering drawings and making animation

simulation of products; The general dimensions and tolerances, geometric dimensions and tolerances in accordance with ISO standards shall be adopted;

e) Draw the motion diagram of the mechanism and judge whether the mechanism has a determined relative motion; The overall scheme can be determined according to the functional requirements of the product;

f) Capable of interpreting technical specifications related to industrial design; Be able to design the mechanism structure according to the principle scheme of the mechanism; Integrated structure design after combination of several parts according to 3D printing manufacturing process characteristics;

g) Be able to use ergonomics, aesthetics and other relevant knowledge to design the appearance of the product;

h) Grinding and polishing skills: students can independently grind and polish the surface of printed parts to improve the surface finish of parts;

I) Spraying and coloring skills: master the spraying process, be able to uniformly color the printed parts and handle the complex surface details;

j) Jointing and Filling Techniques: Learn to repair and bond prints with adhesives and fillers to improve practical capabilities through example operations;

k) Removal of support and cleaning method: master the basic method for removal of support structure and cleaning to ensure that the surface quality is not damaged;

l) Skilled with mainstream 3D scanning equipment and relevant software, capable of accurate scanning and data acquisition of complex shapes;

m) Master the calibration methods and parameter settings of common 3D scanning equipment to ensure high-quality scanning data;

n) Capable of processing and optimizing scan data with professional software to generate accurate digital models;

o) Master common reverse engineering software, and be able to reconstruct CAD model for scanned data;

p) Capable of solving practical engineering and design problems using 3D scanning and reverse modeling techniques.

5.3 Standard of accomplishment

The standard of accomplishment are as follows.

a) Safety and environmental protection awareness: Get familiar with the safety specifications and environmental protection requirements of relevant operations, use protective equipment and meet the environmental protection standards;

b) Quality awareness: establish high standard quality awareness, pursue the perfection of post-treatment effect and effectively improve the quality of finished products;

c) Innovation awareness: develop the ability to analyze complex problems and independently propose innovative solutions;

d) Teamwork awareness: have good teamwork and communication abilities, and can effectively cooperate with the team to realize the collaborative work of the project;

e) Work style: dedication, hard-working, hard-working, practical, down-to-earth and dedication;

f) Workmanship: develop the craftsman spirit of persistence, focus, excellence, carefulness and pursuit of excellence;

g) Persistence consciousness: cultivate the habit of continuous learning and open attitude to new technologies and methods, and be able to adapt to and deal with technical development and industry change.

6 Curriculum content

6.1 Theory of knowledge

6.1.1 Product 3D design and modeling

The theory of knowledge are as follows.

a) Basic principles, knowledge and methods of mechanical drawing and computer drawing;

b) Usage methods and skills of common digital modeling software;

c) Knowledge of tolerance fit;

d) Software operation method for engineering drawing production;

e) Knowledge of mechanical transmission type, principle and application; Mechanical structure design

knowledge 3D printing integrated structure design knowledge;
f) Knowledge of ergonomics;
g) Knowledge of product aesthetic design;
h) Technical specifications for mechanical process product assembly and relevant knowledge of 3D assembly drawing drawing and animation simulation;
I) Understand optimization and post-processing techniques for digital models, including model repair, refinement and optimization, and conversion and export of geometric data;
j) Manufacturing process, materials, mechanics, electronics and other relevant knowledge involved in digital design and manufacturing process.

6.1.2 3D scanning and reverse modeling

The theory of knowledge are as follows.
a) Calibration method of 3D scanner;
b) Method of pretreatment before scanning different types of scanned parts;
c) Parameter setting and scanning method of 3D scanning equipment;
d) Scanning point cloud fata processing and ,model packaging method;
e) Application scenario of 3D scanner;
f) Scanning data acquisition method of multi-feature forming part;
g) Splicing method of forward and reverse scanning data;
h) Methods to cure scan data;
i) Reverse modeling method for scan data;
j) Reverse modeling methods for various solid models.

6.1.3 3D printing and post-processing

The theory of knowledge are as follows.
a) FDM process:
   1) Basic concepts and steps;
   2) Equipment and tools;
   3) Safety knowledge;
   4) Environmental protection;
   5) Quality supervision.
b) Light curing molding:
   1) Technical principles and concepts;
   2) Characteristics of photosensitive resin;
   3) Preparation before printing: model design, slice and resin preparation;
   4) Setting of printer;
   5) Printing process management: printing operation, supporting treatment of parts and post-treatment of parts: removing supporting structure, cleaning and curing, polishing and finishing.
c) Metal printing process.
   1) Operation process of metal machine;
   2) Metal machining environment preparation;
   3) Part data addition technology;
   4) Operating procedures for starting machining of metal machine;
   5) Take out the parts after processing;
   6) Powder treatment technology after metal machine forming;
   7) Post-treatment process of metal machine.

6.2 Skill practice

6.2.1 Product 3D design and modeling

See Table 4 .

Table 4 List of learning tasks for product 3D design and modeling

No.	Learning task name	Teaching hour	Learning target	Skill point
1	Electrical enclosure modeling design	4	Master the basic modeling methods such as stretching, array, fillet and shell extraction Master engineering drawing methods such as basic view, full section view, partial enlarged view, annotation and annotation Have the ability to modify the parameters of the optimized model Capable of issuing basic engineering drawings Be rigorous and careful, and do not omit the dimensions required for drawing and marking of parts	Basic modeling methods such as stretching, array, fillet and shell extraction Drawing and identification of engineering drawings Notes and notes of engineering drawings Modification and optimization of model parameters Rigorous and careful working attitude
2	Bottom plate modeling design	4	Master the operation methods of stretching, shell extraction, tolerance and hole Master basic view, full section view, annotation and other drawing methods Capable of modeling with features such as stretch, redundancy, tolerance, and holes Capable of producing full sectional view and annotation	Methods for operating features such as stretching, shell extraction, difference calculation, and holes Basic view, full section view, annotation and other drafting methods Characteristics of methods for modeling features such as stretching, redundancy, differentiation, and holes Annotation of Full Sectional View
3	Plastic water cup modeling design	4	Master the operation methods of slewing, sweeping, replacement surface, summation and other characteristics Master basic view, semi-sectional view, partial sectional view, annotation and other drawing methods Capable of modeling with features such as slew, sweep, replacement surfaces, summation, etc Capable of producing half sectional view, partial sectional view and annotation	Method of operation for features such as slew, sweep, replacement surfaces, summation, etc Drawing methods such as basic view, semi-sectional view, partial sectional view and annotation Issuance and annotation of semi-sectional view and partial sectional view
4	Pipe body modeling design	4	Master the operation methods of pipeline, stretching, hole and other characteristics Master the plotting methods of basic view and full section view Have the ability to use pipe, stretching, hole and other special Product 3D modeling Capable of full sectional view and annotation	Operation methods for features such as pipes, stretching, and holes Drawing method of basic view and full section view Ability to create 3D models of products Issuance and annotation of full sectional view

Table 4 *(continued)*

No.	Learning task name	Teaching hour	Learning target	skill point
5	Spiral shaft design	4	Master the operation methods of features such as rotation, spiral, sweep, hole, and array Master the drafting methods of partial view and partial enlarged view The ability to model using features such as rotation, spiral, sweep, hole, and array	Operation methods for features such as rotation, spiral, sweep, hole, array, etc Drawing methods such as partial views and partial enlarged views It is capable of producing and annotating full section views
6	Bottle shape	4	Ability to use the edit curve command. The ability to use surface modeling commands such as N-sided surfaces and sweeping along guide lines The ability to use features such as face rounding, fillet, and shelling With the ability to independently produce engineering drawings Ability to self-review and check drawings	Operations of N-sided surface, sweeping along the guide line and other surface modeling commands Operations for features such as face rounding, fillet, and shelling Issue engineering drawings and standards independently Self-review and check of drawings
7	Toy plane modeling	4	Master the operation methods of curves, curve grids, bounded planes, stitching, and other features Have the ability to model using features such as curves, curve grids, bounded planes, and stitching Have the ability to independently produce engineering drawings Ability to self-review and check drawings	Operation methods for features such as curves, curve grids, bounded planes, and stitching Utilize features such as curves, curve grids, bounded planes, and stitching for modeling Issue engineering drawings and standards independently Self-review and check of drawings
8	Outer cover design	4	Master the operation methods of prominent blocks, bending edges, normal material removal,mirroring, and other features Master the basic drawing methods of sheet metal parts The ability to draw sheet metal parts using features such as protruding blocks, bending, normal material removal, stretching, and mirroring Have a rigorous and meticulous attitude, and do not miss the dimensions required for part marking	The operation methods for highlighting blocks, bending edges, normal material removal, mirroring, and other features Basic drawing methods for sheet metal parts Sketching techniques for sheet metal parts, highlighting features such as blocks, bending, normal material removal, stretching, and mirroring Have a rigorous and meticulous attitude, and do not miss the dimensions required for part marking

Table 4 *(continued)*

No.	Learning task name	Teaching hour	Learning target	skill point
9	Chassis shell modeling	4	Master the operation methods of protruding block, bending, contour bending, bending, normal material removal, pit, solid stamping, straightening, re-bending, mirroring and other features Master the basic drawing methods of sheet metal parts The ability to draw sheet metal parts using features such as protruding blocks, flanging, contours, bending, normal material removal, pits, solid stamping, straightening, re-bending, mirroring, etc Have the ability to self-review and check drawings	Master the operation methods of prominent blocks, bending edges, contour bending edges, bending, normal material removal, pits, solid stamping, straightening, re-bending, mirroring and other features Basic drawing methods for sheet metal parts The ability to draw sheet metal parts using features such as protruding blocks, flanging, contours, bending, normal material removal, pits, solid stamping, straightening, re-bending, mirroring, etc Self-review and check of drawings
10	Bottle opener mechanism design	4	Be able to draw the motion diagram of the mechanism; Determining that the mechanism has a determined relative motion Be able to design the structure according to the principle scheme of the mechanism Be able to carry out the integrated structure design after the combination of several parts according to the characteristics of 3D printing manufacturing process Be able to determine the overall plan according to the functional requirements of the product. Have the ability to review and check drawings by themselves	Ability to draw the motion diagram of the mechanism Evaluate the design organization's ability to move Integrated design capability of product function and structure Self-review and check of drawings
11	Jack-type assembly design	4	Master the methods of assembly part positioning, constraint tools and assembly array Have the ability to correctly assemble parts Be able to use assembly constraint tools Capable of applying component array	Methods for positioning and restraining tools and assembly assembly components Assembly methods and skills of parts Assembly constraint of tools,capability of application component array

Table 4 (continued)

No.	Learning task name	Teaching hour	Learning target	skill point
12	Appearance design of intelligent home remote controller	4	Be able to draw the motion diagram of the mechanism; Be able to judge that the mechanism has a definite relative motion and carry out structural design according to the principle scheme of the mechanism Be able to carry out the integrated structure design after the combination of several parts according to the characteristics of 3D printing manufacturing process Be able to use ergonomics, aesthetics and other relevant knowledge to design the appearance of the product Be able to produce animation simulation of products	Product 3D modeling design method Basic principle and method of internal structure design Basic principle and method of motion design of product transmission mechanism View expression of the overall assembly structure design of the mechanism
	Remarks	48		

6.2.2 3D scanning and reverse modeling

See Table 5 .

Table 5 List of learning tasks for3D scanning and reverse modeling

No.	Learning task name	Teaching hour	Learning target	Skill point
1	Data acquisition of shaft sleeve	2	Understand the principle and structure composition of handheld 3D scanner Master the equipment connection and calibration methods of handheld laser scanner, and understand the precautions during calibration Understand the function of each module of the scanner software and get familiar with the method flow of acquiring 3D data	Complete the connection of handheld 3D scanner Calibrate the handheld 3D scanner Correctly complete scanning point cloud data processing and model packaging method
2	Model reconstruction of shaft sleeve	2	Understand the importance of coordinate system alignment and how to use it Understand how to use face sketch Master the use methods of stretching and rotating	Coordinate system alignment of scan data using reverse modeling software Initial use of the patch sketch feature of reverse modeling software Model reconstruction is preliminarily carried out by stretching and rotating

Table 5 *(continued)*

No.	Learning task name	Teaching hour	Learning target	Skill point
3	Data acquisition of product cup bottom	2	Get familiar with the preparation work before scanning the workpiece Master the scanning method of workpiece Understand the splicing method of scanning data	Pre-processing the workpiece before scanning Scan the front and back data of workpiece Completely splice the scanning data on the front and back sides
4	Model reconstruction of product cup bottom	4	Grasp the selection method of alignment elements for coordinate system alignment Familiarize with the projection method of the sketch area contour of the face piece	Coordinate system alignment using datum features Proficient in model reconstruction using the Patch Sketch function of reverse modeling software
5	Headlight data acquisition	2	Understand the functions of the smart marker point Master the technique of multi-angle scanning of marker points	Skillfully use the smart mark point function of scanning software Conduct multi-angle scanning on the marked points on the workpiece
6	Model reconstruction of headlights	6	Grasp the reverse process of common mold parts, and understand the position and angle judgment of draft surface and parting line Master the command of moving surface Master the command of draft	Split the scanning data Proficient in moving surface features of reverse modeling software Proficient in using the draft function of reverse modeling software to complete model reconstruction
7	Data acquisition of connection base	2	Understand the differences between multiple and single lasers Master the method of switching laser during scanning Familiar with the technique of single laser	Supplement defect data with a single laser During scanning, preliminarily switch multiple or single lasers for scanning Be skilled in scanning such features as deep holes with a single laser
8	Model reconstruction of connection base	6	Understand the division of curved surface and fit the order of making curved surface Master the use method of fitting patch Master the method of setting out bridge surface	Complete the division of surface field with reverse modeling software Skilled in fitting patch function of reverse modeling software Model reconstruction method of surface with reverse modeling software
9	Data acquisition for turbine blades	2	Master the scanning angle skills of multiple lasers and single laser Master the skills of scanning narrow gaps	Be able to flexibly switch multiple or single lasers as required during scanning Scan the narrow gap of blade

Table 5 *(continued)*

No.	Learning task name	Teaching hour	Learning target	Skill point
10	Model reconstruction of turbine blades	8	Master the use method of the command of adjusting the surface Master the use method of inversion normal Master the skills of seaming synthetic entity	Skilled in adjusting surface function of reverse modeling software Apply the command of reversing normal line flexibly according to the actual situation of blade data Complete model reconstruction by using seaming entity command of reverse modeling software
11	Data acquisition of firing gun	2	Consolidates past knowledge of the use of handheld 3D scanners Master the processing method of scanning data	Skillfully scan the complete data of workpiece Simplify, refine, smooth, fill and popularize the scanned data
12	Model reconstruction of firing gun	10	Master the method of symmetric workpiece coordinate system alignment Master the use method of 3D sketch Master the method of 3D sketch cutting sheet Master the use method of face filling order	Select proper coordinate system alignment method according to data requirements of firing gun Familiar with 3D sketch function of reverse modeling software Skilled in 3D sketch cutting slice function with reverse modeling software Complete the model reconstruction by using the face filling command of the reverse modeling software
Remarks		48 hours.		

6.2.3 3D printing and post processing

See Table 6 .

Table 6 List of learning tasks for 3D printing and post processing

No.	Learning task name	Teaching hour	Learning target	Skill point
1	Basic training of 3D printing	14	Understand the basics of 3D printing Understand the different processes and common problems of 3D printing Learn basic modeling and retrieve model files Learn to use slice software and adjust slice parameters Learn to use 3D printers	Cognition of basic theory of 3D printing 3D Printing and analysis and handling of model common problems Use of basic modeling, model retrieval and slicing software Use of 3D printer, feeding and returning of consumables, and use of solid adhesive

Table 6 *(continued)*

No.	Learning task name	Teaching hour	Learning target	Skill point
2	FDM printing post-processing	12	Understand post-treatment tools and select materials correctly Remove the support structure and leave the mock-up undamaged Learn grinding, hole filling, polishing, etc Understand the delivery process and quality inspection requirements	Selection of post-treatment tools and materials Removal of supporting structure Surface optimization: grinding, hole filling and polishing Quality inspection and delivery
3	LCD photocuring printing and post-treatment	14	Understand the impact of post-processing on the quality and performance of photocured prints Master modeling methods Correctly set printing parameters to ensure the quality and accuracy of printed documents Master the use method of printer Master the correct way to clean and dry photo-cure printouts Master the supporting structure removal and printing part polishing and finishing skills Master the basic steps and skills of painting and coloring	Post processing of photocuring printing and its influence on print quality CAD software modeling Move, rotate and support the model Configure printing parameters such as layer thickness, exposure time and motor speed Clean printing platform and install resin tank Prepare required materials and equipment Prints are completely dried. Check for complete removal of residual resin Remove the supporting structure with appropriate tools High-quality sanded and painted prints
4	Metal Printing and Post-treatment	24	Get familiar with the operation before starting the metal machine and prepare for printing of the metal machine Master the printing operation process of metal machine Master post-processing methods and skills of metal printouts	Inspection of protective articles and wearing correctness Inspection of electrical safety, cooling water volume and protective gas volume Powder material quality, storage and technical parameters inspection Equipment and computer startup and equipment return to original point operation Installation and leveling of base plate Check and replace the powder spreading scraper, and adjust the thickness of metal powder powder spreading layer Preparation and adjustment of processing environment Part data addition, extraction after machining and powder treatment after forming Remove the supporting structure with appropriate tools. High quality polished (including polished and

Table 6 *(continued)*

No.	Learning task name	Teaching hour	Learning target	Skill point
				blasted) printouts
	Total	64		

7 Teaching implementation

7.1 Content distribution

Teaching Implementation: It is suggested to implement the curriculum in real or simulated working situations by using the action oriented teaching method. The teaching duration is 48 class hours for Product 3D Design and Modeling, 64 class hours for 3D Scanning and Reverse Modeling, and 160 class hours for 3D Printing and Post-processing. The proportion of theoretical teaching to practical teaching is about 20%--80%.

7.2 Teaching organization and teaching method

7.2.1 Teaching organization

The following organization modes are selected according to specific contents, site and equipment conditions:

a) Centralized teaching. The trainer will focus on the curriculum contents;
b) Practice in groups. Organize group discussion and practice on the computer in groups;
c) Online and offline mixed teaching. Expand learning time to meet individual needs and motivate students.

7.2.2 Learning methods

The following 3 learning methods are mainly used.

a) Self-paced learning. Students watch videos before classes, inquire materials, and learn scanning and detection features to lay a solid foundation for learning in classes;
b) Group discussion. During the collaborative completion of work plan formulation, process preparation and other link projects, the knowledge of knowledge points and the ability of communication and cooperation shall be improved by participating in or leading the group discussion;
c) Practical method of operation. The whole process for students to complete practical tasks independently or in groups.

7.2.3 Teaching methods

Based on the specific content, site and equipment, the following teaching methods are selected:

a) Scenario teaching method. The students experience the real work situation, enhance the sense of professional substitution and gain work experience;
b) Task driven method. With the help of teachers, students explore independently and learn cooperatively around the online inspection and processing activity center;
c) Four-stage teaching method. Teacher preparation, demonstration, students' simulation, practice, four stages of teaching breakthrough learning focus.
d) Evaluation and feedback.
   1) Periodic evaluation: Conduct periodic checks on students' practical operations, and conduct quizzes at the end of each module;
   2) Final evaluation: After the course ends, each group submits a complete work and proposal report, and undergoes a learning quality assessment.

7.3 Teaching resources

7.3.1 Site and equipment

The site and equipment requirements are as follows.

a) Product 3D design and modeling. Build 3D product design and modeling training room: it is suggested to configure according to the station, and each station is equipped with modeling and other relevant software;

b) 3D printing and post-processing. Construction of 3D printing and post-processing training room: the training room must be provided with good lighting and ventilation conditions, including centralized teaching area, grouping training area, information retrieval area, tool storage area, material storage area and achievement display area, and equipped with multimedia teaching equipment;
c) 3D scan and reverse modeling. Construction of 3D scanning and reverse modeling training room: it is suggested to configure by station. Each station shall be equipped with reverse modeling software and other relevant software. The equipment shall be equipped with more than 10 hand-held 3D scanners and more than 10 sets of curriculum training samples.

7.3.2 Tools and materials

The tools and materials requirements are as follows.

a) Product 3D design and modeling. Modeling requires a computer as the primary tool;
b) 3D scan and reverse modeling. It is recommended to equip tools and materials such as marking points and daubs according to the working position of the scanner;
c) 3D printing and post-processing.
    1) Tools:scraper knife, scissors, small tool knife, cutter knife, abrasive paper (150-220 meshes), abrasive paper (400-600 meshes), abrasive paper (600-2000 meshes), heating furnace (Temperature: 200 ° C~1500 ° C; Vacuum degree ≤ 10^{-3} mbar , Pressure: 100~200 MPa, Furnace Size: 300 × 300 × 300 mm) , wool brush, wire cutting machine, sand blasting equipment, etc.;
    2) Materials: PLA materials, ABS materials, protective equipment, 50-60 ℃ warm water, ethanol or isopropyl alcohol, filling glue or putty, polishing paste, polishing cloth, paint spray or paint, metal powder (316L, etc.), etc.;
    3) Equipment: work station, polishing machine, spray gun or paint brush, grinding machine, etc.

7.3.3 Teaching materials (including resource base)

Including but not limited to text materials, presentation materials, graphics (images) materials, audio materials, video materials, animation materials and virtual simulation materials.
Paper materials to be prepared before class mainly include:

a) Product 3D design and modeling. Teaching materials such as assignment book, work plan template, acceptance form, work record form template, etc;
b) 3D scan and reverse modeling. Teaching materials such as task book, 3D scanner operation manual, reverse modeling software operation manual, work plan template, acceptance form, work record form template, etc;
c) 3D printing and post-processing. Working page, 3D printing process description document of teaching material, 3D printer specification, acceptance sheet template, etc.

8 Teaching evaluation

8.1 Evaluation objective

The teaching evaluation of this course combines various methods such as process assessment, practical results, printed work scores, course design/project assignments, and exam scores to comprehensively and objectively evaluate the learning outcomes and course quality of students. These evaluation methods not only help students to timely understand their learning progress and existing problems, but also provide important basis for teachers to adjust teaching methods and course content, thereby continuously improving the teaching quality and learning effectiveness of the course.
The course evaluation adopts a combination of process evaluation and summative evaluation, with process evaluation accounting for 60% of the total score and summative evaluation accounting for 40% of the total score. After the course is completed, students' comprehensive vocational abilities are assessed separately.
Process evaluation mainly includes process assessment, practical assessment, work evaluation, and passport examination, with process assessment accounting for 20%, practical performance accounting for 20%, printed work evaluation accounting for 10%, and skill passport examination accounting for 10%.
The final evaluation is mainly conducted through exams, accounting for 40%.

8.2 Evaluation method

8.2.1 Content Introduction

The teaching evaluation of this course combines various methods such as process assessment, practical results, printed work scores, course design/project assignments, and exam scores to comprehensively and objectively evaluate the learning outcomes and course quality of students. These evaluation methods not only help students to timely understand their learning progress and existing problems, but also provide important basis for teachers to adjust teaching methods and course content, thereby continuously improving the teaching quality and learning effectiveness of the course.

Suggest using the evaluation criteria in the BRICS Group Standards《 Additive Manufacturing Competition - Competition Standards 》 as the basis. The teaching assessment adopts a combination of process evaluation and summative evaluation, with process evaluation accounting for 40% to 60% of the total score and summative evaluation accounting for 60% to 40% of the total score. After the course is completed, the comprehensive vocational ability of the students is assessed.

8.2.2 Process assessment and professional competence evaluation

Process assessment is the fundamental evaluation stage of this course, which adopts a scoring or grading system. By establishing clear scoring criteria, it mainly tests the students' learning attitude, participation, and daily homework completion in the classroom. The evaluation content includes classroom attendance rate, enthusiasm for questioning and answering questions, contribution in group discussions, and the quality and timeliness of homework submission.

Adopting the internationally popular COMET (Competency Oriented Model of Educational Targets) assessment method, the comprehensive professional abilities of athletes are evaluated through written tests. COMET International Vocational Ability Assessment Technology starts from 8 key competency indicators, including intuitiveness, functionality, value orientation, economy, work process orientation, social acceptance, environmental friendliness, and creativity. Through 40 specific observation points, it comprehensively and meticulously assesses students. Through this evaluation method, students' comprehensive professional abilities in the field of additive manufacturing can be more accurately understood, and their corresponding professional ability levels can be evaluated based on this, providing important references for their future career planning and development.

8.2.3 Final exam and skill passport

The final exam is the final evaluation stage of this course, which comprehensively tests the students' understanding and mastery of the course knowledge, skills, and methods. The evaluation of exam results adopts a percentage or grade system, and detailed scoring standards are formulated based on the exam outline and requirements to ensure fairness and consistency in the evaluation. The exam covers multiple aspects such as basic principles, operating procedures, equipment maintenance, safety regulations, and practical applications.

The practical results directly reflect the students' skill level and safety awareness in actual operation, and are evaluated through various methods such as on-site observation, video playback, operation records, and safety reports. At the same time, a spot check or full inspection system is adopted to ensure that each student has the opportunity to showcase their skill level. The evaluation content covers product 3D design and modeling (including reverse engineering), printing preparation, work printing, post-processing, etc. The final evaluation score of the work is determined by a weight of 2/3/5 for self-evaluation, group evaluation, and teacher evaluation.

The assessment content of the skills passport exam closely revolves around the core skills of the course, including but not limited to product 3D design and modeling (including reverse engineering), printing preparation, work printing, post-processing, etc. Based on the performance of the students in the course learning process, such as process assessment and practical results, the skill level of the students will be comprehensively recognized, and corresponding international skill passports will be issued. The specific assessment criteria refer to the "Additive Manufacturing Competition Skills Standards" to ensure the authority and professionalism of the evaluation.

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